Proceedings

2nd International Conference on Rabbit Production in Indonesia
3rd Conference of Asian Rabbit Production Association

"Empowering Rural Economy Through Small-Medium Scale Eco Rabbit Farming"

Bali, August 27-29th 2013

Proceedings

2nd International Conference on Rabbit Production in Indonesia
3rd Conference of Asian Rabbit Production Association

"Empowering Rural Economy Through Small-Medium Scale Eco Rabbit Farming"

Bali, August 27-29th 2013

Editors: Dr. Elizabeth Wina, M.Sc.
Dr. Yono Rahajo
Dr. Ir. L. Hardi Prasetyo, M.Sc.
Ir. Tati Herawati, M.Agr.
Prof. Dr. Arnold P. Sinurat
Prof. Dr. Sofjan Iskandar
Dr. drh. Yulvian Sani, M.Sc.
Prof. Dr. Qin Ying he
Prof. Dr. Nguyen Van Thu
Dr. Thierry Gidenne
Prof. Dr. A.R. Alimon

Indonesian Centre for Animal Research and Development
Indonesian Agency for Agricultural Research and Development
Ministry of Agriculture
2014

Catalogue in publication

INDONESIAN CENTER FOR ANIMAL RESEARCH AND DEVELOPMENT
Proceedings 2nd International Conference on Rabbit Production in Indonesia: Empowering Rural Economy Through Small-Medium Scale Eco Rabbit Farming: Bali, August 27-29th 2013/Editors, Elizabeth Wina ... [et al.].--
xiii, 274 p.: ill.; 29,7 cm
636.92
1. Rabbit Production 2. Indonesia
I. Title II. Wina, Elizabeth

ISBN 978-602-8475-94-5

Layouters: Pringgo Pandu Kusumo
Ruliansyah Lubis
Linda Yunia
Cover design: Dadang Sudarman

Indonesian Centre for Animal Research and Development
Jl. Raya Pajajaran Kav. E-59 Bogor 16151
Phone : (0251) 8322185
Fax. : (0251) 8380588
E-mail : criansci@indo.net.id

PREFACE

This book is the result of the 2nd International Conference on Rabbit Production and also 3rd Conference of Asian Rabbit Production Association which was held by the Indonesian Agency for Agricultural Research and Development on August 27-29th 2013 in Bali, Indonesia.

Rabbit farms in Indonesia and in other countries are still new industry. Nevertheless, there has been increasing development of technology over the years with different levels in each country due to the differences of priority. Regular international scientific meeting was conducted involving experts who delivered results of various rabbit research activities and technology from various countries. The present conference theme was "Empowering Rural Economy Through Small-Medium Scale Eco Rabbit Farming". This conference enhanced the technology and knowledge on rabbit industry, which can be used as the policy base of meat production. Therefore, the aims of this conference were to exchange information on technology and veterinary to support the development of rabbit industry; to disseminate research results; and to improve information networks among scientists from research institutes, universities and stakeholders.

There are 48 papers, 31 from overseas and 17 from Indonesia. The papers contain various aspects including nutrition, genetics, breedings, reproduction, management, social economics, policy, post-harvest and veterinary. However, some are only abstracts because some of them have been published in our journal and others.

I hope this proceedings will be useful for scientist, rabbit entrepreneurs and also policy makers.

Bogor, December 2013

Dr. Bess Tiesnamurti
Chairman of the OC

REMARKS FROM DIRECTOR GENERAL OF IAARD

Bali, August 27th, 2013

The Honourable

- Director General of Livestock Services and Animal Health
- Governor of Bali Province
- President of the World Rabbit Science Association (WRSA)
- President of Indonesian Branch of WRSA
- President of Asian Rabbit Production Association
- Indonesian Senator
- CEO of Kangda Food Co. Inc.
- Director of Indonesian Centre for Animal Research and Development
- Distinguished delegates from overseas, my fellow, participants of the conference

Ladies and Gentlemen,

It is indeed my pleasure to welcome you all to Indonesia, especially to those who come to Indonesia at this very first time. My warmest welcome and appreciation is extended to you for your participation in this 2nd International Conference on Rabbit Production and 3rd Conference of Asian Rabbit Production Association in Indonesia. The Indonesian Agency of Agricultural Research and Development (IAARD) is very delightful to host this meeting.

As may also occur to some other countries, rabbit has become very popular livestock raised by farmers in the villages. Such case also occurs in Indonesia and especial nowadays, interest in raising rabbit increases very rapidly. From North Sumatera to Papua, except in Kalimantan, Maluku and Nusa Tenggara, raising rabbit is not longer strange to farmers. Rabbit gains its popularity. Initially, as early as 1980, rabbits were widely distributed by Government to farmers in the village areas to improve animal protein consumption. At such time a concept of rabbits as “mini meat factory” was popular. At present, however, the objective has shifted to raising rabbits as a significant earnings for rabbit farmers. It is also reported that many farmers increase the numbers of their rabbit population. Although the majority of farmers raised small number of rabbits (5-20 does), it is no longer surprising if some farmers have significant numbers of rabbit (200-500 does). The rabbit farming is moving from hobby to industry. Therefore the theme for this conference: “Empowering Rural Economy Through Small-Medium Scale Eco Rabbit Farming” is considered as appropriate for the development of rabbit farming, especially for Indonesian situation.

There, of course, some problems still exist that may discourage this development; in productivity, including high mortality before and after weaning, psychological feelings (‘bunny syndrome’) in consuming rabbit meat, as well as economic consideration. However, I do believe that through this meeting, exchange of experiences, research results and ideas may to some extent overcome these various problems and give benefit to the development of rabbit farmers here and elsewhere. Moreover, through this initiative, the collaboration of the IAARD and the scientists as well as industries from overseas can be established to improve better rabbit farming and production.

A special thank is offered to Governor of Bali, Mr. I Made Mangku Pastika for his kindness in providing the venue and facilities for this conference. Sincere thank is extended to the World Rabbit Science Association and to its Indonesian Branch, and Asian Rabbit Production Association, that have significantly play an important role on this conference, and also to the Director of ICARD, Dr. Bess

Tiesnamurti and members committee of this conference who had been working very hard to make this conference successful.

And last, but not least, I hope you enjoy this conference and your stay in Bali. Thank you very much.

And by the help and grace of God, Our Lord, I pronounce this 2nd Conference in Rabbit Production and 3rd Conference of ARPA opened.

Bali, August 27th 2013

Dr. Haryono
Director General of IAARD

CONFERENCE CONCLUSION

The first aim of this conference is providing a forum of communication for information exchange between research institutions, universities, private industries and farmers. Hopefully, after the conference, many new information, new technologies can be applied to strengthen food security.

A variety of papers and poster titles could be classified as papers on policy and role of government in each country, and papers explained the current status of rabbit research and development in Vietnam, Egypt, Malaysia, India, Costa Rica, Thailand, and Indonesia. Papers on nutrition aspects including feeding strategy (France, Vietnam), effect of using various source of feed such as waste product, spinach, sweet potato, sunflower meal, cat fish oil, coco peat, effect of dietary various fiber, different levels of NDF. Papers on breeding and reproduction aspects including breeding of Angora rabbit, reproduction, association between polymorphism, function of the rabbit gene, gene as a marker. Management aspect discussed under the topic of the effect of rabbit performance in hot climate, housing system, maintenance of waste product, religion aspect, supporting of banking system, quarantine, factors influencing rabbit hair and electric stimulation. Limited papers described about veterinary science, including vaccine component, application of proteome analysis, anti fungal and the immunomodulatory. And the last aspect was industrial rabbit production in China.

There and/or of course some problems still exist that may discourage this development including high mortality and/or low of consuming level of rabbit meat. However through this meeting, exchange experiences, research results and many ideas may to some extent overcome these various problems and give benefit to the development of rabbit farmers in each of our country. Moreover, through this initiative, the collaboration of Indonesian scientist and the scientist from other countries as well as industries from overseas had been built to improve better rabbit farming and production.

CONTENTS

NUTRITION

INVITED SPEAKER

Policy in Rabbit Research and Development in Indonesia

Haryono

Indonesian Agency for Agricultural Research and Development
Jl. Ragunan 29, Pasar Minggu, Jakarta 12540
Corresponding e-mail: www.litbang.pertanian.go.id

ABSTRACT

Increasing population, world economic globalization, global warming and domestic crisis including manpower quality are among challenges faced by many nations, including Indonesia, to provide food, shelter, job opportunity and welfare to the people in the country. Rabbit, among many animal species has high potential to provide a substantial amount of meat, hence contribute to more food security. Problems in raising rabbits in Indonesia, as a hot humid country includes lack of availability of quality rabbit breeds and quality feed, lack of appropriate technology for production or management and frequent diseases incident. A short of capital and small size of land use, as commonly occurs in many developing countries, cause a difficulty to produce effective and efficient production. Policy in research is prioritized to producing breeds that are adaptable to Indonesian situation, efficient feeds and feeding management fitted to local condition and also to handle disease problem. Farming management in farmers group is also a concern. A small-medium scale industry-type operation based on farmers cooperation which is integrated with organic plant production is a short term goal. A more integrated commercial type production supported by high investment and technology is a longer term objective.

Key Words: Policy, Rabbit, Development

INTRODUCTION

In 2007, world population has reached 7 billion and, and along with current birth rate, the population will reach more than 9 billion in 2050 (FAO 2012). This huge number of population will mostly live in the developing countries, where food, clean water and energy supply are less available than the developed countries. Beside the above demand, global warming which may affect the agricultural production and economic globalization, which need skillful labor, have to be well considered. Failure to meet the demand may cause poverty, famine and even chaotic situation to the country. One of the consequences of having high population is less land availability for agriculture. In Indonesia, where average land use per family is less than 0.25 ha (BPS 2012), it seems justifiable that in the future, intensification, opening more land for agriculture and selection for high productivity commodity is a priority. In the area of animal production, selection for fast growing and prolific animal, yet small in size, such as poultry and rabbit, will be an alternative.

LIVESTOCK PRODUCTION IN INDONESIA

Indonesia is a humid tropic country. It has highly fertile soil, especially those in Java, Bali, Sumatera and Sulawesi and some in Kalimantan. Hence, theoretically the agriculture production can be maximized. However, some limitations including climate changes, availability of funds and skillful labor, diseases, which to some extent, somewhat hinder these potential agricultural production. Animal production is mostly dominated by poultry, hybrids or local chickens, local ducks, which provide 1,797,500 ton of meat, and then followed by beef cattle (505,500 ton), sheep and goat (115,100 ton) and a few from buffalo (35,300 ton), and swine (234,700 ton) in certain areas (BPS 2012). Rabbit (200 ton) is a relatively new livestock fairly new to be commercially farmed. Except for the poultry hybrids and dairy cattle, which are mostly fully commercially operated, other birds (ducks, quails) and livestock are farmed in small or medium scale operation. Beef cattle and goat and sheep farming are almost entirely operated through grazing and cut and carry system. In most areas, except in Eastern Nusa Tenggara, this ruminant farming is mostly also operated in small scale.

PROBLEMS IN SMALL SCALE FARMING

Small scale farming is usually practiced by most farmers in the rural areas. Problems with small scale include: (a) subsistence; (b) depend almost entirely on the nature to provide forage feed; (c) low or hardly any capital investment; (d) farming technology is limited; (e) less ability of farmers to market their products; (f) less cooperation between farmers in the group; (g) less interest in the organization. Consequently it is difficult to develop and sensitive to quitting. Nevertheless, even micro farming is important as a source of cash income, nutrition and organic fertilizer for the farmers.

ALTERNATIVE ANIMALS

High population that demand more availability of food, less land availability for agriculture, global warming that may decrease agriculture production, long production cycle for ruminants, competitive feed for poultry and swine, a more frequent diseases outbreak are problems that has to be solved in order to secure food, or particularly, meat production in the animal sector. An alternative animal that has high productivity, requires small land to use, fed mostly feed that is not competitive to human food, easy to handle and 'halal' to certain community, is worth considering. Rabbit is one among other possible animals to choose.

RABBIT PRODUCTION STRATEGY AND ITS PROBLEM

Rabbit potential has been reported elsewhere (*eg*. Owen 1976; Cheeke 1986; Lukefahr 2007; *etc*.). At a traditional practice, a doe rabbit can produce 40 kg of meat (Raharjo 2007), and 120 kg/year at most commercial farming (Maertens 2007). At a rural operation a SSRPM model (Lukefahr 2010) fits the situation. At a more commercial rural farming, a model of an integrated rabbit-horticulture village based on farmer cooperative (Raharjo 2010) combined with fish pond is an initial step to move toward industrial farming. At industrial farming, a food processing plant and more comprehensive training and marketing system is integrated to the system. The crucial problem for this system could be management of farmer cooperation, diseases that may arise from the this extensive large scale rabbit population and promotion to rabbit meat consumption at this large scale operation.

RESEARCH PRIORITIES

In an attempt to achieve the above goal, research on: (a) producing high productivity tropically adaptive lines; (b) improvement of growth and reproduction and reduction of mortality through efficient use of feeds/forages and additives especially for small and medium scale farming, and improvement of health digestion system in the nutrition area; (c) improvements of reproductivity of does and bucks; (d) management in housing system, and management of farmer organization; and (e) diseases prevention and treatment.

GOVERNMENT ROLE IN DEVELOPING RURAL RABBIT PRODUCTION IN INDONESIA

Fauzi Luthan

Directorate General of Livestock and Animal Health
Ministry of Agriculture, Indonesia
Corresponding e-mail:

ABSTRACT

Agricultural sector including livestock and animal health plays a role in the formation of Gross Domestic Product (GDP) in Indonesia, increase employment and foreign exchange, increase people's incomes and poverty alleviation. The Ministry of Agriculture in 2010-2014 has four main targets to be achieved, including the achievement of self-sufficiency and sustainable self-sufficiency, realization of food diversification, to increase the added value and competitiveness and improving the welfare of farmers. In achieving those four main targets, Directorate General of Livestock and Animal Health (DGLAH) issuing policies that one of which is the development of Minor Livestock Production (such as rabbit, quail, deer meat) farming system to support meat sufficience for farmers. The farming system which can be developed in rural condition and do not require large area of land is rabbit husbandry. To improve the rabbit farming and production, needs to develop the pattern of cooperation with stakeholders and the availability of village rabbit breeding center should be enhanced to provide good quality of rabbit breed.

Key Words: Programs, Government Policies

INTRODUCTION

An intention in national economic development is to make agriculture as a leading sector because of the strategic role of this sector as a food provider for the nation and to improve raw materials availability established for food and non-food industries. In addition, the agricultural sector including livestock and animal health plays a role in the formation of Gross Domestic Product (GDP), increase employment and foreign exchange. The agricultural sector in turn can increase people's incomes and poverty alleviation.

Indonesia had been known as agricultural society as a legacy from generations to generations. Based on the results of the National Labor Force Survey (Sakernas/BPS-Statistic Indonesia), that the labor force engaged in the agricultural sector dominates non-agricultural sector up to the year of 2009. The labor force in Indonesia, is around 104 million and 40% (or about 41 million) of that were absorbed in the agricultural sector and mostly living in the countryside (BPS 2009). The growth of the labor force in the agriculture sector tends to decrease, such as in the period between 2002-2005 decreased growth reached 2.91 and during 2005-2009 to 2.41 (BPS 2009). Declining in labor force growth in the agricultural sector was because of switched professions to other sectors such as in the Trade, Services, Mining and Building.

Reduced of labor force in the agricultural sector is caused due to margin gains are minimal and land use is not adequate foreconomic business. Land owner farmers in Indonesia, especially in Java has limited area with an average of 0.2 hectare, some farmers even more as peasants (as the rural landless laborers), in addition, there also a replaced functions of productive agriculture land become infrastructure development, industrial and residential.With limited land owned by farmers, the role of the livestock sub-sector can be expected as an alternative to supporting farming in increasing the added value of the income and welfare of farmers.

The Ministry of Agriculture in 2010-2014 has four main targets to be achieved, namely:

1. the achievement of self-sufficiency and sustainable self-sufficiency;
2. realization of food diversification;
3. to increase the added value and competitiveness;
4. improving the welfare of farmers.

In achieving those four main targets, DGLAH issuing policies that one of which is the development of Minor Livestock Production (such as rabbit, quail, deer meat) which is directed to support Achieving Self-Beef meat Sufficiency Program and Increased Provision of Safe, Healthy and Halal Animal Food.

Meat consumption according to the standard of National Food Nutrition Widya Karya - LIPI for animal protein derived from livestock is 6 g/person/day is equal to 10.3 kg of meat/person/year meat, and 6.5 kg eggs/person/year and 7.2 kg milk/cap/year. In 2013 beef consumption reached 2.2 kg/person/year and for poultry meat reached 6 kg/person/year (LIPI 2013). The meat shortage can be supported by one of the livestock diversity meat, especially of rabbit meat. In support of these programs, a suitable farming system which can be developed in rural condition and do not require large area of land is rabbit husbandry. Domestic scale of rabbit husbandry in Indonesia is mostly performed around the back-yard.

At the moment, rabbit meat consumption has not been as popular as beef or poultry. In that case, aggressively promotion of consuming rabbit meat should be done by promoting that rabbit production is rapid due to its prolific characteristic and the advantages of rabbit meat for health issue such as low in cholesterol, high in protein and flavor that resembles poultry meat. Another benefit of rabbit husbandry is its added value of the rabbit hide and fur that can be used for handy crafts or industrial scale such as for jackets, hats, scarves, shoes, dolls, bags and miscellaneous accessories. Other added values in rabbit husbandry are urine and feces products that can be used as organic fertilizer for horticultural crops and vegetables.

PROBLEMS

Rabbit breeding conditions in Indonesia have not been spread evenly, and it is developed as backyard-small farm family activity with limited number of holdings and capital, low quality breeds, as hobbyist and pets. For meat production, mortality rates are still high due to limitation in access to medications, information and technology. It leads to non-economical production, less reliable continuity of meat supply and varies in product quality.

Based on these conditions, the rabbit production scheme needs to be revisited in order to gain a profitable livestock business to develop agribusiness and environmental-friendly activity. This effort leads to empowering rural economy through small and medium scale rabbit farming for developing sustainable rural livestock production.

ROLES OF DIRECTORATE GENERAL OF LIVESTOCK AND ANIMAL HEALTH IN RABBITS PRODUCTION DEVELOPMENT

Steps had been taken and achieved in the cultivation of rabbits in support of Achieving Self-Beef Meat Sufficiency Program and Increased Provision of Safe, Healthy and Halal Animal Food, DGLAH have been involved in development of rabbit farming with several activities such as:

Rabbits production development

1. Empowerment of rabbit breeders groups through the strengthening of venture capital and social assistance had been conducted since 2006 until today. Assistant of Rabbit development had been spread to 88 farmer groups in 16 provinces and 46 districts/cities in Indonesia.
2. Village Building Undergraduate Program (SMD) during 2009-2010 had been allocated funds to 36 farmers groups in 9 provinces.
3. Other aid in the form of soft loans to farmers in the form of Credit Food Security and Energy (KKP-E).
4. In 2012 a pilot project was carried out for rabbit village development using state funds and focused in 5 Provinces, 5 Regency/City on 6 groups of farmers.
5. Current conditions (in 2013) assistance to farmers in the form of agriculture-machinery allocated through the de-concentrated state budget funds through auction procurement process.

Rabbit breeder group coaching

The activities was given to the selected group of potential recipient and location and memorandum of understanding was signed and known by local official. The selected groups were then given a letter of recognition signed at least by Agriculture District Director and will receive assistance routinely performed gradually from the central, provincial and district/city to perform a Good Farming Practicess. Monitoring and evaluation were also performed to the recipient group regularly to detect problems and checking the progress.

Increase promotion and dissemination rabbit meat consumption

Indonesian people have not been accustomed eating rabbit meat and there are also still doubts in terms of halal according to the Islamic law. According to Indonesian Ulama Council Fatwa (MUI 1983) it was pronounce that rabbit meat is halal. Processed rabbit meat products in the form of a satay, steak, meatballs, fried rabbit and nugget needs were promoted and showed in any event both at work and exhibitions.

Coordination between related agencies (IRIAP/University and Directorate General of Food Crops and Horticulture)

Integrated farming system in rabbit production have been carried out by DGLAH and Directorate General of Horticulture. The pattern is based on the same mutual expectation, equality and profitable. From the rabbit husbandry, the feces and rabbit urine can be utilized as organic fertilizer and plant by-product of vegetable and horticulture were used as additional food for rabbits.

The aim of all the government support in providing assistance in the development of rural rabbit farming is to grow and increased the economy in rural areas, increase economic independence, fostering the spirit of entrepreneurial among the group, reduce urbanization with job creation and improvement of rural people's nutrition.

The programs are not only carried out by the central government but also from local government through budget funds, private individual/Association, through funding partnerships/CSR and Universities.

Role of Stakeholders is expected that rabbit production and distribution can be spread all over Indonesia. When sustainability of rabbit meat is available, then we hope the consumption of rabbit meat become more popular in the community.

FUTURE DEVELOPMENT OF RABBITS FARMING

Prospect of rabbit farming in the future is reliable considering the development of animal husbandry today and beyond especially in the midst of globalization. To face this era of globalization, need the readiness of the group Breeders, Livestock Infrastructure, Government Policy, Private sectors, Associations and Universities to face the global conditions and are required readiness to take a role. This condition should be seen as an opportunity increasingly open world market.

Breeders are given protection, especially when farmers are facing difficulties in order to establish a livestock business. Kind of protection can be given when facing against the plague, selling price fluctuating production, climate change that can lead to uncertainty for businesses and most of the time farmers are powerless to deal with it.

The breeders who have the same goals and visions are encourage to join and form groups of farmers so that the presence this group can improve in:

1. Efficiency of business in term of animal production infrastructure (livestock breed, and solving problems in feed nutrition and price, marketing)
2. Strengthening the bargaining position (the price can be controlled)
3. Facilitate coaching and supervision

Protection for farmers in continuity of animal production business are also set in Law No. 18 and 2009 regarding Animal Husbandry and Health (DPR-Presiden RI 2009). The Government also provides protection that farmers can possibly accessed widely to the resources of land, water, genetic resources, and to the development of seeds, feed, animal health, veterinary public health as well as on the downstream aspects.

CONCLUSIONS AND SUGGESTIONS

To improve the rabbit farming and production, needs to develop the pattern of cooperation with stakeholders.

The availability of village rabbit breeding center should be enhanced so rabbit production farmers easy to get a better quality of breed.

Research and development by the agricultural research and higher education in creating antibody/vaccine to reduce the mortality rateare continued.

The role of government, private sector, and the farmers group/association and universities in promoting the consumption of rabbit meat in the community should be improved.

REFERENCES

BPS-Statistic Indonesia. 2009. Sakernas/BPS-Statistic Indonesia. Jakarta (Indonesia): Badan Pusat Statistik, Direktorat Diseminasi Statistik.

DPR-Presiden RI. 2009. Undang-Undang Republik Indonesia Nomor 18 Tahun 2009 tentang Peternakan dan Kesehatan Hewan. Jakarta (Indonesia): Dewan Perwakilan Rakyat dan Presiden Republik Indonesia.

MUI. 1983. Indonesian Ulama Council fatwa regarding rabbit meat. Jakarta (Indonesia): Majelis Ulama Indonesia.

LIPI. 2013.

INDUSTRIAL RABBIT PRODUCTION AND KANGDA RABBIT PRODUCTION

Gao Yan Xu

President of ARPA, CEO, Kangda Food

ABSTRACT

An industry or a company cannot develop well without a good policy support from the government. This presentation will address two issues, the industrialized rabbit production and the industrialized rabbit production of Kangda Group. Expanded rabbit production will increase healthy meat supply to meet the increasing meat consumption requirement in Asia, while reduce, in great extend, the fodder crop consumption by livestock industry, thus, alleviate the grain crisis pressure. Expanded rabbit industry will also provide jobs for the farmers and increase their income, and flourish rural economy. Increasing in the world rabbit meat production is 90% of the increase comes from Asia countries. Asian Rabbit industry plays a very important role in world rabbit production. Great majority of rabbit production in Asian countries are still micro and small scaled backyard farming, facing. constraints and problems, such as, limited capital, knowledge (technology), source of feed, management, high breeding cost and low quality and productivity, low risk resistance etc. which cannot meet the increasing demand for meat of developing countries. Qingdao Kangda Food Ltd is an integrated company involving rabbit breeding, processing ,researching and marketing. Kangda has now become China's largest leading rabbit production enterprise.

Key Words: Breeding, Industrial, Rabbit Production

In the name of the President of ARPA, and on behalf of the Executive Committee of ARPA, to extend our warm welcome to scientists and experts from WRSA and colleagues from Asian rabbit industry to attend this conference and also our sincere thanks to Indonesian Ministry of Agriculture as well as the Indonesian Rabbit Production Association for their effort in organizing this conference and their support to ARPA.

The theme of this conference is "Towards Small and Medium Industries of Eco-friendly Rabbit Farming" means that it has to empower rural economy through small and medium scale eco-rabbit industry .This issue is of great significance to the Asian developing countries. And it is also the objective of ARPA as stipulated in ARPA constitution, that is to facilitate and conduct the exchange of knowledge, experience, new technology and market information and promote international cooperation among rabbit breeders, processors, researchers, traders, institutions and organizations in Asian countries on rabbit breeding, processing, marketing, researching, experiments, with the aim to further promote rabbit breeding, processing and scientific research as well as rabbit meat consumption so as to further develop rural economy, improve farmers` livelihood in Asian countries.

Since the founding of ARPA in 2008 during the Seminar on Organic Rabbit Production held in Vietnam. ARPA has conducted a series of activities around the theme to promote small and medium sized rabbit industry.

In September 2009, ARPA organized the first ARPA International Conference on Rabbit Production in Asia in Changchun China,

In June 2010, ARPA held the Sino–Indonesian Joint Seminar on Rabbit Production Cooperation in Qingdao, Sichun, China.

In July 2010, co-sponsored with Indonesian Rabbit Breeders Association and Indonesian Ministry of Agriculture, ARPA organized Asian Rabbit Workshop and Exhibition.

In November 2011, ARPA sponsored China (Kaixian) Rabbit Fair, Indonesian Rabbit Association send a delegation to participate the fair and conducted a field study on rabbit breeding.

In December 2011, ARPA held the second ARPA International Conference on Rabbit production in Asian, co-sponsored with the Ministry of Agriculture of Vietnam and The Rabbit Association of Vietnam.

In 2012, The Indonesian Delegation visited China and conducted technical exchange of China.

The ARPA activities had great influence in Asian countries, With the promotion of ARPA, Rabbit breeders in Malaysia and Philippines established their national rabbit association in 2009 and joined ARPA as group member.

We are glad to see that all our activities made contribution to the fast development of rabbit farming in member countries like Indonesia and Vietnam, their rate of expansion of rabbit farming is fast growing, interest of farmers and government on rabbit breeding is increasing. The present conference is just a prove for that.

All our achievement is due to the efforts of all ARPA members. I'd like especially mention that Dr. Yono, our Secretary- General. has made a great contribution to ARPA development in the past five years, I'd like to propose all of us to give a warm applause to Dr. Yono for his contribution to ARPA.

Dr. Yono asked me to give a introduction on the intensive and industrial rabbit production of Kangda Group. I must say that an industry or a company can not develop well without a good policy support from the government.

My presentation will address two issues , the industrialized rabbit production and the industrialized rabbit production of Kangda Group.

Rabbit farming has the most significant potential among all livestock husbandry. Expanded rabbit production will increase healthy meat supply to meet the increasing meat consumption requirement in Asia, while reduce, in great extend, the fodder crop consumption by livestock industry, thus, alleviate the grain crisis pressure. Expanded rabbit industry will also provide enormous jobs for the farmers and increase their income, and flourish rural economy.

Since late 20 century, more and more developing countries, especially, Asian countries, achieved fast development in rabbit production According to FAO statistics, the world rabbit meat production increased from 1269575 tons in 2000 to 1712856 tons in 2011, an increase of 35%. At the same time ,the rabbit meat production in Asian countries increased from 428891 tons in 2000 to 829603tons in 2011, increased 94%.

Table 1. Rabbit meat production of the world and Asia 2000-2011

Country	2000 (tons)	2011 (tons)	Increase (%)
World total	1,269,575	1,712,856	35%
Asian countries	428,891	829,603	94%
Asian shares in world total	33.8%	48.4%	

Source: FAOSTAT (2012); Livestock Primary Production

We can see 90% of the world increase comes from Asia countries, which shows Asian Rabbit industry plays a very important role in world rabbit production. But we had to realize that there is still a great gap between Asian countries and the developed countries in rabbit production, great majority of rabbit production in Asian countries are still micro and small scaled backyard farming, facing, constraints and problems, such as, limited capital, knowledge (technology), source of feed, management, high breeding cost and low quality and productivity, low risk resistance etc. which cannot meet the increasing demand for meat of developing countries. How to solve these problems? FAO gives us the right answer.

FAO (2013) stated in its article "world agriculture; towards 2015/2030" that, in order to meet the increasing demands for meat consumption, a continued shift in production methods can be expected away from extensive grazing systems and towards more intensive and industrial methods. More industrial and commercial forms of production will gradually increase in both number and scale. The development of Chinese rabbit industry proves that it is the best solution for the rabbit industry of developing countries to shift from backyard production towards intensive and industrial methods.

The development of intensive and industrial rabbit farming concerns many important issues, such as fine breeds selection system, disease prevention system, standardized breeding and production, quality traceability system, pasture planting, feed processing, slaughtering and processing, new product developing and marketing, *etc*. These are the fundamental elements to ensure a sustainable, efficient, high productive production. It is absolutely impossible for scattered household rabbit breeders to meet these requirement. The only way is to support and foster industrialized leading enterprises who will play a leading role in organizing numerous family breeders to form a benefit-sharing, risk-sharing community and implement within the community, standardized, intensive, scaled breeding and production so that to achieve “quality, safety, efficiency and high productivity” rabbit production.

The characteristics of China’s industrialized management of agriculture is an integrated farming operation. It takes the forms of “leading enterprises + agricultural cooperatives + farmers”, with the leading enterprises supported by the government as the core of the implementation of agricultural industrialization, This forms of operation enables the farmers to be organized in planting and breeding operations and in marketing ,reducing their risk in farming and marketing. improving the overall agricultural efficiency. In last century, like most developing countries. China’s agricultural operation was also based on individual farmers. From late 1990s, Chinese government started to implement the strategy of agricultural industrialization, under the policy support from the government , many leading agricultural enterprises and farmer’s cooperatives emerged. China’s rabbit industry entered a fast developing stage. Before the mid-1990s, China’s rabbit production relied solely on rural farmers’ sideline production, with the annual rabbit meat production hovering at 100,000 tons. Since late 1990s, with the fast growing demand for rabbit meat in domestic and foreign market, and encouraged by government’s policy for agricultural industrialization, leading companies engaged in integrated operation of rabbit breeding, processing, research and marketing as well as rabbit farmers cooperatives, rabbit production associations emerged in rabbit producing provinces. China stepped in the stage of intensive and industrialized rabbit production and this change of rabbit production mode resulted in fast growth of rabbit meat production.

From FAO statistics, we can see that China’s rabbit meat production in 2011 is 620% increase than 1990, and 85% than 2000.During the same periods, the world rabbit meat production increased respectively 82% and 34.8%, In 1990, China’s rabbit meat production accounted for 10 % of the world total, In 2011, China’s production accounted for 40% of the world total. This figure shows the industrialized rabbit production brings about fast growth of the rabbit production.

Qingdao Kangda Food Ltd. has been developed along with the process of China’s agricultural industrialization, and witnessed the industrialization progress of China’s rabbit industry. Qingdao Kangda used to be an export-oriented trading company, with limited processing facility to process rabbit meat with rabbits purchased from individual farmers. Since 2003, Kangda started the transformation from a trading and processing company into an integrated company involving rabbit breeding, processing ,researching and marketing.

Table 2. Rabbit meat production of the world and China 1990-2011

	1990	1995	Increase (%)	2000	Increase (%)	2011	Increase (%)
World	938,716	1,099,557	17.1	1,269,575	15.4	1,712,856	34.8
China	96,000	268,000	179.0	370,000	38.0	685,000	85.1
China share in world total (%)	10.0	24.3		29.1		40.0	

Source: FAO statistics (2012); Livestock Primary Production

Within several years, Kangda has now become China's largest leading rabbit production enterprise with integrated production of rabbit breeding, commodity rabbits breeding, research, feed production, slaughter and processing, marketing and investment , Kangda established proprietary rabbit breeding base and processing facilities in China's four main rabbit producing provinces - Shandong, Jilin, Hebei, and Sichuan Province, its' proprietary breeding farms with more than 10 million rabbits raised and processing plants with processing ability of 20 million rabbits annually. Kangda has established 50 tons rapid cooling facility, twenty thousand tons cold storage capacity and 101 EU registered rabbit breeding farms checked and approved by the EU official experts. In addition to its own breeding farms, Kangda adopted the approach of "company + farmer's cooperatives + farmers", in cooperation with local government and farmers, more than 200 professional rabbit breeding villages (rabbit breeding community) established around kangda's facilities. Kangda provides standardized management to all breeding villages and farmers. Kangda provide low interest loans to help farmers to construct rabbit farm and rabbit sheds. Kangda provide technical training to the farmers through farmers cooperatives and sign agreements or contracts with cooperatives and farmers to define the rights, obligation and benefits of each party. Kangda provide young rabbits to farmers and purchase back the commodity rabbits with pre-determined protective price. Kangda implement "five unified management" to contracted farmers and cooperatives. Kangda is responsible for unified supply of young rabbits, rabbit feeds, rabbit drugs, unified disease prevention and unified slaughter and processing. Farmers are only responsible for breeding. These contracted cooperatives and farmers provide Kangda 8-10 million commodity rabbits each year. Kangda pay the farmers 5-8 yuan net profit for each commodity rabbit, the net annual income of the farmers is around 40-50 million yuan. This approach effectively guarantees the interests of the farmers and the company.

The practice of Kangda in developing intensive ,industrialized rabbit production in form of "leading enterprise + cooperatives + farmers" shows the following advantage of intensive, industrialized rabbit production which will effectively solve the constraints and problems facing small individual backyard rabbit farmers.

THE COMPANY AND FARMERS FORM A COMMUNITY OF COMMON INTERESTS AND DEVELOPMENT, COMPLEMENTED EACH OTHER

Industrialized enterprises normally compete with traditional small households farmers. Intensive farming of low cost and high productivity tend to make small farmers marginalized or even bankruptcy. Under the production mode of leading enterprises + cooperatives + farmers, the company and farmers formed a community of common interests which will avoid this problem.

Individual farmers normally feed 20-30 females, 5-6 males, with annually production of 700-1000 commercial rabbits. Every female rabbit provides 25-35 commercial rabbit on average.

In the intensive production of Kangda. each breeding unit keeps 1500-2000 breeding females by way of artificial insemination, providing 7-90,000 commercial rabbits annually, per breeding female provide 35-45 commercial rabbits on average.(yet, this figure is still low to compare with the developed countries). It is absolutely two different levels. But the company and farmers formed a benefit-sharing and risk-sharing community through the production form of "enterprise + cooperatives + farmers" , and avoid to compete with the farmers. Both the company and the farmers benefited from the fast growth of Kangda. This production mode enabled the production of Kangda reaching 20 million rabbits just in few years.

THE CONTRACTED FARMERS NO LONGER WORRY ABOUT THE PROBLEM OF BREEDING CAPITAL

Under Kangda production mode, the company provide low-interest loans to the contracted farmers to help them to build their breeding farm or sheds, the company provide young rabbits, feed, drugs, and will buy back commodity rabbits with pre-determined contractive price, the contracted farmers are only responsible to breed the rabbits, had get net profit paid by the company, the contracted farmers no longer worry about the capital problem.

ENABLES THE RABBIT INDUSTRY ADOPT STANDARDIZED PRODUCTION AND ADVANCED TECHNOLOGY TO REDUCE PRODUCTION COST AND ENSURE QUALITY AND FOOD SAFETY

Individual backyard breeding is of high cost and low productivity and it is difficult to implement standardized production and to apply advanced technology to ensure the quality and food safety, and raise productivity. The industrial and intensive production of Kangda effectively solved this problem.

The company established strict quality-control system and standardized production and whole process monitoring system of food safety and quality control, Kangda passed the ISO9001 and ISO14001 quality certification. And has HACCP registration in Japan, USA, and the EU. all breeding farms are equipped with advanced breeding cages, automatic feed and water supply and environment-control equipments. Besides management of its own farms, the company also designed and build uniform standardized animal houses for the 200 breeding villages and provided technical training to the farmers and carried out unified quality control, disease prevention and production management over the breeding villages. The company established research center which is cooperated with agricultural universities, and institutions so as to study and apply advanced feeding, breeding and quarantine technology Kangda has a strong technical team, including three PhD, 6 Masters, and 40 college graduates. The company established its own laboratory equipped with advanced experiment and testing instruments, providing quality control for Kangda and the contracted farmers. All these helps the company and the contracted farmers improve the productivity, decrease production cost and up-grade the quality.

ENABLES THE INDUSTRY TO ESTABLISH RABBIT DISEASE PREVENTION SYSTEM

Rabbit disease control and prevention has always been the most difficult problem to resolve for scattered individual households farming. Rabbit diseases often cause individual households farmers go bankruptcy. Relying on its strong technical team and facilities, Kangda established a complete rabbit disease control and prevention system for its own breeding farms and the related breeding villages, which help the company and contracted farmers effectively prevent and treat rabbit diseases and lowered disease risk.

INDUSTRIALIZED PRODUCTION ENABLES THE LEADING COMPANY TO CULTIVATE FINE RABBIT STOCK OF HIGH YIELD AND QUALITY TO INCREASE PRODUCTIVITY

To cultivate high yield and quality synthetic line of meat rabbit stock is crucial to the rabbit industry in developing countries in order to lower production cost and upgrade the quality. Only leading enterprise has the ability to shoulder this task. China used to rely on import rabbit stock, and spend millions of foreign exchange to import rabbit breeds periodically. In order to foster its' own synthetic line of meat rabbit stock, Kangda invested 5 million US dollars in 2004 in setting up two core rabbit stock breeding farms, 6 grand parents rabbit stock breeding and production farms and a research center , with 8,000 sets in grandparent farms, 240,000 sets of parents, In 2008, Kangda established a Sino-French rabbit stock breeding and cultivating joint venture ,and succeed in cultivating its own synthetic line of meat rabbit stock in 2011. The quantity of which are more than enough for its own usage (including contracted farmers), and also supply to other enterprises and farmers. This is unimaginable before 2000, when individual backyard breeding accounted 90% in China rabbit production.

INCREASE MARKET ACCESS ABILITY FOR FARMERS PRODUCTS, AVOID THEIR MARKETING RISK

It is always a big problem for farmers to market their rabbit, market fluctuation often lead to farmers bankruptcy. The integrated leading company has specialized marketing personnel to explore market that help the individual farmers to sell their products. Kangda has a big domestic market shares, and also export rabbit products to the EU, Russia, Japan. Southeast Asia countries and regions The products of the farmers are marketed though Kangda and they no longer worry about the market risk.

SUMMARY

The fast development of China's rabbit production has benefited from China's Agricultural industrialization in the mode of "leading enterprises + cooperative + farmers" The fast growth of Kangda rabbit production within less than ten years also benefited from China's policy of agricultural industrialization. Chinese farmers are especially benefited from this policy. Different developing countries may adopt different methods to industrialize their rabbit industry. On the whole, agricultural industrialization is the best choice for rabbit industry of Asian developing countries to develop.

REFERENCES

FAOSTAT. 2012. The Statistics Division of the FAO. http://faostat.fao.org/.

FAO. 2003. World agriculture: Forwads 2015/2030 an AO perspective. Bruinsma J, editor. London (Engaland): Earthscan Publication.

Feeding Strategy for Small and Medium Scale Rabbit Units

François Lebas

WRSA president of Honour; Cuniculture Association, 31450 Corronsac - France

Corresponding e-mail: lebas@cuniculture.info

ABSTRACT

Feeding strategy of rabbit breeders depends first of all on the type and source of feeds available for the unit. For units situated in a urban context, with no or only a very small surface cultivable for rabbits, the main source of feeds can be only raw or manufactured materials (complete feeds) purchased from the local market. Fresh material obtained from a small garden or as kitchen waste could have only a marginal contribution in rabbits feeding, if the number of rabbits simultaneously present in the unit exceed 4-5 individuals. If the complete pellet feed is available locally, the use of this type of feed is the easiest and most frequently cheapest solution. If not available, a simple solution is the use of dry forages purchased from the market (*i.e.* hay in most of the situations) distributed ad libitum plus cereal grains distributed in limited quantities, and fresh water. According to climate and conditions of cultivation, with 1000 m² of crop cultivated exclusively for rabbits, one may expect to produce 15 to 60 slaughter rabbits per year. For units located in the countryside, if the breeder can cultivate a sufficient area, he can feed his rabbits almost exclusively with the production of his field: forage, cereals, etc. and some crop by-products. It's necessary to purchase only minerals, (salt, calcium for the does and probably phosphorus), and cages design must be adapted to healthy distribution of grains (feeders) and forages (rack). But the breeder must pay attention to the relative income he can obtain from the same field, if it is cultivated for rabbits feeding or cultivated for a production directly marketable. He must also compare the economical result of rabbit feeding with purchased complete feeds, if locally available. The nutritional balance of grains and fodder obtained from the crops must be at the centre of the cultivation planning. The strategy should be adapted to the type of rabbits in consideration. After weaning, growing rabbits are relatively easy to be fed: they grow for the quantity and quality of the provided feeds: low feed quantity and/or unbalanced diet = low growth rate; on the other hand if feed quality is good and quantity sufficient, growth rate is higher. The only important point is to provide enough fibre. On the contrary breeding does and more specially lactating ones must receive balanced diets in the proper quantity. If this objective is not obtained, the doe produces milk by drawing nutrients from her poor reserves. The milk quantity is too low for the young, the doe's health declines quickly and its reproduction stops. Forages, green or dry, provide the required level of fibre, one part of the digestible energy and of digestible proteins. Grains provide energy and an appreciable quantity of proteins, largely greater for legume grains than for the cereals grains. It must be pointed out that in cereals and grass, in general, the proportion of lysine in the proteins is too small to cover rabbit's requirement, but the sulphur amino acids (SAA) content is generally sufficient. On the contrary, in legumes grains and forages, the lysine content of proteins is sufficient but the SAA content may be too low. Some data on suitability of different forages, grains and crops by-products are given in the text particularly as source of proteins and minerals. These data were mainly extracted from the Feedipedia online encyclopedic database. The final remark is that rabbit feeding every day with green fodder is time consuming and in many cases working time is the limiting factor of this technique. Utilisation of dried stored forages (hay) provides a greater flexibility in the daily feeding practice.

Key Words: Rabbit, feeding, feed resources, growth, reproduction

INTRODUCTION

For rabbits as for any type of animal raised by farmers, feeding strategy would be based on feeding behavior et nutritional requirements whatever the dimension of the production unit. Once these initial points known, for small and medium scale unit feeding strategy of rabbit breeders depends first of all of the type and source of feeds available for the unit. For units situated in a urban context (about 41% of the total population in Asia, Anonymous 2013), with no or only a very small surface cultivable for rabbits, the main source of feeds can be only raw or manufactured materials (complete feeds) purchased from the local market. For units situated in the countryside, the situation would be more open with the same possibilities than in urban areas and in addition the possibility of utilization of raw materials produced on the farm for rabbits or collected around it. These different points would be shortly developed in this paper.

RABBIT REQUIREMENTS AND FEEDING BEHAVIORS

Requirements

For small and medium scale rabbit units it is reasonable to consider only one type of recommendation for all types of rabbit, corresponding in the nutritional Tables to a mixed or single feed (Lebas 2004; de Blas & Mateos 2010). The main nutritional recommendations are summarized in the Table 1. More detailed recommendations, specially the ratios between the different fibrous fractions are available in the international literature (Gidenne et al. 2010).

For a possible modulation of these recommendations according to the physiological situation, crude protein level could be increased up to 18% for lactating does, and calcium could be reduced down to 0.8% for growing rabbits. An other important point is that nutritional requirements expressed as composition of a complete diet are the same whatever the genotype of rabbits.

Feeding behaviors

A detailed description of rabbit feeding behavior could be found in the publications of Gidenne & Lebas (2006) or Gidenne et al. (2010).

Different points must be underlined and taken account in the daily practice of rabbit feeding

1. Total digestive transit is relatively short (16-24 hours) when compared to other herbivorous animal (about 60 hours for a cow or 30 hours for a guinea pig).
2. Contrary to the ruminants, an increase of the diet's fibrous content induces acceleration of the transit time in the rabbit. Correspondingly, rabbit has a high capacity to adapt its feed intake to the fiber level of its ration: daily feed intake increases with the diet's fibrousness as demonstrated in the figure 1. This is mainly the consequence of the regulation of the energy daily intake : fiber digestibility is lower than the average digestibility value of the diet. Thus, an increase of the fiber content induces a decrease of the digestible energy content. In order to obtain enough energy, the rabbit offset the lowest energy concentration by an increase of the daily intake of the more diluted ration.

Table 1. Main nutritional recommendations for a balanced feed for all types of rabbits (without other indication nutrients in percentage of the diet, supposed to contain 89% of dry matter)

Nutrients	%	Nutrients	%
Digestible energy (MJoules/kg)	10.0	Starch	<16.00
Crude protein	16.0	Lipids	2.50
Digestible protein	11.5	Vitamin A (IU/kg)	10,000.00
Lysine	0.80	Vitamin D (IU/kg)	<1500.00
Methionine + Cystine	0.60	Vitamin E mg/kg	>50.00
Threonine	0.65	Calcium	1.10
Crude fiber	15.0	Total Phosphorus	0.50
NDF	31.0	Sodium	0.22
ADF	17.0	Potassium min	>0.60
ADL	5.5	Potassium max	<1.80

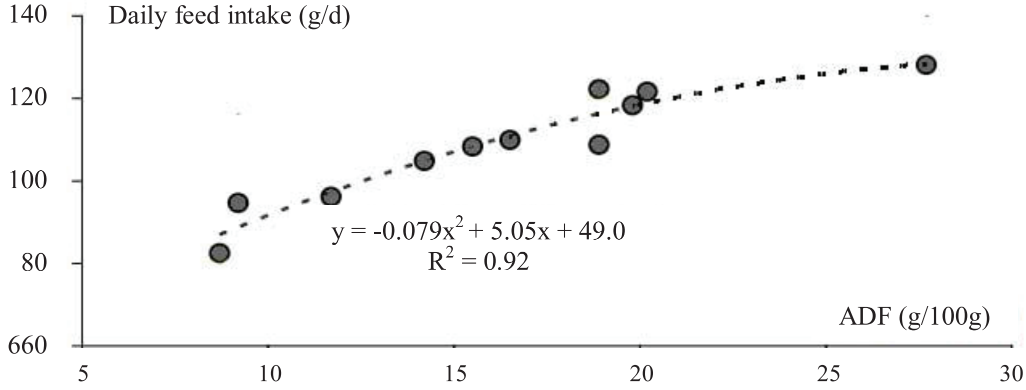


Figure 1. Average feed intake of growing rabbits between 4 and 11 weeks of age in relation with the complete feed's ADF content (Gidenne & Lebas 2006)

3. The instantaneous capacity of ingestion is limited by the stomach small capacity: a content of about 15-18 g of dry matter for a stay of 1 to 2 hours and an average daily intake of 110-120 g (for a growing rabbit of 2 kg).
4. When it is fed *ad libitum* pelleted complete diet, the rabbit makes about 35-40 meals per day (3-5 g each), mainly during the dark part of the 24 hours. If the feed is distributed in limited quantity, the ingestion begins immediately after the distribution, but the rabbit makes the same number of meals per day just more close to each other.
5. With pellets feeding, the rabbit spends about 10% of the 24 hours cycle to feed (Mirabito et al. 2005). If the feed is presented as meal instead of pellets this duration is multiplied by 1.5 to 2 and a great part of this time is devoted to scratch in the feeders to search more interesting fractions or particles. If the daily ration contents an important part of forages, this time could be multiplied by 3 or 4.
6. Two or 3 rabbits are able to eat simultaneously in the same feeder without competition problems because once the feed is taken in the feeder (5-10 seconds) each rabbit removes his head from the feeder to chew during 0.5 to 1 minute and then after introduces again the head in the feeder for 5-10 seconds.
7. When ambient temperature increases above 28-30°C the feed intake is reduced. This drawback could be partially, but only partially, offset by increasing the lipid concentration of the feed or by increasing the protein/energy ratio of the diet. Conversely, if the ambient temperature is below 10°C, the rabbit increases its food intake to compensate for the energy cost of thermoregulation. It can even endure a temperature of minus 15 to 20°C below zero in the condition of having a water source (roots, unfrozen water).
8. When a concentrate (low fiber diet compound diet) and dry fibrous material are proposed as free choice to rabbits, they prefer the concentrate. The fibrous material is consumed in only small quantities and the growth rate may be reduced (Lebas et al. 1997). The consequence is also an immediate increase of the sanitary risk for rabbits with digestive disorders by lack of fiber. If the fibrous material is a presented fresh (green) the balance between concentrate and forage is more difficult to predict, and the recommendation is to propose the more palatable in restricted quantity.
9. The maximum intake capacity of a rabbit per day is about 5 to 9% of it's live weight expressed as dry matter. For example dry matter intake of a rabbit doe varies from 3.5% of her live weight when she is empty and dry, up to 8-9% of the live weight at the peak of lactation. With the high speed growth selected lines, the dry matter intake may represent up to 10% of the live weight at peak of growth (when 35-40 days old).

10. The need of water is about twice that of the dry matter intake, with an increase of the proportion when temperature is above 28-30°C. It means that if rabbits receive a daily ration with a minimum average content of 70-75% of humidity, water distribution is not "necessary" even if it is strongly recommended. In any other cases the distribution of clean water is absolutely necessary.

AVAILABLE SOURCES TO FEED RABBITS

The sources of raw material usable for rabbit feeding are very numerous but according to the country or the urban environment, only some raw materials are effectively available for practical rabbits feeding. To help in the choice of the most suitable ones, a list was established out of the encyclopedic data basis "Feedipedia". This data basis is freely available on Internet at the URL www.feedipedia.org. It is still under construction by the French animal nutrionists (AFZ, INRA, CIRAD) with the help of FAO, but a lot of information is already available. In fact it has replaced officially the old FAO "Afris" data basis since the end of 2012.

The chemical composition is available in the Feedipedia data basis, but unfortunately the amino acid composition is lacking for many forages. More frequently the digestible energy for rabbits and the crude protein digestibility are also lacking.

To offset this lack of information it's possible to use the equations recently proposed by Lebas (2013) for the estimation of digestible energy and protein digestibly of raw materials for rabbits using the classical parameters of the chemical analysis, summarized for example in the Feedipedia encyclopedic database.

DE-Rab = 15.627 + 0.000982 CP^2 + 0.0040 EE^2 - 0.0114 MM^2 - 0.169 ADF ± 1.250 MJ/kg DM (R^2 = 0.912)

Protein-Digestibility = 64.734 + 0.646 CP + 2.170 CF + 0.414 NDF - 2.894 ADF ± 9.338 % (R^2 = 0.825)

DE in MJoules/kg DM; DM = Dry matter;
CP = % crude protein in DM;
EE = % ether extract (lipids) in DM;
MM = % minerals (ash) in DM;
ADF = % acid detergent fibre in DM;
CF = % crude fibre in DM;
NDF = % Neutral detergent fibre in DM.

Rabbits are more or less able to correctly regulate their daily feed intake according to the diet's digestible energy concentration. If a feed ration respects the nutritional recommendations summarized in the Table 1 even without consideration of the digestible energy, the corresponding diet is necessarily within the range of digestible energy ingestion regulation. Thus the next most important parameters to estimate the nutritive value of a feedstuff to be introduced in a balance diet are:

1. the proteins level and these proteins amino-acids balance;
2. the quantity and type of fiber (highly or poorly digestible according mainly to the lignin level);
3. the ability to provide calcium and phosphorus.

For the rabbit, a raw material could be an interesting source of protein, of amino acids, of fiber or of minerals if the content exceeds recommendations reminded in the Table 1. For this reason in the Table 2 to 9, the nutrients content of each material is presented as percentage of rabbits requirements. This type of information makes easy to determined the interest of a given raw material for such or such nutriment as well as its inadequacy for some others.

A little bit more than two hundred raw materials usable for rabbit feeding are presented in the following Tables with their aptitude to cover rabbits nutritional requirements.

All cereals are poor in proteins and lysine, covering on average only 62 and 65% of requirement respectively, with the noticeable exception of quinoa grains rich in lysine. On the contrary, their proteins are relatively rich in sulfur amino acids (116% of requirements on average). For other studied nutrients, cereals provide a small to very small proportion of requirements. Thus cereals are mainly sources of energy and secondarily of sulfur amino acids.

Table 2. Cereal, their by-products and the percentage of cereal and to cover rabbit nutritional requirements (for an "all rabbits" diets)

Feeds	Protein/ DM	Lysine/ Prot	Met+Cys/Prot	Calcium/ DM	Phosph /DM	NDF /DM	ADL /DM
	Rabbit's requirements % DM, or % CP						
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Cereals and other poaceae seeds							
Barley grain	66	74	105	7	71	62	20
Finger millet *Eleusine corcana* grain	49	60	111	41	62	68	38
Fonio *Digitaria exilis* grain	47	52	189	8	38	22	5
Foxtail millet *Setaria italica*, grain	66	48	151	23	60	na	na
Job's tears *Coix lacrima-jobi* seeds	61	38	157	1	na	na	na
Kodo millet *Paspalum scrobiculatum* grain	67	72	81	48	58	na	na
Maize grain	52	62	119	4	55	35	11
Oats grain	61	86	127	9	65	102	45
Pearl millet *Pennisetum glaucum* grain	69	56	97	3	60	49	18
Quinoa *Chenopodium quinoa* grain	84	106	95	9	75	na	na
Rice brown grain	58	72	108	4	47	9	36
Rice grain as Broken rice	58	82	92	4	58	45	15
Sorghum S*orghum bicolor* grain	60	44	97	3	60	31	20
Tritical grain	65	70	108	6	71	42	20
Wheat grain	70	58	103	6	65	40	20
Cereal by-products							
Brewers' grain	145	62	100	20	105	163	100
Corn distillers	163	60	108	13	144	98	80
Maize bran (maize offals)	67	90	119	40	62	104	40
Oat hulls	29	80	89	16	33	217	129
Pearl millet *Pennisetum glaucum* bran	76	38	na	7	105	94	38
Rice bran (not defatted)	71	88	97	6	251	98	124
Sorghum bran (sorghum offal)	65	82	119	7	89	123	91
Sorghum brewers' grain	144	76	119	64	147	114	91
Wheat bran	96	80	97	12	202	129	69
Wheat distillers	207	50	97	20	155	92	82

na: not available

Some cereals by-products on the contrary could provide an appreciable proportion of proteins rich in sulfur amino acids but again with a low proportion of lysine. They could provide a high proportion of phosphorus requirements, with the exception of maize and sorghum bran and oats hulls. But for all of them as for the cereals grains, the content of calcium is very low. Cereal by-products represent an interesting source of fiber (123% of NDF requirement) but with a lignin content a little bit too low for rabbits (84% of requirements for ADL).

All studied legume seed are interesting sources of proteins (148% of rabbits requirements on average) with the only exception of tamarind seeds. Most of them are also sources of lysine (125% of requirements on average) but they provide only few sulfur amino acids (65% of requirements on average). Their contribution to calcium, phosphorus and fiber balance are also poor.

Table 3. Legume gains or seeds, and by-products: ability to the percentage of legume grains to cover rabbits nutritional requirements

Feeds	Protein/ DM	Lysine/ Prot	Met+Cys/ Prot	Calcium/ DM	Phosph/ DM	NDF/ DM	ADL/ DM
	Rabbit's requirements % DM, or % CP						
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Legume grains and seeds							
African locust bean *Parkia filicoidea* seeds	177	134	68	18	31	81	na
African yam bean *Sphenostylis stenocarpis* seeds	130	172	97	5	60	139	109
Babul *Acacia nilotica* seeds	113	114	89	66	62	106	76
Black gram *Vigna mungo* seeds	132	140	68	18	89	53	5
Black gram V*igna mungo* seeds	132	140	68	18	89	53	5
Butterfly pea *Clitoria ternatea* seeds	236	122	95	6	104	na	na
Cajan pea *Cajanus cajan* seeds	129	130	76	32	58	44	na
Chickling vetch *Lathyrus sativus*, seeds	135	194	49	54	55	51	9
Chickpea *Cicer arietinum* seeds	123	136	54	14	76	31	4
Common beans *Phaseolus vulgaris* seeds	138	136	54	21	89	46	4
Common vetch *Vicia sativa* seeds	158	116	49	52	87	45	16
Cowpea *Vigna unguiculata* seeds	138	132	70	9	75	40	18
Elephant's ear *Enterolobium cyclocarpum* seeds	121	136	81	57	51	na	na
Faba bean *Vicia faba* seeds	161	126	54	13	102	45	18
Guar *Cyamopsis tetragonoloba* seeds	156	80	54	29	36	na	na
Jack bean *Canavalia ensiformis* seeds	162	116	49	15	87	98	29
Jack beans *Canavalia ensiformis* seeds	162	116	49	15	87	98	29
Lablab bean *Lablab purpureus* seeds	149	118	46	17	78	89	20
Lentil *Lens culinaris* seeds	149	130	57	9	82	37	29
Lima beans *Phaseolus lunatus* seeds	136	120	68	33	100	38	27
Lupin white *Lupinus albus* seeds	214	98	65	32	78	61	18
Mung bean *Vigna radiata* seeds	141	122	54	18	84	40	22
Peas *Pisum sativum seeds*	133	144	65	10	82	41	7
Sword bean *Canavalia gladiata* seeds	172	110	65	16	95	na	na
Tamarind *Tamarindus indica* seeds	86	130	81	25	31	146	120
Umbrella throrn *Acacia tortilis* seeds	164	92	na	47	133	86	35
Velvet beans *Mucuna pruirens* seeds	154	84	68	16	89	55	16
Legume seeds by-products: pods, husks							
Babul *Acacia nilotica* dry pods	65	80	78	52	31	77	104
Camel thorn *Acacia erioloba* dry pods	73	88	57	55	24	127	82
Carob pods (without seeds)	28	76	59	41	16	95	309
Chilean mesquite *Prosopis chilensis* pods	58	66	na	24	27	108	127

Table 3. Legume gains or seeds, and by-products: ability to the percentage of legume grains to cover rabbits nutritional requirements (continued)

Feeds	Rabbit's requirements % DM, or % CP						
	Protein/ DM	Lysine/ Prot	Met+Cys/ Prot	Calcium/ DM	Phosph/ DM	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Common bean *Phaseaolus vulgaris* crop resi	84	80	62	134	44	109	75
Elephant's ear *Enterolobium cyclocarpum* pods	92	128	68	74	98	103	195
Groundnut *Arachis hypogaea* hulls	38	92	62	20	13	198	427
Groundnut *Arachis hypogaea* tops	62	90	57	92	27	148	185
Guar *Cyamopsis tetragonoloba* meal	233	82	62	58	116	59	5
Mesquite *Prosopis juliflora* dry pods	106	80	59	38	27	132	104
Paperback thorn *Acacia sieberiana* dry pods	68	54	41	37	33	102	105
Soybean *Glycine max* hulls	73	126	78	46	29	183	44
Umbrella thorn *Acacia tortilis* dry pods	89	94	na	82	58	98	93

Most of the legume seed by-products are poor sources of protein with the noticeable exception of the guar meal (germ + husk obtain after mechanical separation of the guar seed endosperm). The proteins are also poor in lysine (in opposition with the seeds proteins) and sulfur amino acid, only the elephant ears pods are rich in lysine. The contribution of legume by-products to Ca and P is poor with again the exception of the elephant ears pods, rich in calcium, and the guar meal rich in phosphorus.

The first remark about Table 4 is the relatively small number of grasses included in this list while it's well known that a greater number of grasses could be used in rabbit feeding (Lebas 2004). But because most chemical analysis are made at the occasion of studies with ruminants, the amino acid composition of proteins is most generally not determined and then not available for rabbit nutrition. For ruminants, because of the important transformations of nitrogenous compounds in the rumen, the amino acid composition is of poor interest to estimate the nutritive value of a forage, but this not the case for rabbits.

This drawback remains nevertheless relatively small since most of grasses can contribute only partially to the protein content of rabbit ration (59% of requirements on average). The lysine content of these proteins may vary widely and cover from 62 to 126% of lysine needs. Contrary to the grass seeds and grains, the sulfur amino acids content of forage grasses proteins, is below the rabbits requirements for almost all of these raw materials. If the contribution for calcium and phosphorus remains poor around 40% of requirements, the contribution on total fiber is really substantial: 188% of NDF requirements on average, but that of lignin is more variable and represent on average only 91% of requirements (from 44 to 113%).

Table 4. The percentage of grass forages to cover rabbits nutritional

Feeds	Rabbit's requirements % DM, or % CP						
	Protein/ DM	Lysine/P rot	Met+Cys/ Prot	Calcium/D M	Phosph./D M	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Grass forages							
Barley forage fresh	62	132	95	42	27	150	44
Bread grass *Brachiaria brizantha fresh*	58	120	103	38	40	191	102
Coastal bermuda grass *Cynodon dactylon* hay	57	65	81	35	35	186	76
Cocksfot *Dactylis glomerata fresh*	91	126	97	34	51	171	82
Cocksfot *Dactylis glomerata* hay	73	76	62	33	49	182	82
Columbus grass *Sorghum x Almum* fresh	56	70	32	38	75	197	95
Gamba grass *Andropogon gayanus* fresh	43	106	78	32	29	205	109
Guinea grass *Panicum maximum fresh*	62	112	95	41	44	207	111
Jaragua *Hyparrhenia rufa* fresh	39	142	100	32	31	207	113
Kikuyu *Pennisetum clandestinum* fresh	84	64	54	26	67	187	78
Napier grass *Pennisetum purpureum* fresh	54	62	43	30	53	204	104
Pangola grass *Digitaria eriantha* fresh	45	68	59	42	47	204	107
Ryegrass *Lolium sp* hay	83	65	85	54	58	142	95
Sugarcane tops *Saccharum officinarum* fresh	26	92	14	23	22	199	82
Timothy *Phleum pratense* hay	51	68	51	28	38	187	80

na: not available

On average the legume forages or fabaceae forages according to the last denomination, provide a proportion of protein in dry matter corresponding to the rabbits requirements (98% on average), but variations from one forage to the other are very wide: covering from 51% of proteins requirement with low quality stylosanthes hay, up to 136-137% with fresh white clover or with Sesbania fresh leaves. Some reasons of such variation are the classical variations with vegetative stage and type of plant but also with conditions of harvesting. The small leaves are very rich in proteins (up to 28-30%/DM) but they are also easily lost during the harvesting and drying process. See for example the higher protein contribution of fresh sainfoin or berseem , compared to the hay protein contribution of these 2 forages (Table 5).

Table 5. The percentage of legume forages to cover rabbits nutritional

Feeds	Rabbit's requirements % DM, or % CP						
	Protein/ DM	Lysine/P rot	Met+Cys/ Prot	Calcium/D M	Phosph./D M	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Legume forages							
Alfalfa *Medicago sativa* fresh	114	112	78	162	45	112	138
Alfalfa *Medicago sativa* hay	101	86	68	140	47	128	138
Berseem *Trifolium alexendrinum* fresh	111	86	68	161	49	127	93
Berseem *Trifolium alexendrinum* hay	87	112	78	183	47	141	96
Butterfly pea *Clitoria terneata* aerial part	118	88	97	106	53	167	165
Caribean stylo *Stylosanthes hamata* fresh	87	94	73	120	31	147	165
Centro *Centrosema pubescens* aerial part	105	70	70	79	47	158	155
Common vetch *Vicia sativa* aerial part fresh	128	106	54	100	80	105	111
Common vetch *Vicia sativa* hay	109	144	78	121	53	110	118
Cowpea *Vigna unguiculata* aerial part fresh	101	66	62	110	44	119	80
Green leaves Desmodium *intortum* fresh	83	74	68	85	56	155	191
Kudzu *Peraria montana* aerial part fresh	84	88	78	103	44	154	142
Lablab bean *Lablab purpureus* aerial part	101	112	54	98	53	127	142
Lebbek *Albizia lebbek* leaves fresh	90	88	76	161	31	143	180
Leucaena leucocephala fresh aerial part	129	110	97	89	38	117	196
Lima bean *Phaseolus lunatus* vines	108	72	57	100	55	109	135
Mung bean *Vigna radiata* aerial part	95	82	54	206	62	114	127
Pea forage *Pisum sativum* aerial part	98	132	68	155	71	89	87
Perrenial soybean *Neotonia wightii* fresh	95	96	57	124	45	145	144
Perrenial soybean *Neotonia wightii* hay	78	80	76	83	56	175	231
Persian clover *Trifolium resupinatum* fresh	120	104	54	183	71	81	49
Persian clover *Trifolium resupinatum* hay	78	84	49	124	33	123	120
Puero *Pueraria phaseolides* aerial part fresh	107	64	78	82	49	123	135
Red clover *Trifolium pratense* fresh	106	132	89	120	62	103	64

Table 5. The percentage of legume forages to cover rabbits nutritional (continued)

Feeds	Protein/DM	Lysine/Prot	Met+Cys/Prot	Calcium/DM	Phosph./DM	NDF/DM	ADL/DM
	Rabbit's requirements % DM, or % CP						
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Red clover *Trifolium pratense* hay	102	86	57	113	164	102	102
Sainfoin *Onobrychis viciifolia* fresh	94	104	70	118	84	101	171
Sainfoin *Onobrychis viciifolia* hay	84	104	70	114	56	136	164
Sesban *Sesbania sesban* aerial part fresh	136	106	46	133	60	77	82
Sirato *Macroptilium atropurpureum* fresh	90	92	59	87	31	145	133
Soybean forage *Glycine max* fresh	76	70	70	128	51		82
Soybean forage *Glycine max* hay	87	70	70	72	45	169	175
Stylo *Stylosanthes guianensis* fresh	78	86	57	115	42	113	155
Stylo *Stylosanthes guianensis* hay	51	70	78	81	29	156	218
Trifolium subterraneum hay	84	88	41	95	42	132	138
Tamarind *Tamarindus indica* leaves	66	118	59	156	38	157	427
White clover *Trifolium repens* fresh	137	90	108	84	60	80	69

Because of their relatively high level of protein, legume forages present some potential interest for pig or even laying hens nutrition, *i.e.* other monogastric animals. For this reason a higher proportion of these forages was analyzed for the amino acids content. In the proteins, the lysine content is relatively close to rabbits requirement (94% on average) but with variations between 70% for example in the aerial part of soybean plant or *Centrosema* forage, up to 132% in the aerial part of common pea (*Pisum sativum*). It must be underlined that it is not possible to establish a simple relation between the lysine content of the seeds and that of the forage of the same plant. Some legume forages could be a good source of calcium but for some other the content is too poor for rabbit feeding. Nevertheless on average the legume forages content represents 127% of rabbit requirements. For phosphorus the contribution is only 53% on average. Systematically the NDF content cover largely rabbits requirements (127% on average) and frequently, but not systematically that of lignin : 142% on average with variations from 69% up to 230%.

Most of the leaves and forages of the studied other plants (non grass nor legume) could be considered as interesting sources of proteins. Only sunflower forage and sweet potato dried vines have a too low level (72-73% of requirements). Some of them are interesting source of lysine and even of sulfur amino acids such as sweet potato green forage and *Azadirachta indica* fresh leaves. Most of them are important sources of calcium but not of phosphorus. The NDF content is most frequently close to the rabbits requirement, and the lignin level, when determined, is generally higher.

The dry matter of the water plants contains an appreciable proportion of proteins, but these are deficient in sulfur amino acids, particularly water hyacinth and water spinach. Mineral content of these plants depends largely of the composition of the water on which they are grown, thus the values of the Table 6 are only indications.

Roots, tuber or fruits are poor providers of proteins, and these proteins are in addition relatively poor in lysine and in sulfur amino acids. Only the relatively high proportion of lysine in the proteins in fodder beet, carrots and potato deserves some attention. These types of feeds are also deficient in calcium, phosphorus and fiber.

Table 6. The percentage of other forages and water plants to cover rabbits nutritional requirements

Feeds	Rabbit's requirements % DM, or % CP						
	Protein/ DM	Lysine/ Prot	Met+Cys/ Prot	Calcium/ DM	Phosph/ DM	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Other forage plants: leaves and forages							
Abelmoschus esculentus Okra fresh leaves	132	116	89	240	69	na	na
Acanthus mollis aerial part fresh	118	82	na	80	64	na	na
Amaranthus sp aerial part fresh	111	109	70	150	98	99	na
Beta vulgaris Beet fresh leaves	93	116	49	92	67	na	na
Cassava *Manihot esculenta* foliage dryied	142	96	59	174	58	121	145
Cassava *Manihot esculenta* foliage fresh	138	118	89	99	67	121	171
Celery *Apium graveolens* fresh leaves	119	70	49	225	309	68	na
Chromolaena odorata Queens weed, fresh	184	118	92	66	67	na	na
Helianthus annuus Sunflower fresh forage	72	108	81	146	56	113	176
Ipomoea batatas Sweet potato, dry forage	73	96	132	103	56	115	205
Ipomoea batatas Sweet potato, fresh forage	92	72	124	79	53	122	151
Jerusalem artichoke *Helianthus tuberosus* aerial part fresh	85	108	81	157	60	116	209
Margosa *Azadirachta indica* fresh leaves	92	200	227	167	45	123	335
Moringa oleifera Moringa fresh leaves	116	104	78	220	47	81	127
Morus alba White mulberry; fresh leaves	108	120	86	228	82	91	91
Morus nigra Black mulberry; fresh leaves	98	84	81	180	24	na	na
Symphytum x uplandicum Russian comfrey fresh	103	72	na	156	89	53	na
Taro *Colocasia esculenta* aerial part fresh	128	99	78	75	56	101	116
Trichanthera *Trichanthera gigantea* fresh	106	80	68	417	75	114	151
Water plants							
Azolla filiculoides whole plant	99	100	81	49	22	na	na
Azolla pinnata whole plant, sun dried	92	76	65	119	56	137	na
Duck weed (average common, inflated, great and rootless duckweed) dried	154	84	81	253	71	107	na
Water hyacinth *Eichornia crassipes* whole	102	94	43	79	115	164	156
Water spinach *Ipomoea aquatica* leaves	119	85	64	58	102	86	182

na: not available

Table 7. The percentage of roots, tuber, fruits to cover rabbits nutritional requirements

Feeds	Rabbit's requirements % DM, or %CP						
	Protein /DM	Lysine/ Prot	Met+Cys /Prot	Calcium/ DM	Phosph./ DM	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Other forage plants: roots, fruits							
Beet root, fodder type, fresh roots	37	124	76	23	36	38	18
Breadfruit *Artocarpus artilis* dried fruit meal	22	69	48	8	29	na	na
Carrot *Dacus carota* fresh roots	51	104	68	32	53	34	18
Cassava *Manihot esculenta* dry sliced roots	16	78	86	14	20	23	31
Desert date *Balanites aegyptiacus* fresh fruits	62	54	95	13	73	na	na
Jerusalem artichoke *Helianthus tuberosus* tuber fresh	41	90	62	15	58	26	104
Phoenix dactylifera Date palm fruit	21	54	84	33	49	69	142
Phoenix dactylifera Date palm, depitted fruit	27	24	68	62	15	na	na
Potato *Solanum tuberosum* tuber raw	60	98	51	6	40	20	24
Taro *Colocasia esculenta* fresh tuber	31	89	94	32	80	na	na
Other plants by-products							
Ananas comosus Pineapple, dry canning by-product	25	40	22	41	24	119	71
Beet molasses	79	28	22	9	5	1	0
Beet pulp dehydrated	52	124	76	129	18	137	44
Brewer's yeast	270	126	65	25	240	25	15
Cabbage leaves (wastes), fresh	98	70	59	38	69	36	31
Cassava *Manihot exculenta* dry peels	27	46	35	14	38	66	222
Citrus pulp dried	39	72	59	142	18	60	49
Cocoa hulls	99	102	70	31	80	133	316
Cocoa husks	43	100	49	48	62	158	244
Coffe pulp dehydrated	63	68	16	27	24	140	165
Grape marc dehydrated	78	82	103	71	56	183	629
Grape pulp dehydrated	76	108	105	82	47	184	605
Soybean hulls	73	126	78	46	29	183	44
Sugarcane molasses	31	2	41	77	13	2	1
Sunflower hulls	39	102	130	37	24	213	404
Tomato pomace, dehydrated	116	160	116	38	64	159	458

na: no available

Table 8. The percentage of oil seeds and meals to cover rabbits nutritional requirements

Feeds	Rabbit's requirements % DM, or % CP						
	Protein /DM	Lysine/ Prot	Met+Cys /Prot	Calcium/ DM	Phosph./ DM	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Oil seeds							
Cashew *Aanacardium occidentale* nut kernel (45.4% EE)	122	80	68	13	60	na	na
Cotton seeds (19,7% EE)	121	80	84	13	107	139	193
Soya beans (toasted) (21,3% EE)	220	124	78	28	111	39	22
Linseeds (36,6%EE)	132	70	111	25	115	72	95
Rape seeds (00) (46,1%EE)	116	124	122	41	135	60	116
Sunflower seeds (47,9%EE)	92	78	108	21	107	85	115
Oil Meals a Cakes							
Attalea speciosa Babassu oil meal, decorticated (1,8%EE)	104	110	224	10	153	110	202
Canola meal (4,0%EE)	217	112	122	62	211	77	144
Cocoa oil meal (2,0%EE)	157	80	76	18	135	126	336
Coconut copra oil meal expeller (9,8% EE)	124	52	68	10	105	156	122
Coconut copra oil meal solvent (2,8% EE)	131	62	78	6	118	161	145
Cottonseed meal (3,1%EE)	262	80	84	18	248	77	111
Crambe abyssinica oil meal (1,5%EE)	244	96	114	75	193	85	138
Groundnut cake decorticated (10,1%EE)	272	70	51	10	118	40	44
Groundnut meal (2,0%EE)	304	64	54	14	113	69	91
Hempseed meal (11,3%EE)	179	52	109	23	160	137	240
Linseed meal, expeller (10,2%EE)	190	78	100	36	164	69	113
Maize germ meal (5,9%EE)	84	76	105	4	131	103	29
Mustard oil meal (9,%EE)	194	88	105	4	202	na	na
Palm kernel meal expeller (9,2%EE)	93	58	81	23	109	209	244
Palm kernel meal solvent (2,8%EE)	104	64	84	23	120	209	233
Papaver somniferum oil meal (10,3%EE)	200	84	132	253	255	97	227
Papaver somniferum oil meal (1,2%EE)	206	74	86	217	182	125	255
Rapeseed meal (00) (2,8%EE)	213	110	119	72	231	90	178
Safflower meal (9,4%EE)	138	112	127	23	122		
Sesame meal (11,1%EE)	247	50	132	165	231	61	31
Sheanut cake *Vitellaria paradoxa* oil meal (4,5%EE)	78	80	92	25	44	103	395

Table 8. The percentage of oil seeds and meals to cover rabbits nutritional requirements (continued)

Feeds	Rabbit's requirements % DM, or % CP						
	Protein /DM	Lysine/ Prot	Met+Cys /Prot	Calcium/ DM	Phosph./ DM	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Soybean meal high protein (1,8%EE)	297	126	81	30	138	31	9
Soybean meal low protein (2,0%EE)	288	122	78	33	125	39	15
Sunflower meal dehulled (1,8%EE)	209	70	108	38	236	111	156
Sunflower meal non dehulled (2,3%EE)	174	72	108	36	202	133	204

na: no available analysis; EE: ether extract % in DM

For the by-products of this heterogeneous group of feeds, the contribution to rabbits requirements varies widely from one product to the other. It could nevertheless be underlined that it is in this by-product group, that are feed ingredients with the highest lignin level, even if the ADL method don't always separates correctly the true lignin and tannins.

With few exceptions, oil seed and the corresponding meals or cakes are potential important sources of proteins. Only sunflower seeds, maize germ oil meal, and sheanut cake have protein content lower than the rabbits requirement. According to botanical source these proteins are rich in lysine or sulfur amino acids, rarely in both together as it is the case for rapeseed meal, canola meal or safflower meal. On the other hand, some meals or cakes frequently used such as groundnut meal or palm kernel meal are simultaneously deficient in lysine and sulfur amino acids. With few exceptions, the calcium content of this group of products is lower than requirements (44% on average) but rich in phosphorus (151% on average). The NDF content (40 to 209% of requirements) and that of lignin (9-395% of needs) vary so widely from one product to the other, that the calculation of an average is totally meaningless.

Most of the animal products are good sources of proteins. Fish meal and blood meal are interesting sources of lysine and the silkworm pupae meal also. Feather meal and silkworm pupae meal are good sources of sulfur amino acids, but attention must be paid to the correct hydrolysis of feather meal, otherwise the proteins digestibility, and consequently that of all amino acids, are quite nil. The animal products are generally interesting sources of calcium and phosphorus and, despite some chemical results, completely devoid of fiber.

Among the classical sources of calcium and phosphorus only bone meals and dicalcium phosphate are sources of phosphorus. Egg shells, oyster shells and limestone provide exclusively calcium.

PRACTICAL FEEDING

Use of pellets and complete feeds

If complete pelleted (or even non-pelleted) feeds are used for rabbits as exclusive source of nutrients, whatever the dimension of the rabbit unit, the best solution is to follow recommendations proposed by the feed manufacturer and to distribute *ad libitum* clean water in addition to the pellets. This is why this solution is not more broadly described herein. The only additional remark is that if the commercial so called complete feed has a too low level of fiber, it is advisable to distribute in addition some very palatable fibrous forages (grasses in general) to provide the fiber lacking in the pellets. The quantity may represent 10-20% of the daily dry matter intake, and the farmers must remember that almost always rabbits prefer the feeds in that order: green forages > pelleted complete feeds > dried forages > non-pelleted complete feeds. Small units and direct use of raw materials.

In small units of production, if raw materials are at the basis of rabbits nutrition, the breeder, if possible with the help of the technician of an extension service, must search in his environment (crops, market, uncultivated areas) which raw materials are available or possible to produce in the farm. Then he determines the ability of each to cover rabbits nutritional requirements. To obtain a more or less balanced diet it is necessary to be able to propose to rabbits at minimum one raw material rich (more than 100% of requirement) for each of the main nutrients listed in the Tables 2 to 9. According to climate and conditions of cultivation, with 1000 m² of crop cultivated exclusively for rabbits, one may expect to produce 15 to 60 slaughter rabbits per year. This idea of productivity may be useful to determine to real possibilities of rabbits feeding with home made products, or with raw or manufactured material purchased on the market.

It is not advised to mix roughly non processed raw material because of the great ability of rabbits to select some parts of a mixture, to eat only the most palatable ones and then destroy the nutritional balance proposed by the breeder. In addition, when a rabbit seeks the most palatable parts, he scratches inside of the feeder and can waste up to 40-50% of the distributed mixture. One of the best ways is to distribute the dry concentrates such as cereals or cakes separately, in limited quantity in the morning. This makes possible a visual control of the real intake. The quantity distributed must be completely eaten within 6-7 hours. In many conditions, the concentrated raw materials may be economically replaced by complete rabbit feeds if possible pelleted. In this situation it is advisable that the pellets don't represent more than 40-50% of the daily dry matter ration, the

Table 9. The percentage of animal products and mineral sources to cover rabbits nutritional requirements

Feeds	Rabbit's requirements % DM, or % CP						
	Protein/ DM	Lysine/ Prot	Met+Cys/ Prot	Calcium/ DM	Phosph./ DM	NDF/ DM	ADL/ DM
	18.0	5.0	3.7	1.2	0.55	35.0	5.5
	Percentage coverage of rabbits requirements						
Animal products							
Blood meal	523	174	62	11	40	0	0
Feather meal (hydrolyzed)	476	42	135	106	149	159	100
Fish meal 60-68% protein as fed	392	150	95	362	507	0	0
Fish meal low protein	269	140	103	661	724	0	0
Hatchery by-product	127	84	89	1592	56	0	0
Meat and bone meal high fat (12,1%EE)	305	100	65	842	885	0	0
Meat & bone meal low fat (5,3%EE)	344	100	70	787	833	0	0
Silkworm pupae meal	350	140	122	32	109	14	2
Whey, sweet, dehydrated, skimmed	69	152	89	43	116	0	0
Mineral sources							
Bone meal calcinated	0	0	0	2525	2545	0	0
Bone meal steamed	44	270	95	2708	2727	0	0
Dicalcium phosphate hydrated	0	0	0	2083	3273	0	0
Eggshells	31	30	86	3058	29	0	0
Limestone	0	0	0	3208	4	0	0
Oystershells	0	0	0	3167	9	0	0

na: no available

other part being constituted by various forages. It must be pointed out that in no case rabbit pellets + cereals can constitute a balanced diet, specially for reproduction.

At the end of the afternoon, green forages can be distributed, in racks but never on the floor of the cage, in such quantity that, in the next morning, only very few or none of the distributed quantity remains in the rack. This remaining part should be discarded. Dry forages (hay) could be distributed ad libitum but in a different part of the rack if they are used simultaneously with greens.

In most regions, forages, the main source of the fiber for rabbits, are not necessarily available in the green form all the year round with optimum nutritive value. Consequently, the production and storage of dried forages is strongly encouraged for small breeders. The green forages can be harvest in small quantities, day after day, during the rainy season and/or at the beginning of the dry season, and dried in the immediate vicinity of the farmer's house. This sun drying can be done on large tarpaulins, on cemented or rocky areas, or on the roof terrace of the farmer's house (Figure 2). The advantage of drying in the vicinity of the house, is the possibility for the farmer or his family to temporarily and quickly put the forage during drying process, out of the rain in a shed or an annex to the house for a few hours, waiting for the return of the sun.

Figure 2. Sun drying of berseem on an house terrace in Afgahnistan

Almost all forages, tree leaves or foliages can be sun dried. In the above chapters it was mentioned that during the drying process, one part of the nutrients could be lost, mainly the small leaves rich in proteins. But it is clearly preferable to have forage with a little bit lower quality than not having one at all. Moreover the farmer could harvest cultivated forages, weed forages or spontaneously grown forages or tree leaves, at the optimum of their nutritive value, while for the green forages the nutritive value declines gradually and irremediably as the plant matures.

Medium scale units and direct use of raw materials

All recommendations done for small units are suitable for medium one. Only the drying process of forages needs a better organization and specific means because quantities are greater.

Medium scale production units can produce their own complete feed, alone or in association with some (3-4) nearby other medium rabbit units.

The only equipment strictly necessary are a forage grinder and a balance This small equipment is available for example from different Chinese or Indian companies for a reasonable amount of money (Figure 3).

Figure 3. Small forage grinding machine at work in Benin, with a diesel engine, loaded by hand

Figure 4. Small pelleting machine at work in China, with an electric engine (protected inside the box below the pelleting device), loaded by hand

This type of forage grinder with a large "entry" is perfectly able to grind dried forages, cereals and any type of dry by-product. In extreme cases it is even able to grind half-dried products (used without grid), the obtained wet meal being easier to dry completely than the raw product. The interest of grinding is to obtain an homogenous coarse meal (not a powder) whatever the processed raw material. The adequate quantity of the meal obtain from each raw material used in a dietary formula are weighted and then mixed together and with additives (minerals in powder, premix, pure amino acids if necessary) A correct mixture can be obtained by hand with a shovel on a cemented area, or with a mechanical mixing device. The later is not a necessary equipment if the quantities to be mixed at one time are not too important. If the mixed raw meal obtain is not too dusty, the mixture can be distributed in this form to rabbits. Nevertheless it is strongly advised to pelletize this meal. Efficient pelleting machines are available on the international market at low cost (Figure 4). The small pelleting machine can be loaded by hand and the obtained pellets can be refrigerated by simple repartition in thin layer on a cemented area. If the hot pellets are refrigerated on a tarpaulin, it is easier to pick them up from the ground than if they were directly placed on the cemented area. If the farmer must choose between a mixer and a pelleting machine because of the price of the whole equipment, he has clearly to choose the pelleting machine.

As mentioned for the small units, the home made pellets can be used alone or as a complement of green or dried forage. The farmer can easily produce different types of feed adapted for example to reproducing does, to just weaned or fattening rabbits, *etc*. Because the whole equipment is not very bulky it can be placed "fixed" on a trailer and transported in the vicinity to be used by 3 or 4 other breeders successively. It may be easier to carry the complete processing equipment, than to carry to a single working location the raw materials produced by the different farmers. If the option of making pelleted diets at home is not chosen a commercial diet can used without problem in the conditions described for small units.

CONCLUSIONS

In small or medium units, rabbit feeding must be the object of a great attention by the breeder as it is the case for larger units. Because rabbit is an herbivorous but also a monogastric animal, it is able to valorize raw forages and concentrates. But like for pigs and poultry and in opposite with ruminants, a great attention must be given to the quality of the proteins distributed to rabbits, *i.e.* to the composition in amino acids of these proteins.

To provide daily the fiber necessary for the rabbit's digestive health, green forage or dried forages can be used. But it is clear that dried forages provide a greater flexibility in the everyday feeding than green ones. In small or medium units, rabbit feeding must be the object of a great attention by the breeder as it is the case for larger units. For medium-sized units, making feed pellets with locally available raw materials, can be an economical solution, because only few cheap machines are really necessary.

REFERENCES

Anonymous. 2013. Population urbaine en 2008 et 2010 in Statistiques mondiales [Internet]. [consultation, 31 July 2013]. Available at: http://www.statistiques-mondiales.com

De Blas C, Mateos GG. 2010. Chapter 12 - Feed formulation, De Blas C and Wisemann J, Nutrition of the rabbit, 2nd edition. Wallingford (UK): CAB International. p. 222-233.

Gidenne T, Lebas F. 2006. Feeding behavior in rabbits. In: Bels V. Feeding in domestic vertebtates. Wallingford (UK): CAB International. p. 179-194.

Gidenne T, Lebas F, Fortun-Lamothe L. 2010. 13. Feeding behaviour of rabbits. In: de Blas C, Wiseman J. Nutrition of the rabbit. Wallingford (UK): CAB International Ed. p. 233-252.

Gidenne T, García J, Lebas F, Licois D. 2010. Chapter 10. Nutrition and Feeding Strategy: Interactions with Pathology. In: de Blas C, Wiseman J, editors. Nutrition of the rabbit 2nd ed. Wallingford (UK): CAB International. p. 179-199.

Lebas F. 2004. Reflections on rabbit nutrition with a special emphasis on feed ingredients utilization. Proc 8th World Rabbit Congress, Puebla Mexico, 686-736. [Internet]. Available at: http://world-rabbit-science.com/WRSA-Proceedings/Congress-2004-Puebla/Puebla-2004-a.htm.

Lebas F. 2013. Estimation of protein digestibility and digestible energy content of raw materials for the rabbit, with a system of equations [in French] 15e Journées de la Recherche Cunicole, 19-20 Nov. 2013, Le Mans (France), Accepted Communication.

Lebas F, Coudert P, Rochambeau H, de Thébault RG. 1997. The Rabbit - Husbandry, Health and Production FAO publ.. Rome, 223 pp. [Internet]. Available in: http://www.fao.org/docrep/t1690E/t1690e00.htm.

Mirabito L, Dumont F, Galliot P, Souchet C. 2005. Group housing of breeding does: behavior [in French], 11e Journées de la Recherche Cunicole, 29-30 Novembre 2005, Paris, 57-60.

Results of Research and the Development of Rabbit Production in Vietnam from 2000 to 2012

Dinh Van Binh, Nguyen Kỳ Sơn

Vietnamese Rabbit Production Association
Corresponding e-mail: binhthovietnhat@gmail.com

ABSTRACT

Vietnam is tropical country located in Southeast Asia with a monsoon climate. The total area of country is 33.2 million hectares, In the 2012, total population were 88.78 million consisted of 52 million farmers which are 67% of total labors who are working in the agricultural sector. The cultivated area is about 11 million ha. The agriculture is based mainly on rice production of 39-42 million tons per year. The agriculture output value contributes 25 of GDP of which food production from 73% and livestock production from 27% dealing mainly with pigs, cattle, chicken, ducks, goats and rabbit. Rabbit production have been raised in small household extensive systems in Vietnam for long time. Rabbit production is popular in rural areas and is considered to be a self-sufficient system with low productivity. In the recent years, (from 2010 to 2012 when bird flu (H5N1), Green ear and FMD diseases in the poultry and other animals have happened in Vietnam), rabbit production has been paid more attention by farmers and government agencies as a means to improve the income of the rural poor. So some achievements have been obtained in the field of breeding, nutrition, processing, preventing diseases. The population of rabbits has increased at over the last 10 years from 1,985,000 heads in 2000 to 3,450,000 in 2005; and 5,452,700 heads in 2010, 6,379.660 heads in 2011 and 7,655,590 heads in 2012 an average annual rate of increase about 17.8%. During this time, the price of rabbit products has increased from 35,000 to 80,000 VND/kg of live weight rabbit meat. Rabbit breed includes local indigenous breeds of Re Rabbit, Black rabbit and Grey Rabbit have been found to perform well under improved management conditions. Some new rabbit breeds have been imported from Hungaria and France (New Zealand white rabbit, California rabbit; Panon rabbit and Hyplus rabbit) with adaptation studies for furred keeping and crossing with local rabbit to improve meat production. A series of studies using local feed resources and strategic disease control measures were carried out in the context of developing sustainable and integrated small animals farming systems. These studies showed that up to 35% improvement in productivity can be achieved by such techniques. Some programs and projects have been carried out with the joint support of the Vietnamese government and international organizations, and have resulted in highly successful outcomes. In 2007 a new rabbit station have been setup with 1500 rabbit does to produce 30,000 rabbit provide for farmers raising per year. In 2012, there were 150 heads New Zealand and 50 heads California GP breeds were imported from France to improve productivity of rabbit. It is clear that rabbit production can play an important role in improving the incomes for poor farmers in the rural areas and is contributing to poverty and hunger alleviation in Vietnam.

Key Words: Rabbit, Production, Breed, Vietnam, Prices, Development

INTRODUCTION

Vietnam is tropical country located in Southeast Asia with a monsoon climate. The total area of country is 33.2 million hectare, with a population of 87 million, 52 million farmers occupant 67% of total labor are working in the agricultural. The cultivated area is about 11 million ha. The agriculture is based mainly on rice production of 43.7 million tons per year (in 2012) in 77% of the cultivated area supported by other crops such as maize, potato, cassava, groundnut, soybean, sugarcane, fruit trees and other perennial commercial trees as coffee, tea, rubber and coconut. The agriculture output value contributes 25 of GDP of which food production from 73% and livestock production from 27% dealing mainly with pigs, cattle, chicken, ducks and goats. From 1990 to now rice production in Vietnam is not only enough for consuming but also for exported 6.5-7 million tons per year become one of the first largest country rice exported in the world.

Rabbit production has been raised in small household extensive systems in Vietnam for long time. Rabbit production is popular in rural areas and is considered to be a self-sufficient system with low productivity. In the recent years (from 2010 to 2012 when bird flu (H5N1), green ear and FMD diseases in the poultry and other animals have happened in Vietnam) rabbit production has been paid more attention by farmers and government agencies as a means to improve the income of the rural poor. So some achievements have been obtained in the field of breeding, nutrition, processing, preventing diseases. Under the support of government and international organizations some programs and projects were carried out with satisfied impact. It is clear that rabbit production is playing an important role in improvement of the incomes for poor farmers in the rural areas and is contributing to poverty and hunger alleviation in Vietnam. So, this review we discuss about the situation of research and development and also strategy of development of rabbit production in Vietnam.

Table 1. Livestock population and percentages change from 2000 to 2012 in Vietnam

Animals	Year					Growth rate (% per years)	
	2000 (1000 heads)	2005 (1000 heads)	2010 (1000 heads)	2011 (1000 heads)	2012 (1000 heads)	2000-2010	2010-2012
Pig	20,194.00	26,435.00	27,373.00	27,055.98	26,493.92	+3.50	-3.20
Cattle	4,127.90	5,540.70	5,916.00	5,436.56	5,194.18	+4.30	-12.20
Dairy cattle	n.a.	n.a.	n.a.	142,702.00	166,989.00	n.a.	+17.00
Poultry	316,400.00	321,890.00	321,497.00	322,568.90	308,460.00	+0.13	-4.40
Buffaloes	2,897.00	2,922.00	2,913.00	2,712.03	2,627.81	+0.50	n.a.
Goat, sheep	552.50	1,070.00	1,178.00	1,267.80	1,343.64	+10.60	+6.12
Rabbit*	1,985.00	3,450.00	5,360.00	6,379.66	7,655.59	+16.20	+18.50

n.a.: not available

Source: Vietnam National Statistic Department (2000; 2005; 2010; 2011-2012)

Table 2. Animal products and percentages change from 2000 to 2012 in Vietnam

Products	Unit	2000	2005	2010	2011	2012
Total meat	1.000 tonnes	1,997	2,835	4,017	4,169	4,271
	%	49.7	70.6	100	103.8	106.3
Pork	1.000 tonnes	1,513	2,288	3,027	3,098	3,160
	%	50.0	75.6	100.0	102.3	104.7
Buffaloes	1.000 tonnes	86.56	85.87	87.8	87.79	88.47
	%			100	100	100.77
Poultry	1.000 tonnes	322.6	321.9	615.9	696	789.4
	%	52.3	52.3	100	113	128.1
Beef	1.000 tonnes	149.1	202	361.1	287.2	294
	%	41.3	56.5	100	79.5	81.4
Goat and sheep	1.000 tonnes	6.5	12.6	15.8	17.2	18.9
	%	41.2	79.7	100	109	119.6
Rabbit	1000 tonnes	5.7	9.9	15.4	19.4	24.7
	%	57.5	64.3	100	125.9	160.3

Average Livestock Products per capital in 2012: Meat (LW) is 45 kg; Egg: 65 Pieces; Fresh Milk: 3.5 kg

Source: Vietnam Agriculture Department-MARD (2000; 2005; 2010; 2011; 2012)

SITUATION OF RABBIT PRODUCTION IN VIETNAM FROM 2010 TO 2012

According to the data of Vietnam Agriculture Department-MARD (2010; 2011; 2012). In 2010 there are about 5,365,000 rabbits (of which 42.3% rabbit population could be found in the Northern; 18.3% in the Center and 39.4% in the Southern). Since 2005-2010 population of rabbit were quickly increased and reached to 6,379,660 rabbits in 2011 and 7,655,590 rabbits in 2012. Of which 53.1% rabbit population could be found in the Northern; 15.4% in the Center and 31.5% in the Southern. Rabbit population in the Northern were increased higher than in the southern and the center). Most of rabbit were distributed to rural areas (shown in Table 3).

Recent prices of rabbit products are being raised to be higher than the other animal's. 1 kg live weight of rabbit for meat is 80,000 VND and for breed is 120,000 VND (comparing with the cost of 1 kg live weight of beef or pig just is 40,000 VND or 45,000 VND). The high price of the products gives a higher income for the raisers and promotes rabbit production in Vietnam.

Table 3. Land area and distribution of rabbit population in different areas of Vietnam

Locations	Land area* Sp. km^2	Rabbit population** in 2010		Rabbit population ** in 2012	
		1000 heads	%	1000 heads	%
North of Vietnam	166,6	2,265,141	42.3	4,060,457	53,1
Midland and northern mountainous	102,9	826,000	15.4	1,226,000	16,0
Central of northland	51,2	352,141	6.6	752,141	9,9
Red river delta	12,5	1087,000	20.3	2,082,316	27.2
Centre of Vietnam	98,7	983,002	18.3	1,183,002	15.4
South-central coastal	44,2	630,000	11.7	730,000	*9,5*
Central high land	54,5	353,002	6.6	453,002	*5,9*
South of Vietnam	65,8	2,112,131	39.4	2,412,131	31,5
Southeast	23,5	1090,131	20.3	1,190,131	15,5
Mekong river delta	42,3	1,022,000	19.1	1,222,000	16.0
Total	331,1	5,360,274	100.0	7,655,590	100.0

Source: *Vietnam National Statistic Department (2012)
**Vietnam Agriculture Department-MARD (2010; 2011; 2012)

Table 4. Comparison price of rabbit meat to other products (VND/kg live weigh of meat)

Kind of animals	2010 (VND/kg)	2012(VND/kg)	% Change/year 2010 to 2012
Goat	50,000	90,000	180
Sheep	55,000	100,000	181
Cattle	25,000	40,000	160
Pigs	30,000	45.000	150
Local chicken	55,000	80,000	145
Rabbit	40,000	70,000	175

Source: Binh et al. (2010;2011;2012)

Table 5 showed that breeding doses per farm level had different change between 2010 and 2012. In all locations around country, it has been increasing number of farms and breeding doses levels from 1298 to 1631 farms. The average change of breeding does level per farm from less than 50 to over 150 at estimated increase of 25%, especially in 2012, there were 18 farms which raised over 500 breeding does. This is evidence that rabbit production development has been giving the benefit for farmers and significant improve the rural household economic in present.

RESULTS OF STUDY ON RABBIT PRODUCTION

Breeding

Local breeds

- Re rabbit: This breed is very small in size live weight at adult 2.3-2.7 kg and is usually brown, grey and white in color with their eye are black.
- Grey rabbit: This rabbit breed was selected for 10 years at Goat and Rabbit Research Centre (GRRC) their live weight at adult 3.0-3.5 kg and usually grey in color with their eyes are black.
- Black rabbit: This rabbit breed was selected for 10 years at GRRC; their live weight at adult 3.0-3.5kg and usually black in color with their eyes are black.

Local rabbit is a meat type, which is widely distributed around the country with 25-30% total rabbit population. Their performances are shown in the Table 6.

Imported breeds

Imported from Hungary in 1980, there were 1000 rabbits with New Zealand rabbit, California breed. In 2002 and 2004, there were 250 rabbits with New Zealand, California, Panon rabbit breeds and 50 Hyplus rabbits were imported from Hungary and France to Vietnam. After more than 10 years, they were adapted in Vietnamese ecological condition, their productivities are shown in Table 7.

In February 2012, there were 150 Grand Parent (GP) rabbits of New Zealand breed and 50 GP rabbits of California breed were imported from France to Vietnam. The performance of productivities is shown on the Table 8.

Table 5. Change of Rabbit population per farms in Vietnam from 2010-2012

Locations	Unit	2010 (Breeding doses)				2012 (Breeding doses)				
		<50	50-100	>100-150	>150	<50	50-100	>100-150	>150	≥500
North of Vietnam	Total	310	240	213	102	166	342	254	216	15
Midland and northern mountainous	farm	67	81	56	62	65	111	81	54	2
Central of northland	farm	56	63	45	55	40	50	58	48	1
Red river delta	farm	187	96	112	85	61	156	115	114	12
Centre of Vietnam		90	58	30	26	71	99	81	42	1
South-central coastal	farm	34	24	18	15	30	50	55	28	1
Central high land	farm	56	34	12	11	41	49	26	14	-
South of Vietnam		57	74	56	32	64	115	123	58	2
Southeast	farm	23	34	12	9	29	43	36	22	1
Mekong river delta	farm	34	40	44	23	35	72	87	36	1
Total farms		477	362	299	160	301	556	458	316	18
Total farms/year		1298				1631				
(P. rabbit per farm level)	%	36.7	27.8	23.2	12.3	18.5	34.1	28.0	19.0	1.1

Source: Binh et al. (2010;2011;2012)

Table 6. The performance of local rabbit breeds

Parameters	Re rabbit	Black rabbit	Grey rabbit
Body weight (female - male)			
At birth (g)	34.7	40.1	41.4
At weaning (30 days) (g)	346.4	415.7	424.3
At 3 month (kg)	1.3-1.5	1.5-1.7	1.6-1.8
At adult (kg)	2.7-2.9	3.2-3.5	3.3-3.6
Reproductive performance			
Litter/does/per years	6.0	6.3	6.2
Litter size (rabbit per litter)	6.1	6.2	6.1
Mortalities to weaning (1 month) (%)	18.5	17.6	15.5

Source: Binh et al. (2001)

Table 7. The performance of imported rabbit breeds in Vietnam

Parameters of rabbit	New Zealand rabbits	California rabbits	Panon rabbits	Hyplus rabbits
Body weight				
At birth (g)	66.500	64.010	69.640	67.500
At weaning (30 days) (g)	714.700	707.200	804.500	716.500
At 3 month (kg)	2.870	2.737	3.006	2.870
At adult (kg) (female - male)	5.150-5.634	5.120-5.554	5.550-6.580	5.150-5.630
Reproductive performance				
Litter/does/per years	6.570	6.450	6.370	6.570
Litter size	7.350	7.200	7.300	7.500
Mortalities to weaning (1 month) (%)	12.200	12.000	13.000	12.100

Source: Binh et al. (2009)

Table 8. The performance of productivities of GP rabbit breeds

Parameters of rabbit	New Zealand GP rabbit breed	California GP rabbit breed
Body weight		
At birth (g)	86.500	74.010
At weaning (30 days) (g)	814.700	807.20
At 3 month (kg)	2.870	2.737
At adult (kg) (*female - male*)	5.150-5.634	5.120-5.554
Reproductive performance		
Litter/does/ per years	8.020	7.450
Litter size (rabbits per litter)	8.350	7.200
Mortalities to weaning(1 month) (%)	12.200	14.000

Source: Vinh et al. (2013)

Cross breeds

Those imported rabbit breeds were developed widespread in whole Vietnam and used those buck to cross with local rabbit breeds. The results on research shown that live weight of crossed breeds at 3 month are higher than local breed 18.5-22% result were applied widely to the whole country.

CHANGE KIND OF RABBIT BREEDS IN RABBIT FARM OF VIETNAM FROM 2010-2012

In Table 9, in general, rabbit population has been increasing. However, number of New Zealand rabbit breed is the highest from 1.124 million heads (49.6%) in 2010 to 1.614 million heads (69.8%) in 2012. It means that the farmers are concentrating on the high productivity rabbit breed which is New Zealand rabbit breed. This means that the profit of NZ rabbit farm is higher than other breed.

Housing system

Most rabbit farms housing system are raised on the cages with one floor or two floors. Studying on raised underground shelter or raised cages for rabbits with basal diet of fresh leaves of *Trichantera gigantea*; sugar cane stalk and rice bran. The main effect of the housing system was on the ambient temperature. In the underground shelter compared with the raised cage, it was warmer in the morning, colder at the midday and warmer in the evening. The temperature in the shelter varied 2.8°C during the day white the temperature in the cages varied 8°C. The differences were significant. The temperature in the underground shelter was more uniform than in the cage which should be better for rabbit reproduction. The effect to the performances production of rabbit in Table 10.

Table 9. Rabbit population per breeds in rabbit farm of Vietnam from 2010-2012 (heads)

Locations	2010			2012		
	New Zealand	Hybrid	Local	New Zealand	Hybrid	Local
North of Vietnam						
Midland and northern mountainous	194,203	100,211	70,341	264,441	67,345	44,387
Central of Northland	177,362	76,356	82,235	244,895	65,438	52,856
Red river delta	404,513	76,211	45,212	584,782	84,208	23,076
Centre of Vietnam						
South-central coastal	20,588	25,667	52,661	37,163	17,403	20,588
Central high land	28,322	26,516	52,756	40,550	20,161	21,344
South of Vietnam						
Southeast	106,004	80,731	73,627	218,221	50,233	98,455
Mekong river delta	193,104	78,034	74,331	224,384	54,276	76,551
Total	1,124, 096	489,882	51,163	1,614,436	359,064	337,266
%	49.6	21.6	28.8	69.8	15.6	14.6

Source: Binh et al. (2010;2011;2012)

Table 10. The performance of local rabbit on raised underground shelter or raised cages

Parameters of rabbit	Raised cages	Underground shelter	SE/P
Body weight of female			
At the beginning experiment (g)	1652	1659	±20.9
At the end experiment (g)	2637	2810	11.200/0.001
Reproductive performance			
Litter/does per years	5.80	6.21	0.120/0.001
Litter size (rabbit per litter)	5.45	6.80	0.170/0.040
Mortality to weaning (1 month) (%)	10.50	18.60	-
Weight gain of growing rabbit (g/day)	48.30	52.80	0.095/0.001

Source: Ha & Binh (2000)

Table 11. Biomass yield (tonnes/ha/year) of some promising forage species in the Bavi region of North Vietnam

Species	Biomass	Dry matter	Crude protein
Flemingia macrophylla	60.7	13.4	2.24
Trichanthera gigantea	82.7	10.7	1.83
Leucaena hybrid KX2	54.8	13.7	2.84
Leucaena leucocephala K636	49.7	12.9	2.60
Mulberry (*Morus alba*)	23.0	3.9	0.67
Bananas (pure stand)	90.7	13.4	-
Trichanthera gigantea	82.4	10.6	-
In association with banana			
Panicum maximum cv likoni	75.5	12.8	1.66
Brachiaria ruziziensis	76.9	13.8	1.38
Elephant grass	88.6	15.0	1.55

Source: Nguyen et al. (2001b)

Feed and feeding

A lot of experiments on planning, processing, storing and using forages multipurpose trees and by-products for rabbits were carried out. The results as following:

Biomass productivity of some forages and multipurpose trees as feed resources for rabbits

From those results, some kinds of forage and multi-purpose tree, with high biomass and high crude protein were selected. They were used widely by the farmers as they are good feed resources for rabbit especially in dry season.

Feeding system for local rabbit production emphasizing root and bananas

A mash composed of equal parts of banana fruit, cassava root and sweet potato tubers (17% of each) with 33% rice bran and 15% molasses with the same protein-rich foliages as for growing rabbits supported the same reproductive performance (size and growth rate of the litters) as the conventional concentrate/ grass diet with saving cost of feed.

Using water spinach as replacement for guinea grass for growing and lactating rabbits

Water spinach foliage is potential supplement for rabbit and can replace guinea grass of 60-100% in the diet with higher live weight gain and lower feed cost comparing guinea grass alone.

Table 12. Performance of rabbit fed with banana, sweet potato tubers, cassava roots and mixed foliage, compared with the control of cereal concentrate and guinea grass

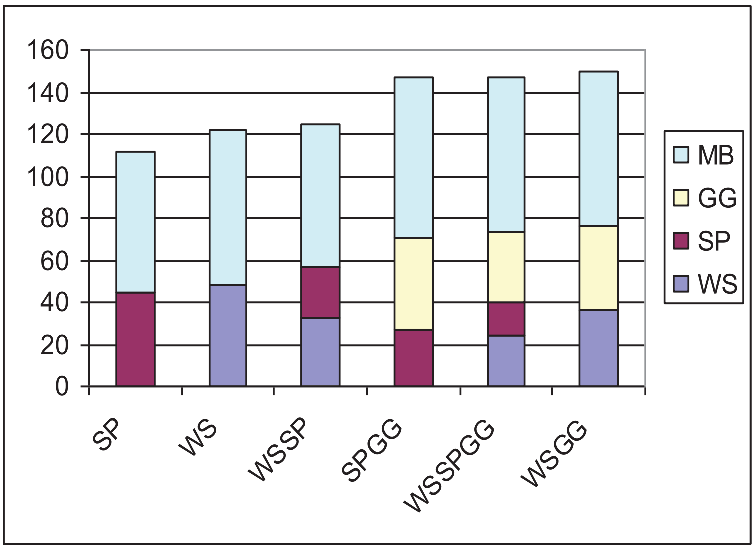
Parameter	Control	Banana	Sweet potato	Cassava root	Mix BSC
Live weight of rabbit					
At birth (g)	51.0±0.9	50.25±3.6	49.5±2.4	50.4±3.2	51.2±3.2
At weaning (30 days) (g)	466.0±2.8	332.0±14.4	420.0±2.1	395.0±3.5	460.0±3.2
Daily gain (g) 1-3 month	285.6±3.5	212.3±3.6	248.4±2.1	216.3±3.5	264.5±3.2
Litter size					
At birth	5.5	5.0	5.5	5.0	5.3
At weaning (30 days)	5.2	4.2	4.8	4.0	5.0
Mortality to weaning (1 month) (%)	15.5	16.4	12.2	18.6	16.1

Source: Luyen et al. (2000)

Table 13. Effect of replacing guinea grass with water spinach on feed intake of growing rabbits

Parameter	Level of replacement: % Guinea grass/water spinach					
	100/0		100/0		100/0	
Initial live weigh rabbit(g)	1390	1443	1413	1403	1473	1420
Final live weigh rabbit(g)	2462	2571	2557	2587	2705	2740
LWG, g/day	25.500[a]	26.900[ab]	27.200[b]	29.190[c]	29.330[c]	29.400[d]
FCR, kg/kg LWG						
DM	4.790[a]	4.660[a]	4.640[a]	4.280[b]	4.260[b]	3.870[c]
CP	0.620[a]	0.668[b]	0.750[c]	0.731[c]	0.711[c]	0.672[b]
Cost, VND/kg LWG	18.310[a]	17.490[a]	17.330[a]	17.250[a]	16.480[ab]	15.290[b]

Source: Chat et al. (2004)



WS: Water spinach hanging; WSGG: Water spinach and guinea grass; SP:Sweet potato vines hanging; SPGG: Sweet potato vines hanging and guinea grass; WSSP: Water spinach hanging + Sweet potato vines hanging; WSSPGG: Water spinach hanging + Sweet potato vines hanging and guinea grass

Figure 1. Effect of water spinach and sweet potato to feed intake of growing rabbits

Table 14. Effect of water spinach and sweet potato on live weight gain of growing rabbits

	WS	WSGG	SP	SPGG	WSSP	WSSPGG	SEM
Live weight (g)							
Initial	980	940	925	970	930	950	0.04
Final	2700	2890	2530	2900	2760	3060	0.06
Daily gain (g)	21.90	26.41	21.11	26.73	23.07	27.24	1.11
DM Feed conversion	10.72	8.23	7.68	7.26	6.21	7.03	0.52
CP Feed conversion	1.73	1.18	1.65	1.22	1.26	1.2	0.87

Source: Gang et al. (2005)

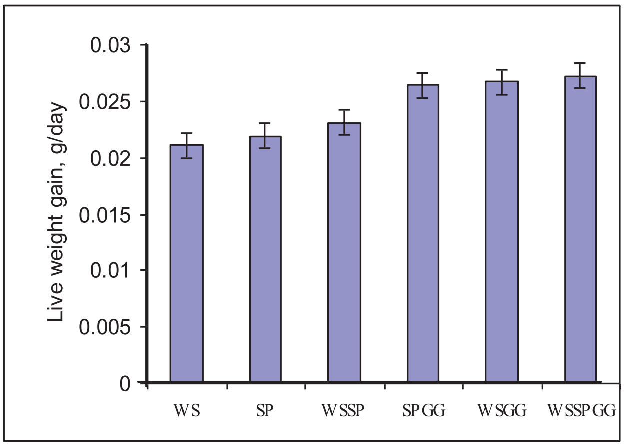


Figure 2. Effect of water spinach and sweet potato on live weight gain of growing rabbits

Using manure from rabbit, goat, buffaloes, and cow as substrate for earthworm production and earthworm as supplement for scavenging chicken

Rate earthworm production was higher on manure from goats and rabbits than buffaloes and cows. Rate of production was slow in the first two month but increased dramatically in month 3 with no further increase in month 4. The optimum growth cycle appeared to be 4 month from inoculation of the manure (0.5 kg earthworm to 100 kg manure) to the point harvest assuming fresh manure is applied each day

The growth rate of the group of chickens supplement with 40 g/day of earthworm appeared to be higher than the control or the group fed 20/days and 60 g/day of earworm.

Table 15. Amount of manure used and earthworm produced and conversion rates of manure to worms

Animals	Manure (kg)		Earthworm	Conversion (kg/kg)	
	Fresh	DM	(kg)	FM	DM
Goat	236	85	5.61	40.9	14.7
Rabbit	306	108	5.38	51.8	18.2
Buffaloes	313	77.6	3.65	87.0	21.6
Cow	276	72.3	2.93	108.0	28.3
SE	10.0	3.0	0.25	1.5	0.6

Source: Nguyen et al. (2000)

Table 16. Growth rate of scavenging chicken supplemented with broken rice and earthworms

	Control	EW 20g	EW 40g	EW60	Probability
Live weight (g)					
Initial	306±81	306±5.60	294±8.22	312±9.80	-
Final	1,348±24.10	1,353±17.20	1,678±41.80	1,414±30.90	0.001
Daily gain	11.60±0.30	11.70± 0.15	15.40±0.420	12.30±0.32	0.001

EW: earth worm

Source: Ha & Binh (2000)

Health management and incidence of diseases

The major diseases reported among rabbits in Vietnam are scabies; Coccidiosis; Hemorrhagic disease; Diarrhea, Pneumonia. The important and dangerous infectious diseases with high mortality were Hemorrhagic diseases (from 1997 till now) that were controlled by vaccination (it was made in Vietnam from 1998). The other infectious diseases were treated effectively with medicines. For rabbit scabies diseases, Ivermectin 0.7ml/3 kg live weight or Dextomax 0.1 ml/3 kg live weight was used. Coccidiosis was controlled by anticoccidiosis medicine, E.coli diseases was controlled by Nory Cogen or Coli 2000; Peziza diseases (skin diseases) was controlled by BT-VN Griseovin 25 g after appropriate treatment 90-95% of all infected animals were cured (Thanh et al. 2011, 2012).

Processing and marketing of products

Products from rabbit production are not usually eaten by Vietnamese people, mainly because they are not commonly available in the markets. However, in recent years, as Vietnam's economy has been liberalised,' living standards of people are improving, and this is a favourable environment in which to promote rabbit products. The market for selling products from rabbits has become easier. In addition, since 2004 the bird flu were happened in Vietnam there a strong demand for rabbit meat in many different areas of Vietnam. Some small processing units for rabbit meat were set up. Markets for these products are being readily found in the cities providing farmers with greater income and new opportunities to further develop their rabbit production systems. The rate of increase in rabbit production in Vietnam is not sufficient to meet this demand. As a consequence, the price of rabbit meat in increasing rapidly, and the limit to meeting this demand is the lack of suitable rabbits available for breeding. This need could be partly met by expanding to current centre for rabbit production in North Vietnam to new areas in central and South Vietnam. This expansion is currently one of the new initiatives actively being pursued by the GRRC and Rabbit Breed Station at Ninh Binh province for the future.

PLANNING FOR DEVELOPMENT OF RABBIT PRODUCTION IN VIETNAM FROM 2011-2015

The plan for development rabbit production in Vietnam.

1. Set up a GP rabbit breed station at Ninh Binh province (in the Central Area) with 1000 dose to develop appropriate regional strategies and provide 30,000 rabbit breeds per year for the breeding system farms in the Central and Southern regions of Vietnam.
2. Set up small rabbit processing units in all area of Vietnam.
3. Training and dissemination of information on new technologies for improving rabbit productivity and model farm demonstrations of sustainable and integrated rabbit farming systems.
4. Develop further collaborations with International and regional agencies and organisations in Southeast Asia as a means to increase the rate of application of relevant technologies to rabbit in Vietnamese farming systems.

Table 17. Development planning of rabbit production in Vietnam from 2011-2015

Year	2011	2012	2013	2014	2015
Rabbit product (million rabbit)	5.30	5.80	6.30	6.80	7.30
Rabbit meat (tonnes)	12,000	12,500	13,000	13,500	14,000

CONCLUSIONS AND RECOMMENDATION

In the past 10 years, research and development of rabbit production in Vietnam has resulted in some very good achievements. The population of rabbits has increased at over the last 10 years from 1,985,000 heads in 2000 to 3,450,000 in 2005; and 5,452,700 heads in 2010, 6,379.660 heads in 2011 and 7,655,590 heads in 2012 an average annual rate of increase about 17.8 %. During this time, the price of rabbit products has increased to from 35,000 to 80,000 VND/kg of live weight rabbit meat. Rabbit production is playing an increasingly important role in the improvement of the income of poor farmers and is contributing significantly to poverty and hunger alleviation in Vietnam Rabbit production has been paid more attention by farmers and Government agencies as a means to improve the income of the rural poor. So some achievements have been obtained in the field of breeding, nutrition, processing, preventing diseases. Specific studies of the selecting of local rabbits breeds and imported and introduced new breeds, of nutrition and feed resource availability and quality, animal health and product processing has lead to training programs in improved rabbit production for livestock advisers and farmers and to village demonstrations of how rabbits can be integrated into sustainable livestock farming systems for Vietnam. Vietnam has a recognised potential to develop and further expand rabbit production systems. This potential is being progressively realised through collaborative research programs run by staff of GRRC and Rabbit Breed Station at Ninh Binh province; livestock advisors and Vietnamese farmers and generously supported by the Vietnamese Government, non-government organisations and international aid agencies. The continued support of all these groups is essential for stimulating further development of rabbit production in all areas of Vietnam.

REFERENCES

Dinh Van Binh, Ly Thi Luyen, Khuc Thi Hue. 2004. Results on adaptation research of New Zealand white, California, Panol rabbits breeds affter 4 years raised under Vietnam condition. Institute of Agricultural Sciences. In: Proceeding of workshop of Animal Production Science. Hanoi (Vietnam): Ministry of Agriculture and Rural Development. p. 235-256.

Dinh Van Binh, Nguyen Kim Lin. 2005. Results of research and development rabbit production in Vietnam. In: Proceeding of workshop of Animal Production Science. Hanoi (Vietnam): Ministry of Agriculture and Rural Development. p. 135-138.

Dinh Van Binh, Nguyen Thi Mui. 2000. Impact study of livestock-based intervention in villages in Bavi district in North Vietnam. Feed resources in sustainable-base on Agriculture in SE-Asia. 5:112-115.

Ly Thi Luyen, Nguyen Quang Suc, Dinh Van Binh. 2000. Feeding system for tropical rabbit production emphasizing root and bananas. Feed resources in sustainable-base on Agriculture in SE-Asia. p.111-115.

MARD. 2000, 2005, 2010, 2011 and 2012. Hanoi (Vietnam): Vietnam Agriculture Department-Ministry of Agriculture and Rural Development.

Ngo Thanh Vinh, Chu Duc Tuy, Nguyen Thi Hang 2013. Results on adaptation research of New Zealand white, California GP rabbits breeds after 2 years raised under Vietnam condition. Institute of Agricultural Sciences. Proceedings of Workshop of Animal Production Science. Hanoi (Vietnam): Ministry of Agriculture and Rural Development. p. 138-142.

Nguyen Quang Suc, Le Thi hu Ha, Dinh Van Binh. 2000. Manure from rabbits, goats, cattle and buffaloes as sub-strata for earthworms. Feed resources in sustainable-base on Agriculture in SE-Asia. p. 95-98.

Nguyen Thi Mui, Dinh Van Binh, Ngo Tien Dung. 2001. Farmers' reception on use of forages in Bavi District. In: Proceedings of workshop of Animal Production Science. Hanoi (Vietnam): Ministry of Agriculture and Rural Development. p. 19-28.

Nguyen Thi Mui, Nguyen Phuc Tien, Ngo Tien Dzung, Dinh Van Binh, Preston TR. 2001. Improving biomass productivity of plants and soil fertility on sloping land in Bavi mountainous area. In: Proceedings of workshop of Animal Production Science. Hanoi (Vietnam): Ministry of Agriculture and Rural Development. p. 116-125.

Tran Hoang Chat, Ngo Tien Dzung, Dinh Van Binh, Preston TR. 2004. Response of water spinach to fertilization with increasing levels of worm cast and urea. Using water spinach as replacement for guinea grass for growing and lactating rabbits. In: Proceedings of workshop of Animal Production Science. Hanoi (Vietnam): Ministry of Agriculture and Rural Development. p. 112-121.

VNSD. 2000, 2005, 2010 and 2011-2012. Hanoi (Vietnam): Vietnam National Statistic Department.

VNSD. 2004. Hanoi (Vietnam): Vietnam National Statistic Department. p. 37-48.

The Status and Prospect of Rabbit Farming in Malaysia

AR Alimon[1], S Noor Rahim[2], AK Fadzilah[2]

[1]*Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, Serdang 43400, Selangor , Malaysia.*
[2]*Department of Veterinary Services, Ministry of Agriculture and Agro-Based Industry, Putrajaya, Malaysia*
Corresponding email: ralimon@upm.edu.my

ABSTRACT

The rabbit industry is a small sector of the livestock industry. It can be equated to the quail industry which supplies meat to limited number of consumers. While rabbit has been hailed as the alternative to chicken meat, especially in times of poultry meat scarcity, its development is rather slow. The rabbit industry in Malaysia can be classified as those that supply rabbit meat, and those that supply live rabbits for breeding and for pets. The pet industry together with eco- and edu-tourism sector is increasing at a slow but steady rate thereby providing a constant demand for live rabbits and rabbit meat for consumption. At these eco- and tourism parks, children are allowed to touch rabbits which can be quite an attraction for children. Rabbits for pets, edu parks and exhibition tend to come in at various colours and sizes. Quite often, these eco-tourism and edu parks sell rabbit meat for those interested. In general, most rabbit farms in Malaysia are small to medium sized, carrying between 500-1000 breeding females. Most common breeds for meat are the New Zealand Whites and Californian Whites, while those for pets comprised of breeds from Europe and other parts of the world. They ranged from small miniature breeds to breeds that are large and weigh 3-5 kg. The farmers in Malaysia follow the protocols set by the Australian and American standards for rabbit rearing, as Malaysia has not come up with specific procedures. Commercial meat rabbits are fed rabbit pellets supplied by a number of feed mills, usually with a crude protein content of 18-20%. Pet rabbits are fed rabbit pellets and supplemented with leafy vegetables or grass hay. As far as small holder farmers are concerned keeping rabbits can be lucrative and profitable and provides added income to the farmer. Small holder farms in Malaysia keep other animals with some rabbits raised in cages and fed whatever feed that is available.

Key Words: Rabbits, Smallholder Farmers, Meat Quality, Feeding

INTRODUCTION

Rabbits (*Orictalagus cuniculus*) belong to the family Leporidae of the order Lagomorpha from phylum Chordata. Rabbit has always been perceived as a pet animal more than a wild or exotic meat. In the early years in Europe rabbits and hares were hunted for their gamey meat much cherished by the European those days. Rabbit hunting was a sport those days and until now it is still practiced in some parts of the world. Rabbits now are raised commercially in farms and are sold for meat, pelts or furs and more common as pets. Countries that produce large amounts of rabbit meat for own consumption and export include Italy, Russia, China, France and Spain which produce more than 100 thousand tones per annum.

History of Rabbit Industry in Malaysia

Back in 1988, the then Agriculture Minister Tan Sri Sanusi Junid encouraged Malaysian small holder farmers and entrepreneurs to go into rabbit farming for both export and local consumption. As rabbits breed easily, and provide lean, low-fat high-protein meat, they could help to diversify the country's exports and provide local consumers with an additional choice of halal meat. It was thought that rabbit production can be a side activity for small holder farmers, as being a small animal they can be fed whatever forage that grow in the farm area at low costs, hence an added income to the family. The following years saw an increase in number of rabbit farms but in the late 90s the growth of the rabbit industry leveled off. Some farms closed down due to poor marketing and high costs of production, especially feed, as most farms used rabbit pellets as the main source of feed. One of the earliest entrepreneur was Mr. David Wong who set up his farm, East Asia Rabbit Ranch, with a few hundred rabbits in a half-hectare plot of land in Semenyih, Selangor. Wong bought his rabbits from Australian Malaysian Livestock Trading (AMLT), a joint venture set up by the Selangor Agriculture Development Corporation (PKPS) and an Australian company to promote rabbit farming. The rabbits were imported from Australia, France, Italy, the United States and New Zealand. East Asia Rabbit Corporation Sdn. Bhd. is now Malaysia's leading integrated rabbit farm. It owns and manages two farms and currently has over 30,000 rabbits. As meat activity is still the core business, EARC is heavily involved in breeding and rearing of parent stocks, slaughtering and processing of rabbit meat into undressed meat and satay meat.

Advantages of rabbit farming

The advantages of farming rabbits are related to its feeding and reproductive behavior. Being a small monogastric herbivore it can be fed easily with local forages or commercial rabbit pellets. Rabbits can be fed cellulose rich materials such as grass, leaves of forages, hay and fresh vegetables. Rabbits are prolific and can produced 6-8 young at each birth and they can breed about 8 times a year. This is due to the fact that females are induced ovulation, have short gestation and lactation periods. Other than that, being small they are easily transported and marketed, with the recurrent costs of maintaining them is low, even after the optimal age for slaughter. Likewise the labour costs are low and the work can be done by family members: women and children, or perhaps aged or handicapped people. Furthermore the initial investment is low and not much land area is needed.

STATUS OF RABBIT FARMING IN MALAYSIA

There has not been much data on rabbit farming in Malaysia. It was thought that rabbit meat being low in fat and low in cholesterol would capture a large portion of the meat market dominated by poultry and beef meats. However, rabbit meat was still expensive and beyond the reach of lower income groups. Furthermore, the consumer perception still view rabbits as a pet animal and were reluctant to accept rabbit meat as a main protein source. In fact, in a survey only 58% of the respondents have tasted rabbit meat, and less than 15% eat rabbit meat regularly (Nursuhana et al. 2012). The department of veterinary services in Malaysia view rabbit farming as a small farming activity for the production of rabbit meat and pet rabbits. Many backyard rabbit farming with numbers ranging from a few rabbits up to 500 rabbits are not registered as a farming enterprise and the department treat it as an activity of the family that provides extra income. Records of number of rabbit farms in Malaysia are scanty and there are few large rabbit farms (Table 1).

The Food and Agriculture Organization of the United Nations (FAO) and governmental and non-governmental development organizations have given good support to rabbit projects in the developing countries. In the last ten years, FAO's Animal Production and Health Division (AGA) has supported and developed rabbit projects in Egypt, Mexico, Haiti and many African countries.

Table 1. The number of registered farm and average number of rabbits in various states in Malaysia

State	Number of farms	Average number of rabbits
Johor	4	80
Kedah	103	1717
Kelantan	16	139
Pahang	3	22
Pulau Pinang	12	1432
Perak	49	3190
Selangor	10	3920
Terengganu	18	664
Sarawak	1	1600

Source: Department of Veterinary Services, Ministry of Agriculture and Agro-based Industries (2013)

The constraints associated with rabbit farming in Malaysia are mainly social, cultural and economic factors: customer acceptance of rabbit meat and ease of marketing; lack of local resources available for balanced, low-cost, locally adapted rations; the existence of rabbit housing and management styles that inhibit the range of rabbit territorial, social, sexual and feeding behaviours. Currently there is no data or report on the amount of rabbit meat being produced or consumed because most of the meat is consumed locally and a significant supply of rabbit comes from the smallholder or backyard farms. It was reported by Lebas et al (1997) that Malaysia is among the countries that produces between 5000-9000 tonnes of rabbit meat.

Breeds of rabbits

In Malaysia there are a number of imported breeds for meat production which include New Zealand White (NZW), Californian, Carolina, New Simonare and Spanish. However, medium-size breeds, the New Zealand White (NZW) and the Californian, are the most popular for meat production in Malaysia. They have white fur and can weigh up to 2-3 kg at slaughter. The NZW is considered the most popular breed overall, because of its mothering ability and carcass characteristics. However, crossing male Californians to female NZWs and then breeding the female from this cross back to male Californians results in larger litter sizes and heavier fryers than using straight NZWs. Other important characteristics of NZW are that they produce 7-9 pups per litter, with weaned rabbits 6-8 animals and can reach 2 kg body weight within two months of age. While rabbit pelts or skins are also important products of the rabbit industry in the western world, this product is not important in Malaysia, possibly because there are no markets for the pelts and wool.

System of farming

1. Backyard or small holder farms. As the term applies, the rabbit hutches occupy a small place in the farm area, at the back of the farm house or by other animal buildings. These farmers tend to keep a few breeding rabbits usually less than 500 in number. The rabbits are fed pellets and supplemented with locally available forages either grown at the farm or elsewhere. These rabbits are kept and sold for meat purposes. However, they do sell them for pets, if pet owners are not particularly concerned about breed. NZW breed do make good pets too.
2. Hobbyist/Enthusiast or show breeders. Also referred to as show breeders. Normally the farm is small, sometimes less than 100 breeders, and concentrate on producing high quality breeds with pedigree. They breed rabbits to produce different colours, fur types and several other characteristics. They do sell their products to specialized pet shops. All rabbits should come with 3 generations pedigrees.
3. Pet farm and edu-park. This farm (or park) is growing rapidly in Malaysia. They have rabbits for show (some are very good quality) while others keep inferior stocks to keep children happy when visiting the park. In Malaysia, many edu-parks have an area where animals that can be touched and handle for children to play with. The typical pet farm is to churn out supplies for pet purposes.
4. Meat Farm. In Malaysia, the meat rabbits are mainly for the meat trade and supplies rabbits for slaughter for food outlets. Their rabbits do make good pets and in fact some are even used in petting zoos/areas. Meat farms tend to keep more than 1000 breeding rabbits and usually they have a small slaughtering facility. The rabbits are usually fed commercial pellets and are kept in cages for ease of handling. The manure of rabbits are also considered as good fertilizer for horticulture and farmers do make some income from the sale of rabbit manure.

Feeding of rabbits

In Malaysia most rabbit farms and pet rabbits owners feed their rabbits with commercial pellets manufactured by commercial feedmillers. Small holder farmers who have plots of land planted with forage such as grass and tree forages, supplement their rabbits with forages although forages may not be the main component of the feed. Pellet feeds contain 18-20% crude protein and the ingredients include wheat milling by-products, soyabean meal and some roughages.

Palm kernel meal (PKM) has been used as an ingredient in rabbit feed. It is a fibrous and protein-rich product that can meet the requirements of high-producing rabbits (de Blas & Mateos 2010). PKM also provides medium-chain fatty acids, whose high concentration in rabbit milk might contribute to explain the protective effect that delaying weaning exerts on rabbit viability (Carrion et al. 2011). It has been shown that PKM can be included in rabbit diets at 20-30% levels without affecting growth performance. PKM is a reasonably cheap protein source and its inclusion in rabbit diets may lower feed costs and makes it an economically viable replacement for more expensive ingredients such as soybean meal, sunflower meal and groundnut meal. However, if PKM is used in high-performance rabbit diets, attention must be paid to the fact this source of proteins is lysine-deficient and also deficient in sulphur amino acids, providing only 58% and 80% respectively of the recommended levels.

Diseases of rabbits

The common diseases of rabbits in Malaysia, are shown in Table 2. In general if rabbits are kept under clean and dry environment they are quite free of diseases. However, as a precaution vaccination against VHD and myxomatosis are recommended. Diseases like ringworm, external parasites and diarrhea are management diseases and can be improved by cleaning the cages and removal of faeces more frequently. The diets of rabbits should also have a significant amount of fibre to encourage fermentation in the caecum.

Marketing

There is no system of marketing rabbits in Malaysia. Many farms sell their rabbits whether live or slaughtered to retailers or third person who come to the farm to select their rabbits. Rabbits for slaughter usually weigh 2 - 3 kg. Retailers would then sell their processed rabbit meat to food processors such as satay sellers, restaurants and home consumers.

Table 2. Common diseases of rabbits in Malaysia

Diseases	Symptoms	Causal agents	Treatment
Snuffles	snotty nose, runny eyes, sneezing and wheezing.	Bacteria stress	Antibiotics
Parasites	Itchiness, falling fur, scratching	External parasites, such as fleas, ticks, mange, and ear mites	External medication available
Ringworm	as bald encrusted areas, spread from rabbit to rabbit, itchy and scratchy	fungus	External medication available
Fly strike	Maggots in the rabbits fur	Flies, moist and soiled fur due to faeces, wet faeces	Change diets from high pellets to high fibre
Myxomatosis	Swollen and watery eyes, does not run when approached	Virus, carried by insects	Cannot be cured, need to vaccinate as a prevention measure
VHD, viral haemorrhage Disease	Respiratory and Heart failure, fatal disease	Virus, carried by insects	Vaccination at 10-12 weeks of age
Diarrhoea	Stomach upset leading to enteritis, depression, diarrhea, dehydration, inappetance	Diet too high in concentrates, change of diets, or coccidial infection	Medication, diet to be high in fibre, if caused by coccidia get anti-coccidia medication

Sources: Various sources from the internet

Some of the farms listed in Table 1, are edu-parks incorporated within a farm. This type of enterprise will sell their animals to customers which are pet owners. Rabbit meat, dressed whole carcass are sold at prices ranging from RM30-35 per kilogram. Raising rabbits for pets are more lucrative as the young rabbits are sold anywhere between RM20 to a few hundred ringgit, pending on the breed. A breeder buck can cost up to RM2000. In general there are no specified slaughter houses for rabbits. Slaughtering are normally done on-farm and usually following the halal procedures. Pet rabbits can be obtained/ purchased from many pet shop, and these pet shops obtain their supply of live rabbits from individual and reliable farmers that are known to supply good quality and disease free rabbits. Pedigreed pet rabbits are rare, most probably in general, pet owners are not concerned about the breeding. Rabbits for breeding are more difficult to obtained, and most large farms import their bucks females from other countries. Food processors and outlets, and restaurants too, obtain their supply of rabbit meat direct from farmers that they know or farms that can provide continuous supply for their outlets.

CONCLUSION

It can be concluded that rabbit farming can be a lucrative business provided that market can be determined. Many success stories in rabbit farming are due to well planned marketing system. As mentioned earlier most supermarkets in Malaysia do not stock rabbit meat. Those consumers who are interested in purchasing rabbit meat usually contact specific suppliers or the farmer. Meat rabbit farmers usually have a small slaughtering unit where they regularly slaughter the rabbits and keep the dressed carcasses frozen for sale.

Certainly, rabbit meat is not like beef or mutton that is readily available in fresh markets or superstores. With good marketing strategies and promotional activities the number Malaysian rabbit meat consumers will be on the increase, thereby increasing the opportunity for rabbit farmers to expand their enterprises.

REFERENCES

Carrion S, de Blas JC, Mendez J, Caida A, Garcia-Rebollar P. 2011. Nutritive value of palm kernel meal in diets for growing rabbits. Anim Feed Sci Technol. 165:79-84.

de Blas C, Mateos GG. 2010. Feed formulation. In: de Blas C, Wiseman J, editors. Nutrition of the rabbit. 2nd edition. London (UK): CAB International.

Department of Veterinary Services (2013). Statistics of livestock. Department of Veterinary Services, Ministry of Agriculture and Agro-based Industries.

Lebas F, Coudert P, de Rochambeau H, Thébault RG. 1997. The Rabbit: Husbandry, Health and Production 2nd Ed. Rome (Italy): Food and Agriculture Organization of the United Nations, Publications Division. (http://www.fao.org/docrep/t1690E/t1690E00.HTM).

Lukefahr SD, Cheeke PR. 1991. Rabbit project development strategies in subsistence farming systems. 2. Research applications. World Animal Review 69(4):26-35. (http://www.fao.org/ag/aga/AGAP/FRG/FEEDback/War/u5700b/u5700b0d.htm# rabbit project development strategies in subsistence farming systems).

Nursuhana AH. Shukor MN, Aminah. 2012. Perceptions on Captive Malayan Porcupine (*Hystrix brachyura*) Meat by Malaysian Urban Consumers. Health and the Environment Journal, Vol. 3: 67-78

SUPPORTING PAPERS

RABBIT FARM
CURRENT STATUS

Past and Present Research on Rabbit Production at The Indonesian Research Institute for Animal Production

Nasrullah, Iskandar S, Raharjo YC

Indonesian Research Institute for Animal Production PO Box 221 Bogor 16002, Indonesia
Corresponding e-mail: nasrullah@litbang.pertanian.go.id

ABSTRACT

Rabbit production has been increasing in Indonesia since the last 10 years. It was increasing since the abruptly breakout of the bird flu. Substantial numbers of household poultry farmers in the village changed their poultry to rabbits. Nationally, small rabbit farming were introduced in the 1980s, as a Government program to alleviate meat protein consumption of the community in rural areas. Since the introduction and widespread distribution of rabbits in the 1980s, rabbit has become an interest for research in Indonesia. However, since rabbit has not been considered as a high priority animal to be developed, its research funds, hence, numbers of its researches were limited. More than six strains of rabbit were available in Indonesia. The most number of strains were found in our research institute and the other were found in small holder farms throughout the country. Researches were mainly dealt with forage and by-product feeds utilization for meat production. In the late 80s and early 90s, when Rex and Satin were introduced, researches were redirected to the production of quality fur including the tanning process. In the late 90s and early 2000s, successful attempt was achieved to produce a breed of rabbit that has Rex-Satin like-fur (named as Reza), with soft, uniform and shiny fur. This breed (Reza) however, was susceptible to enteritis and rather slow in growth. In the last three-four years, the interest of farming rabbits in various areas, although at very small scale farming (5-20 does), increases tremendously. This increase interest may partly be caused of market is widely open, price of rabbit is high, widespread of Avian Influenza, high price of poultry feed and then rabbit farming become an alternative for family who used to be raising local chicken. Problems faced by rabbit farmers are low availability and quality of breeding stock, expensive premixed diet for intensive raising, low availability of good quality forages and high incidence of enteritis. Mortality of 20-40% prior to and 4 weeks after weaning often occurs with the rabbit in small scale farming. Currently, research is directed to have productive Rex, Satin, Reza and produce a medium-big size Reza, reduce mortality through nutrition and possible use of some herbs known to prevent diarrhoea and improve village rabbit management.

Key Words: Rabbit, Research, Indonesia

INTRODUCTION

Rabbit has been raised for a long time by family in the villages. Rabbits were, perhaps kept as pet running around in the house. There was no report on rabbit meat consumption although in the upland area we could find people selling hat from rabbit fur. Introduction of imported exotic rabbit to small farmers in Indonesia, mostly in Java, was in the early 80s by the government. The aim was to improve family meat consumption, a good and *halal* meat (the meat that is allowed to be eaten by Moslem), in the rural areas. However, in the late 80s the program fail the villagers put a high price for rabbit (as breeding stock), while market for meat had not yet developed. Besides, 'bunny syndrome' did exist and effort to promote it was scarce.

Research on rabbit production was somewhat intensified in the late 80s, irrespective of small budget provided by the government. The aims of the research was directed to explore value added of the rabbit through the production of good quality fur, through the introduction of the Rex and Satin rabbits. Fur has been promoted as a material for leather and fur industry, such as for coat, handycraft and toys making. Research was pursued not only on the production but also on post harvest aspect, especially for fur preparation.

Recently, since the outbreak of avian influenza in Indonesia followed with government regulation on killing so many chicken due to suspected death of 105 people throughout the country, rabbit has been becoming popular especially among the

Table 1. Number of research activities carried out at the Indonesian Research Institute for Animal Production

Year	Aspect of research					
	Management	Breeding and reproduction	Nutrition	Post harvest	Health	Total
1980's	9	1	13	2	3	28
1990's	9	2	18	2	6	37
2000's		6	5		6	21
Total	18	9	36	4	15	86

Table 2. Average amount of funds allocated by the government on rabbit research activities

Year	Average amount of budget allocated for rabbit research	
	Rupiahs/year	US dollars/year
1985-1998	40 millions	4,000
1998-2002	None	None
2003-2007	60 millions	6,000

villagers, who might have been trying to avoid avian influenza, while at the same time they also looked for good meat to consume.

There was no report on the AI infecting rabbit or even when they were challenged by AI virus in an experimental condition, rabbit did not show any clinical illness or death (Darminto 2007).

GOVERNMENT BUDGET FOR RABBIT RESEARCH

Through IRIAP the government put a small budget for the rabbit research in the late 80's, covering some aspect of nutrition, managements, breeding, health, and post harvest. A numbers of research activities have been carried out since (Table 1). Other than IRIAP, some universities also do some research in rabbit production (*e.g.* University of Padjadjaran- Bandung, University of Diponegoro-Semarang, University of Jenderal Sudirman-Purwokerto). However, IRIAP could be the only institute that carry out rabbit research continuously.

Most research activities were carried out in the rabbit station of IRIAP at Ciawi, Bogor, anda small number were collaborated with small holders rabbit farms in the villages in West and Central Jawa. The amount of research fund provided by the government is shown in Tabel 2. Government budget on rabbit research was considered very small compared with the budget for chicken and ruminant research. However, to some extent, its results have been contributing considerable technologies needed by small holder rabbit farms throughout the country.

In the years to come IRIAP has to put some effort to convince the government especially the Agency for Agricultural Research and Development, that rabbit will significantly make a substantial contribution to the increase of meat consumption especially in the villages. Rabbits have good opportunity since they are able to produce cheap, good quality meat. Furthermore, in facing the increasing price of grain or grain by products, rabbits have more advantage and can be well developed in forages.

RESULTS DISCUSSIONS

Breeding and reproduction

There were around 12 breeds of rabbit recorded in Indonesia (Raharjo et al. 2005). Number of breeds kept in IRRIAP were the most, whilst farmers kept the most five breeds. Phenotypic characteristics of each breed are presented in Table 3. Variation colors were found in almost all breeds except New Zealand

White. Further, Raharjo et al. (2005) also reported morfometric characters of mature rabbit breed in Indonesian. The characteristics of rabbit at this institute could be considered as a represent the characteristics of rabbit found kept by the farmers throughout the country, except local rabbit, which was a ittle bit smaller compared with other meat-type breed of exotic rabbit. Morfometric characteristics of Indonesian rabbit are presented in Table 4.

Reproductive traits of breeds of rabbit in Indonesia, which were mostly reported by Raharjo et al. (2005) were presented in Table 5. The sortest partus interval was shown by breed of Tan (38 days) dan the longest was by Reza and Angora (45.4 days). Length of pregnancy was almost the same for all breeds. Mini Rex was the poorest litter and weaning sizes among all breeds observed.

Table 3. Phenotypic traits of rabbit breeds in Indonesia

Rabit breeds	Phenotypic traits
Angora	Colour of fur: Pure white, black-white, mix of brown-golden and yellow-grey. Broken ears, flop with oval form and round face
Crossing	Colour of fur: Mix of castor, grey, black and pure. Oval ears lobe standing beside the head and pears form like face
Lion	Black stripes color of fur. Oval ears lobe standing beside the head and pears form like face
Lop	White and brown fur with long, curve and fall oval-ears. Completely round face
Mini Rex	Three colors (white-brown-white) fur with standing and oval ears. Face is round
NZW	Pure white fur with standing and oval ears. Face is round
Rex	The color of fur is vary from two mix colors of black and white, castor, chincila (white-black-brown) to pure white. Standing, oval and narrow ears with round face
Reza	Reza has many colors of fur such as pure white, the mix of brown and black (harlequin), grey and pure black. Standing and oval ears with round face dominate the chracteristic of Reaza
Satin	Fur colors are vary from pure white, pure black to the mix of grey and white. Standing, oval and narrow ears are often found with round face
Tan	Pure black of fur, standing, oval and narrow ears with round face are the characteristics of this breed
Felmish giant	Color of fur were vary covering chinchilla, grey, brown, white-brown, black-brown and white-black. Standing and oval ear with round face like pears
Local	Black-white fur with standing and oval ears and round face like pears

Source: Brahmantiyo et al. (2007)

Tabel 4. Morfometric traits of breeds of rabbit in Indonesia

Breeds	Body measures													
	Body weight (g)		Chest girth (cm)		Body length (cm)		Neck cicular (cm)		Tail length (cm)		Tail cicular (cm)		Ear length (cm)	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Angora	1884	1859	30.8	28.9	36.6	36.8	22.6	22.6	5.40	5.60	3.80	4.00	11.4	11.0
Cross	2116	1842	31.8	32.0	39.4	39.6	25.6	25.2	4.60	4.80	2.80	3.40	11.6	11.6
Lion	2250	2118	36.0	24.3	34.0	34.5	26.0	23.8	5.00	5.00	3.00	3.00	12.0	11.5
Lop	2221	1942	32.7	22.0	34.3	32.0	21.7	22.0	6.00	5.00	4.00	4.00	11.0	11.0
Mini Rex	1087	2112	25.0	29.0	31.0	30.0	25.0	14.0	7.00	3.00	4.00	2.00	10.0	10.0
NZW	3342	3248	35.4	33.6	40.2	37.4	23.2	20.6	5.40	5.60	4.60	4.20	11.0	10.9
Rex	3082	3275	27.9	27.3	40.4	35.2	21.4	21.4	6.70	6.70	4.40	3.80	11.2	11.4
Reza	3062	3177	32.0	32.2	39.4	40.4	25.6	25.6	3.80	4.20	3.00	3.20	10.8	11.0
Satin	2797	3055	29.0	30.6	34.8	34.6	22.8	22.2	5.60	5.60	3.40	4.20	11.5	11.4
Tan	2480	2320	25.0	24.0	36.0	32.0	30.0	26.0	6.00	7.00	4.00	4.00	10.0	11.0
Local	n.a.	1850	n.a.	28.0	n.a.	35.0	n.a.	21.0	n.a.	n.a.	n.a.	n.a.	n.a.	11.0
California	2600	2750	29.0	28.0	40.0	42.0	17.0	16.5	n.a.	n.a.	n.a.	n.a.	13.0	14.5
Flemish giant	2500	3314	29.0	29.6	41.0	42.9	18.0	17.6	n.a.	n.a.	n.a.	n.a.	13.0	14.1

n.a.: not available

Source: Brahmantiyo et al. (2007)

Tabel 5. Reproductive traits of breeds of rabbit kept at IRIAP

Breeds	Partus interval (days)	Length of pregnancy (days)	Litter size (kids)	Weaning size (kids)	Service/ concept (times)	Concept rate (%)
Angora	45.4^{A}	31.6	5.0^{AB}	3.8^{AB}	1.39	26.7^{AB}
Cross	39.8^{AB}	32.4	6.4^{AB}	5.2^{A}	1.94	44.9^{A}
Lion	41.0^{AB}	32.3	4.8^{AB}	3.0^{AB}	1.40	28.9^{AB}
Lop	42.0^{AB}	32.0	7.0^{A}	3.0^{AB}	1.50	33.3^{AB}
Mini Rex	45.0^{A}	32.0	4.0^{B}	2.0^{B}	1.40	28.6^{AB}
NZW	38.2^{B}	33.4	6.8^{A}	5.4^{A}	1.30	22.1^{AB}
Rex	39.4^{AB}	32.0	6.4^{AB}	5.0^{A}	1.90	31.2^{AB}
Reza	45.4^{A}	32.6	6.4^{AB}	3.4^{AB}	1.35	25.3^{AB}
Satin	41.6^{AB}	32.4	4.6^{AB}	3.6^{AB}	1.35	25.3^{AB}
Tan	38.0^{B}	33.0	6.0^{AB}	4.0^{AB}	1.13	11.1^{B}

Value with different superscripts were significantly difference ($P<0.01$)

Special attention was put on Rex and Satin rabbits. Started in the 1998, an idea to produce a breed of rabbit that has soft, uniform in length and shiny fur was developed (Raharjo et al. 1998). The fur of the breed was formed from a combination of recessive gene rr (smooth fur of Reza) and gene sasa (shiny fur of Satin) (Prasetyo 1999). This gene traits (combination of two recessive genes) would not produce variation of the traits, because the segregation of those genes would not produce new character combination. Thus all of offspring would have smooth and shiny fur. This specific phenotype trait would help the selection program. Both Rex and Satin breeds were brought to IRIAP in 1996, through a cooperation with a company.

Evaluation on semen quality of those breeds of rabbit, showed that semen volume of Rex, New Zealand White and Flemish Giant were 0.9, 1.92, and 1,97 mls, respectively. While their sperms were 365,8; 497,6 and 428,9 million/ml and pH of 7.6; 7.7; and 8.2 respectively (Sastrodihardjo et al. 1985).

Current topic of Indonesian research:

1. Open nucleus breeding program, artificial insemination, mating system, semen quality.
2. Nutrition
   - Local forage quality, vegetable waste products
   - Concentrate feed, probiotik
   - Requirements (energy, protein, fiber)
   - Feeding system
3. Management
   - Existing performance under traditional keepings
   - Raising in upland, medium areas by small farmers in Jawa
   - Weaning age, nest box, temperatures, fostering, fattening, number of does kept
4. Post harvest
   - Fur, meat and meat products
5. Health
   - General diseases, skin diseases, cocidiosis, diarrhea

RABBIT STRATEGIC RESEARCH PLAN FOR 2005-2009

- Goal:
  Building rabbit agribusiness based on appropriate technology for industrial scale
- Potentials:
  - Small, cute, edible animal
  - Prolific, eating simple forages
  - Used for meat, fur, manure and pet
  - Synthetic adaptive breed

Table 6. Conditions

Variables	Existing (2005)	Target (2009)
Breed	Rex, Satin, NZW, FG, Reza	Crosses
Concept rate	60-70%	80%
Litter intervals	59-70 d	50 d
Kindling litter size	5.2-8.5 kits	>7.5 kits
Weaning size	3.2-6.1 kits	>7 kits
Weight gain, g/head (2-4.5 months)	15-20	30
Slaughter weight	2.5-3.2 kg	3.5-4.0
Mortality	20-40%	<15%
Skin area	30-36 cm^2	>48 cm^2
Fur quality	Low-high	Mod.-High

REFERENCES

Sastrodihardjo S, Budiman I, Marsoso EA. 1985. Produktifitas semen dari berbagai kelinci pada ejakulasi berbeda. Prosiding Seminar Peternakan dan Forum Peternak Unggas dan Aneka Ternak. Balai Penelitian Ternak Ciawi. p. 446-452.

Sastrodihardjo S, Raharjo YC, Sartika T, Prasetyo LH. 1989. Pengaruh macam rangsangan ovulasi pada induk kelinci Rex terhadap keberhasilan kelahiran anak. Dalam: Pembekuan Inseminasi Buatan dengan Rangsangan Ovulasi dan Semen Segar Kelinci. S. Sastrodihardjo (Ed.). Hasil-Hasil Penelitian Tahun Anggaran 1988-1989, Komoditi Kelinci. Badan Penelitian dan Pengembangan Pertanian, Balai Penelitian Ternak Ciawi, Bagian Proyek Penelitian Ternak Ciawi, Bogor. p. 1-17.

Rabbit Farming: Socio Economic Status in India - A Review

Muralidharareddy V, SK Das Ch. Subhashini, Reddy VM

Rabbit Development Center, Matha socio educational society,Veeram Muralidharareddy Foundation, 10.Bollavaram, Nandikotkur Mandal, Kurnool, Andhrapradesh-518432
Corresponding e-mail: muralireddy@Rediffmail.Com

ABSTRACT

Rabbit was introduced in India as an alternative source of meat production. The commercial rearing in Kerala has been started within private and Government sector. In four districts of Kerala the scheme for rabbit development is being implemented. Kerala Agricultural University has setup the ICAR project for rabbit breeding in 1984. This study shows that Soviet Chinchilla as maximum birth weight of 62 g. While the average body weight at 12 weeks of age was maximum of New Zealand White being 1539 g. Good breeds, good feeding management using local available seeds and millets, good sanitation and disease management, are some factors of success of rabbitry in Kerala, Andhra Pradesh

Key Words: Rabbit Farming, Kerala

INTRODUCTION

Rabbit was introduced in India in the last decade as an alternative source of meat production. A number of entrepreneurs have established private rabbit farms in Andhra Pradesh, Kerala, Goa, Karnataka, Himachal Pradesh, Jammu and Kashmir and hilly areas of Uttar Pradesh, Haryana and Tamil Nadu. Rabbit meat is wholesome, tasty with appreciable juiciness and tenderness. It contains a high amount of protein and low amounts of fat and cholesterol (Lebas et al. 1986; Das & Bujarbarua 2005). Thus people in India showed great acceptance of consumption of rabbit meat. In addition, rabbit has a quite high dressing percentage when compared to ruminants, ranging between 50-65% (Lebas et al. 1986; Roiron et al. 1992). The heritability of different carcass traits is medium to high, and therefore carcass traits might be considered in rabbit selection and breeding. It has been reported that different factors, such as age at slaughter, weight at slaughter, breed, and sex, have an influence on different carcass traits (Parigi-Bini et al. 1992; Bianospino et al. 2006; Gašperlin et al. 2006; Metzger et al. 2006). Rabbit rearing can become remunerative, when scientific management of rabbits is done by keeping in view their natural behaviour. As medium sized rabbits are more productive, heavy weighted does are useful in breeding. Lifting the rabbits by ear reduces their reproduction rate and bunnies touched before 7 days of age do not get mother's milk and die. Such practical behaviour instinct becomes the basis for success in rabbit management. Careful management practices can only ensure a steady production of healthy and vigorous bunnies (young ones). Those who started rabbitries to become rich overnight have not stacked up golden bunnies as per expectation. The reasons are clear, if you start with a unit of 100 females plus 20 males, the expenses for the first year will amount to rupees one lakh. This will include the cost of cages, feed, medicine, labourand rent of the shed. This is a big outlay for an ordinary person getting immediate returns. However, to start a rabbit business one does not need a large initial integument. A few doe's with a ram or buck is enough to start; once the kindling begins the herd rapidly increases in size, so that very soon one can slaughter the young males. Because the does produce offspring regularly they form a regular source of income instead of a large amount at once.

Two factors are responsible for successful rabbit rearing are acquiring veterinary skill and vicinity of market for selling rabbit meat and wool. A farm of 200 rabbit flock can become viable only in areas having a well organized market for wool and meat.The poor farmers, however, can start rabbit rearing only as backyard rearing. This will supplement his income and provide meat for home, but he cannot depend solely on it.

In the context of our country livestock plays a vital role in the economy of our country. Moreover, the major supply of protein comes from the livestock sector of our country. According to the department of livestock services about 36 percent of the total animal protein comes from the livestock products in our everyday life. Countries 25 percent peoples are directly engaged in livestock sector, and 50 percent peoples are partly associated in livestock production. Last year, the contribution of livestock sub-sector to the GDP was 2.95 percent, which was estimated about 17.32 percent GDP to agriculture. Last year, the growth of livestock in GDP was 7.23 percent. In this back drop production of animal species has become a vital factor. Rabbit farming as a source of income has not yet gained popularity among the common people of our country. The rural people of our country can be involved in rabbit farming for changing their socio-economic status. As rabbit farming is easily manageable and sustainable it has a bright future potential in our country as a source of income as well as a source of protein.

Rabbit rearing started gaining popularity in the beginning of 19th century in Western Europe. Rabbit Farming in India is of recent origin and is largely on experimental scale. Rabbit farming and rabbit meat is very popular in whole NE Region and in Eastern Region.Rabbit meat has yet not been accepted as a regular diet item. However in places like Kerala, Karnataka, Andhra Pradesh, Uttar Pradesh and Himachal Pradesh rabbit meat is available in Restaurants and Dabas.Rabbits are more efficient feed converters than other animals and convert feed with high cellulose content to high quality protein. Certain breeds like German Angora, Russian Angora yield precious wool. Rabbit breeding is useful for increasing employment potential in rural sector.

Kerala Agricultural University has setup the ICAR project for rabbit breeding in 1984. This study shows that Soviet Chinchilla as maximum birth weight of 62 g. While the average body weight at 12 weeks of age was maximum of New Zealand White being 1539 g. The litter size was highest in Soviet Chinchilla and it was 4.9 in number. The litter weight at weaning was highest in the cross of New Zealand White and Soviet Chinchilla being 2537 g. Carcass traits showed that the highest dressing percentage at 12 weeks age was in the cross of ND and New Zealand White being 60%. Genetic growth is a significant source of variation for litter size and it was found to be highest in winter followed by autumn and summer and lowest in raining season. Pre-weaning mortality is highest in kids born during these summer season.

The level of production ranges between 200 g to 60 g. The level of production of Angora wool is between 200 g to 600 g per animal per year. The wool sells at an average price of Rs. 800/kg. Angora rabbit hair blends with other fibres like wool, silk, polyster and improves the performance while reducing cost.The rabbit wool has 49.54% carbon, 6.52% hydrogen and 4.02% sulphur. Rabbit hair resists the action of boiling strong acetic acid and cold dilute hydrochloric acid. Dilute nitric acid turns it yellow. The rabbit hair fibres which are usually dyed are Mohaire and Cashimere. Dyed with crome dyes, it has a two tone effect. It mixes well with wool because of its fine texture and diameter. Angora fibre has lowest specific weight (1.2 g/cm^3) if compared to other natural textile raw material. It is smoother than wool and its moisture retention is 2% lower than that of wool. Angora rabbit is popular in Kullu valley in Himachal Pradesh, Jammu & Kashmir and Tamil Nadu. Russia Angora is better suited to Tamil Nadu.

The rabbit project at Garsa was undertaken to study the performance of various breeds. The study showed that Angora, New Zealand White and Soviet Chinchilla had much better adaptability and had maximum survival rate. The fur quality of Soviet Chinchilla and Grey Giant is the best. The rabbit project at Palampur showed that the highest combining ability is possessed by New Zealand White, which also has maximum growth rate.

In Karnataka 6 rabbit breeding farms with 200-300 rabbits in each has been setup. The slaughtering age of rabbit in these farms is between 4 to 6 months within average weight of 3 kg.

The commercial rearing in Kerala has been started within private and Government sector. In four districts of Kerala the scheme for rabbit development is being implemented. The districts are Trivandrum, Eduki, Quilon and Pathanamthitta.

The rabbits require proper feed containing rice bran, groundnut cake, jaggery, soked gram and wheat. They are also given approximately 100 g leafy vegetables per day. The cages for rabbits are usually 36"/20"/18".Medical care of the animals is most important and regular deworming against coccidiosis is necessary.

Rabbit farming is dependent on proper feeding and health care. For meat type the breeds recommended are New Zealand White, Russia Grey Giant, Soviet Chinchilla, While Giant, California and Flemish Giant. For fur purposes the breeds recommended are: German, French and English Angora. For fancy varieties the recommended breeds are: Polish, Palameno, Havana and Florida. Heavy breeds are Bauscat, White Giant and French Lope: average, breed is English Silver, German Silver, New Zealand White and Soviet Chinchilla and light weight breeds are Himalayan Small Chinchilla and French Havana. The doe reaches puberty when it attains 75% of mature weight. Domesticated rabbits are prone to diseases like intestinal and respiratory.Housing is extremely important and the rabbit should be housed in either hutch or shed system. A wire mesh flooring is recommended for easy removal of faecal matter. Rabbit breeding can have positive effect in increasing employment opportunities as well as generating income. Rabbit farming also utilizes kitchen waste. Rabbit meat is a high protein food and is useful for human consumption having low cholesterol level.

STATUS OF RABBITRY IN ANDHRA PRADESH

Rabbit farming in Andhra Pradesh is growing rabbits are mainly using for meat in Kurnool, Hyderabad, Vijayawada and other parts of Andhra Pradesh rabbit farms are knowadays emerging the main region is entrepreneurship, low investments in rabbit farming attracted by educated youth come forward to start rabbit farms in those regions.

Rabbit farm owners are having good contacts with road side national highway dhabas, restaurants and these farmers are directly marked by their own without taking the help of middle men that is the region they are sustaining themselves and their family.

The main reason of success of rabbitry in Andhra Pradesh is as follows:

1. They are using good breeds
2. There are making cases their own
3. Water and feed giving regularly without contamination
4. Feed are making their own with local available millets and other seeds
5. Removing the diseased animals from the farm
6. Farm is maintained totally hygienically
7. With the help of good supportive daily wage other farmers are rearing rabbit

Some of the rabbit farms also closing with neglected management and poor understanding with out taking guidelines from experts. Some are well advanced they having freezers and transportation facilities to transport very fast to the destination to other states, 5 star hotels big restaurants they are getting more income where as compare with other agribusinesses.

REFERENCES

Arrington LR, Kelly KC. 1976. Domestic rabbit biology and production. Gainesville (USA): The University Press of Florida.

Bianospino E, Wechsler FS, Fernandes S, Roça RO, Moura ASAMT. 2006. Growth, carcass and meat quality traits of straightbred and crossbred botucatu rabbits. World Rabbit Sci. 14:237-246.

Cheeke PR. 1987 Rabbit feeding and nutrition, Orlando (USA): Academic Press.

Das SK, Bujarbarua KM. 2005. Carcass traits of rabbit, organoleptic properties and consumption pattern of rabbit meat in NE Region of India. Pan Am Rabbit Sci Newsl. 9:39-43.

Das SK. 2012. Study on the different factors affecting mortality pattern of rabbit in India. Indian J Anim Res. 46:89-91.

Das SK, Bardoloi RK. 2008. Study on the factors affecting carcass traits of broiler rabbit in Eastern Himalayan Region of India. World Rabbit Sci. 16:107-110.

Das SK, Bardoloi RK. 2008. Productive Performances of broiler rabbit under roughage feeding. Indian Vet J. 85:443-444.

Das SK, Bujarbarua KM. 2007. Reproductive performances of New Zealand White and Soviet Chinchilla Rabbit under the agro climatic condition of Meghalaya. Ind J Anim Res. 41:220-222.

Das SK, Sikka AK. 2007. Effect of different housing and feeding system on the performances of broiler rabbit in Eastern Himalayan Region of India. Liv Res Rural Dev. 19:22.

Das SK, Singh NP. 2011. Effect of micro environmental changes on rabbit production. In: The Proceeding of 6th National Extension Education Congress on "Emerging Models of Technology Application for Agri - Rural Development held at ICAR - RC for Goa, Ela, Goa during 17-19th December, 2011. Abst No. 80. p. 44.

Deb SM, Gaur GK. 1996. Performance of broiler rabbit in subtemperate hill. Ind Vet Med J. 20:184-189.

Fullerton G. 2000. A to Z of Australian Commercial Rabbit Farming. Thumper Marketing, 02 4997 3112.

Gašperlin L, Polak T, Rajar A, Skvarèa M, Žlender B. 2006. Effect of genotype, age at slaughter and sex on chemical composition and sensory profile of rabbit meat. World Rabbit Sci. 14:157-166.

Hernandez P, Aliaga S, Pla M, Blasco A. 2004. The effect of selection for growth rate and slaughter age on carcass composition and meat quality traits in rabbits. J Animal Sci. 82:3138-3134.

Lebas F, Coudert P, Rouvier R, Rochambeau HD. 1986. The Rabbit: Husbandry, health and production. Rome (Italy): FAO. p. 203.

Luzi F, Lazzaroni C, Barbieri S, Pianetta M, Cavani C, Crimella C. 2000. Influence of type of rearing, slaughter age and sex on fattening rabbit: Productive performance. In: Proceedings 7th World Rabbit Congress, 4-7 July, 2000. Valencia (Spain): WRC. p. 613-620.

Metzger Sz, Odermatt M, Szendro Zs, Mohaupt M, Romvári R, Makai A, Biró-Németh E, Sipos L, Radnai I, Horn P. 2006. A study of the carcass traits of different rabbit genotypes. World Rabbit Sci. 14:107-114.

Milisits GI, Romavari RI, Szendrö Zs, Masoreo G, Bergoglio G. 2000. The effect of age and weight on slaughter traits and meat composition of Pannon white growing rabbits. In Proc.: 7th World Rabbit Congress, 4-7 July, 2000, Valencia (Spain): WRC. p. 629-636.

McNitt JI, NM Patton, PR Cheeke, Lukefahr SD. 1996. Rabbit production, 7th edition. Danville (USA): Interstate Publishers Inc.

Parig-Bini R, Xiccato G, Cinetto M, Dalle Zotte A. 1992. Effect of age, slaughter weight and sex on carcass and meat quality of rabbit. Anim Breed Abst. 61:257.

Roiron A, Ouhayoun J, Delmas D. 1992. Effect of body weight and age at slaughter on carcass and meat quality of rabbit. Anim Breed Abst. 61:64.

Salroo GM, Prasad VSS, Gupta SC. 1989. Effect of age on carcass traits of the SC rabbit. Indian J Anim Sci. 59:890-892.

Snedecor GW, Cochran WG. 1967. Statistical Methods, 6th edition. New Delhi (India): Oxford and IBH Pub. Co.

NUTRITION

Effects of Supplementation of Paddy Rice and/or Rice Grain and/or Rice Husk to Sweet Potato (*Ipomoea batatas*) Vines as Basal Diet on Feed Intake, Growth Performance and Digestibility of New Zealand White Rabbits

Nguyen Thi Duong Huyen, Nguyen XT, Preston TR

Corresponding e-mail: nghuyen.hua@gmail.com

ABSTRACT

An experiment was conducted to determine effects of supplementation of paddy rice and/or rice grain and/or rice husk to sweet potato (*Ipomoea batatas*) vines as basal diet diets for growing New Zealand White rabbits on feed intake, digestibility, average daily gain (ADG), feed conversion ratio (FCR) and economic returns. A total of 28 male New Zealand White growing rabbits at 6 weeks of age were allocated into 4 treatment groups with 7 rabbits each in single cages. Supplementations were designed as following: 1. Sweet potato vines (SPV): Basal diet without supplement, 2. PRG20: SPV plus raddy rice grain at 20 g/day, 3. BRG20: SPV plus broken rice grain at 20 g/day, 4. BRGH: SPV plus 16 g broken rice grain and 4 g rice husk in separate feed bowls. The experiment lasted 8 weeks following 1 week of adaptation. It was found that total DMI among the experimental and control groups were not significantly different (P>0.05), either in an absolute term (g/head/day) or as percentage of LW. Supplementation of paddy rice, broken rice and rice husk reduced forage intake. Supplementation had a positive effect on ADG and FCR (P<0.05). Moreover, grain supplementation to forage-based diet had a significant economic effect.

Key Words: New Zealand White Rabbits, Paddy Rice, Rice Grain, Rice Husk, Supplementation, Sweet Potato Vines

INTRODUCTION

Rabbits efficiently utilize fibrous feed by courtesy of their feeding and digestive strategies (Leng 2006). Rabbits can get energy from forages; they always have done in the wild state and their digestive system is developed for this purpose. Among other forages, sweet potato (*Ipomoea batatas*) vines is a common vegetable used for rabbit feeding in Vietnam as a basal and even the only diet. To improve the nutritional balance in diets based on forage, supplementation with highly digestible carbohydrate in the form of broken rice was not successful in the experiment reported by Hongthong Phimmmasan et al. (2004). By contrast, in other experiments (Khuc Thi Hue & Preston 2006; Doan Thi Giang et al. 2006), supplements rich in fibre gave positive results with rabbits fed diets based on water spinach. In the experiment reported by Nguyen Huu Tam et al. (2009) in which rabbits fed on water spinach had higher feed intake and live weight gain when they were supplemented with paddy rice. Recently, in the work by Nguyen Thi Duong Huyen et al. (2010), supplementation of paddy rice improved live weight gain but at the same time reduced feed digestibility of New Zealand rabbits fed on either sweet potato vines or water spinach. So far, there have been not yet any answer to the opposing effects of paddy rice on growth and digestibility of rabbits. The present study was aimed to test the hypothesis that there are some characteristics in the rice husk that have beneficial effects on growth of rabbits.

MATERIALS AND METHODS

Treatments and animals

A total of 28 male NZW growing rabbits at 6 weeks of age were allocated into 4 treatment groups with 7 rabbits each in single cages. The rabbits were fed sweet potato vines (SPV) as basal diet. Supplementations were designed as below:

1. Sweet potato vines (SPV): Basal diet.

2. PRG20: SPVplus paddy rice grain at 20 g/day.
3. BRG20: SPVplus broken rice grain at 20 g/day.
4. BRGH: SPVplus 16 g broken rice grain and 4g rice husk in separate feed bowls.

Feeding regime and management

The experiment was carried out at the experimental farm of Hanoi University of Agriculture. It lasted for 8 weeks following 7 days of feeding adaptation. Before the experiment began the rabbits were vaccinated against hemorrhagic diarrhea and drenched against intestinal parasites. The animals were fed three times a day at 8:00, 14:00, and 20:00 h in individual cages. Drinking water was made available at all times.

Data collection and measurements

All animals were individually weighed at the beginning and thereafter once a week until the end of the experiment to calculate the average daily gain (ADG) as the slope of the linear regression of live weight on raising time.

Total feed and faeces collections were taken over 7 consecutive days in the middle of the experiment. The feeds offered and refusals were collected and weighed with samples taken daily in the morning. Representative samples of faeces (10%) were collected daily from the total feaces collection and stored at -25°C. At the end of the 7 days the samples were bulked for individual animals. Feed and faeces samples were subjected to chemical analyses. Digestibility (%) was calculated as = (A-B/A)*100, where A and B are total nutrient intake and total nutrient in the faeces. Feed conversion ratio (FCR) was calculated as a ratio of DM intake/live weight gain.

Economic calculation

The total investment consists of fixed cost and changeable cost

1. Fixed cost: housing investment, water and electricity, animal, medicines, labour cost and other equipment. The fixed cost was the same among control block and experimental blocks.
2. Variable cost: different cost was set up in each block such as ration and supplementation. The changeable cost was calculated based on differences in weight gain, FCR, current rabbit price and current forage price in market at the time of conducting the experiment.

The final profit consists of increased profits and decreased cost. The final profit was calculated based on differences in weight gain, FCR, current rabbit price and current forage price in market at the time of conducting the experiment.

The rabbit price at the time of conducting the experiment was 70.000 VND/kg (like weight).

The forage price was calculated based on fresh biomass, then converted to dry matter.

Economic calculation in each block was calculated according to the equation below:

Final profits = (increased profits + decreased cost) – (increased cost + decreased profits).

Chemical analyses

Chemical analyses of diets and faeces were undertaken following the methods of AOAC (1990) for DM, OM, CP, EE and ash. NDF and ADF were determined following the procedures of Van Soest et al. (1991).

Statistical analyses

The experimental data were subjected to analyses of variance (ANOVA) made for a CRD model using the General Linear Model (GLM) of Minitab 16. Pair-wise comparisons of means were done using the Tukey's.

RESULTS AND DISCUSSION

Chemical compositions of feeds used in the experiement were presented in Table 1.

Feed intake

Feed intake as affected by supplementation is shown in Table 3. Although grain and forage DMI among blocks were significantly different, total DMI did not differ (P>0.05). The present results were significantly higher compared with a study by Nguyen Thi Duong Huyen et al. (2010) on sweet potato DMI (62.99 g/head/d) and water spinach DMI (51.42 g/head/d). Supharoek Nakkitset (2007) reported that DMI of rabbits fed water spinach was 66 g/head/d, this result was lower than the present result. This can be explained by the impact of adverse weather conditions during March. The average temperature was below 20°C and humidity was above 80%. This resulted in heat loss in rabbits, feed intake was therefore increased to meet their maintenance and growth requirements as well as to protest against cold stress. Because of high forage intake, total DMI was higher than previous studies, but lower when compared with a study by Doan Thi Giang et al. (2006) on New Zealand White rabbits, DMI were 119 and 121 g/head/d in the basal diets of water spinach and sweet potato, respectively.

Digestibility

Digestibility as affected by supplementation is presented in Table 4. There in NDF, ADF, and Lipid. Nguyen Thi Duong Huyen et al. (2010) reported that the digestibility of sweet potato and water spinach were 76.40% and 76.20%, respectively. These results were higher than the present study, however, Nguyen Kim Dong et al. (2006) showed that digestibility of Para grass (*Brachiaria mutica)* was 62.7%, it was lower compared with the present study. It is due to the fact that sweet potato is high in protein and low in fiber content compared with Para grass. Nguyen Kim Dong et al. (2006) supplemented water spinach in levels of 0, 25, 50, 75% with basal diets of Para grass, the digestibility was 62.7, 70.5, 71.7 and 73%, respectively.

Table 1. Chemical composition of feeds used in the experiement

Feed	DM (%)	CP (%DM)	NDF (%DM)	ADF (%DM)
Broken rice	88.14	7.61	5.31	3.32
Rice husk	90.17	2.19	80.04	56.32
Paddy rice	90.48	6.56	32.16	15.00
Sweet potato	11.36	25.13	36.12	22.40

Table 2. Chemical composition of the experimental diets

Diet	SPV	PRG20	BRG20	BRGH
DMI (g/head/day)	118.61	129.06	129.26	128.95
Grain DMI (%)	0.00	14.02	13.64	13.74
Sweet potato (%)	100.00	85.98	86.36	86.26
NDF (%DM)	36.12	35.57	31.92	33.98
CP (%DM)	25.13	22.53	22.74	22.57

Table 3. Feed intake as affected by supplementation

	Block 1 (SPV)	Block 2 (PRG20)	Block 3 (BRG20)	Block 4 (BRGH)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Grain DMI	$0^{d} \pm 0$	$18.1^{a} \pm 0.00$	$17.63^{c} \pm 0.00$	$17.71^{b} \pm 0.00$
Forage DMI	$106.04^{a} \pm 3.82$	$90.77^{b} \pm 3.82$	$95.83^{ab} \pm 4.13$	$97.79^{ab} \pm 4.13$
Total DMI (g/head/d)	$106.04^{a} \pm 3.82$	$108.9^{a} \pm 3.82$	$113.5^{a} \pm 4.13$	$115.5^{a} \pm 4.13$
Total DMI (% liveweight)	$6.03^{a} \pm 0.15$	$5.67^{a} \pm 0.15$	$5.89^{a} \pm 0.16$	$5.92^{a} \pm 0.16$
CP intake (g/head/d)	$26.5^{a} \pm 0.85$	$24.73^{a} \pm 0.85$	$25.88^{a} \pm 0.92$	$26.18^{a} \pm 0.92$
NDF intake (g/head/d)	$39.45^{a} \pm 1.22$	$39.43^{a} \pm 1.22$	$35.51^{b} \pm 1.32$	$40.53^{a} \pm 1.32$

^{a,b}: within a row, means without a common superscript differ (P<0.05)

Table 4. Digestibility as affected by supplementation

Digestibility (%)	Block 1 (SPV)	Block 2 (PRG20)	Block 3 (BR20)	Block 4 (BRGH)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
DM	$73.76^{a} \pm 1.42$	$70.56^{a} \pm 1.42$	$75.19^{a} \pm 1.53$	$73.15^{a} \pm 1.53$
OM	$74.58^{a} \pm 1.33$	$72.22^{a} \pm 1.33$	$76.13^{a} \pm 1.44$	$73.99^{a} \pm 1.44$
CP	$80.37^{a} \pm 1.09$	$77.7^{a} \pm 1.09$	$79.58^{a} \pm 1.18$	$79.1^{a} \pm 1.18$
NDF	$62.62^{a} \pm 2.09$	$54.5^{b} \pm 2.09$	$58.44^{ab} \pm 2.26$	$56.14^{a} \pm 2.26$
ADF	$59.4^{a} \pm 2.24$	$49.67^{b} \pm 2.24$	$54.93^{ab} \pm 2.42$	$53.24^{ab} \pm 2.42$
Lipit	$68.14^{a} \pm 1.77$	$63.94^{b} \pm 1.77$	$68.6^{a} \pm 1.91$	$65.89^{ab} \pm 1.91$

[a,b]: within a row, means without a common superscript differ ($P<0.05$)

Live-weight gain and feed conversion ratio

Live-weight gain and FCR as affected by supplementation is shown in Table 5. Live-weight gain among control block and experimental blocks were not significantly different ($P>0.05$). Initial live-weight of control block and experimental blocks averaged 1081 g. After 8 weeks of feeding trial, final live-weight averaged 2167.42 g and there were no significant differences among blocks. On average, live-weight gained 19.4 g each week.

Studied supplementation of Calliandra in basal diets of water spinach and Guinea grass (*Panicum maximum)* to feed New Zealand rabbits, the weight gains were 17.2, 16.6 and 18.8 g/head/d in relation with rations of water spinach, water spinach and Ghine grass, and water spinach and Calliandra. Khuc Thi Hue et al. (2006) reported that weight gains of rabbits fed 100% water spinach and Stylo grass, water spinach and Ghine grass, and water spinach and broken rice were 18.1, 22.4, 23.1 and 22 g/head/d, respectively. Nguyen Thi Duong Huyen et al. (2010) supplemented 0, 2, 3 and 4% paddy rice in rations of water spinach and sweet potato, the weight gains of rabbits were 19.83, 23.67, 23.58 and 24.03 g/head/d, respectively. The present results show that the digestibility as affected by supplementations was lower than the studies by Nguyen Thi Duong Huyen et al. (2010) and Khu Thi Hue et al. (2006). This leads to lower weight gains when compared with previous studies.

The feed conversion ratio among blocks were significantly different ($P<0.05$). The average of FCR was 5.8 kg DM/kg gain which was higher than a study by Supharoek Nakkitset et al. (2007) (3.6 kg DM/ kg gain) and higher than a study by Nguyen Thi Duong Huyen et al. (2010) (3.86 kg DM/kg gain in water spinach group and 4.71 kg DM/kg gain in sweet potato group).

Table 5. Live-weight gain and FCR as affected by supplementation

	Block 1 (SPV)	Block 2 (PRG20)	Block 3 (BR20)	Block 4 (BRGH)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Initial live-weight (g/head)	$1101.43^{a} \pm 73.88$	$1095.71^{a} \pm 73.88$	$1051.67^{a} \pm 79.80$	$1073.33^{a} \pm 79.80$
Final live-weight (g/head)	$2068.57^{a} \pm 59.42$	$2221.43^{a} \pm 59.42$	$2185.00^{a} \pm 64.18$	$2236.67^{a} \pm 64.18$
Total weight gain (g/head)	$967.14^{a} \pm 61.09$	$1125.71^{a} \pm 61.09$	$1133.33^{a} \pm 65.99$	$1163.33^{a} \pm 65.99$
Average daily gain (g/head/d)	$17.19^{b} \pm 1.24$	$19.86^{a} \pm 1.24$	$20.55^{a} \pm 1.34$	$21.26^{a} \pm 1.34$
FCR	$6.36^{a} \pm 0.45$	$5.62^{b} \pm 0.45$	$5.64^{b} \pm 0.49$	$5.56^{b} \pm 0.49$

[a,b]: within a row, means without a common superscript differ ($P <0.05$)

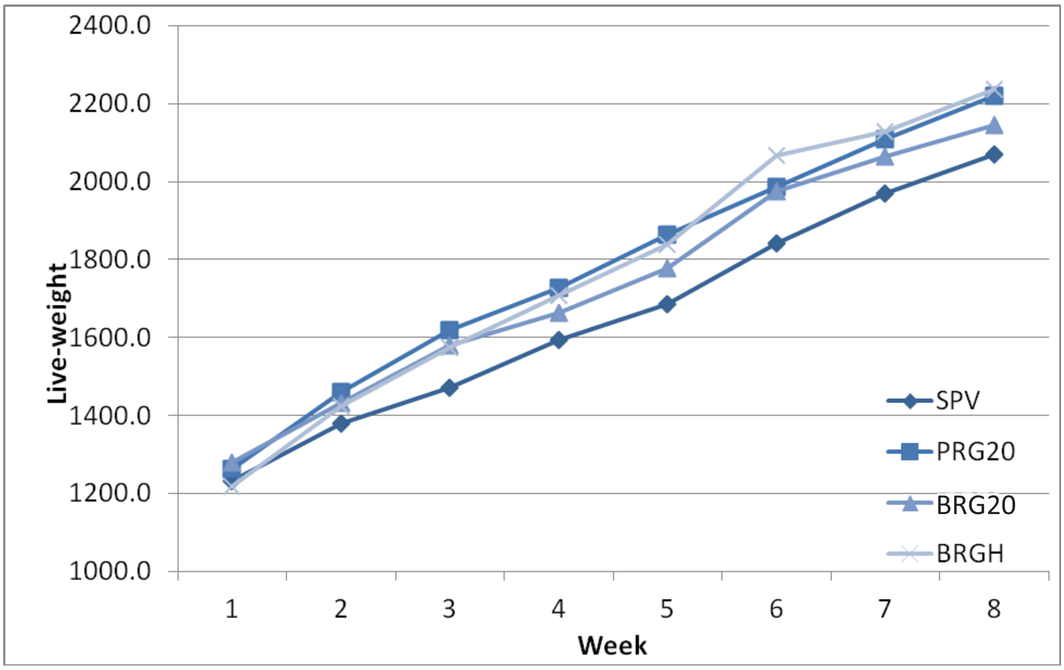


Figure 1. Live-weight gain within eight weeks

Table 6. Current feedstuff prices

Feedstuff	Biomass	Dry matter
Paddy rice	7.500 VND/kg	8.289.125 VND/kg
Broken rice	12.000 VND/kg	13.614.7 VND/kg
Rice husk	500 VND/kg	554.51 VND/kg
Sweat potato vines	2.000 VND/kg	17.196.9 VND/kg

The mean block 2,3,4 – block 1 differences for the weight gain, grain

Variable	Block 1 (SPV)	Block 2 (PRG20)	Block 3 (BRG20)	Block 4 (BRGH)
Weight gain (g)	0	+ 2.67	+ 3.36	+ 4.07
Grain DMI (g)	0	+ 18.1	+ 17.61	+ 17.71
Forage DMI (g)	0	- 7.65	- 6.98	- 7.37

Variable	Block 1 (SPV)	Block 2 (PRG20)	Block 3 (BRG20)	Block 4 (BRGH)
Increased profits (VND) (weight gain)	0	186.9	235.2	284.9
Reduced cost (VND) (forage intake decline)	0	131.4	120.0	126.6
Increased cost (VND) (grain supplementation)	0	150.0	240.0	194.0
Decreased profits (VND)	0	0.0	0.0	0.0
Differences (I + II – III – IV) (VND/head/day)	0	168.3	115.2	217.6

CONCLUSION

Total DMI among experimental groups and control group are not significantly different. Supplementation of paddy rice, broken rice and rice husk reduced forage intake. Effect of supplementation on weight gain was not found significant. Grain supplement to forage-based diet had a significantly economic effect.

ACKNOWLEDGEMENT

We are very grateful to the Swedish International Development Cooperation Agency, Department for Research Cooperation (Sida-SAREC) through the regional MEKARN Project, for the financial support of this study.

REFERENCES

Hongthong Phimmasan, Siton Kongvongxay, Chay Ty, Preston TR. 2004. Water spinach (*Ipomoea aquatica*) and Stylo 184 (*Stylosanthes guianensis* CIAT 184) as basal diets for growing rabbits. Livestock Research for Rural Development. Volume 16, Article # 34. Retrieved from: http://www.lrrd.org/lrrd16/5/hong16034.htm.

Khuc Thi Hue, Preston TR. 2006. Effect of different sources of supplementary fibre on growth of rabbits fed a basal diet of fresh water spinach (*Ipomoea aquatica*). Livestock Research for Rural Development. Volume 18, Article #58. Retrieved June 8, 2008, from http://www.lrrd.org/lrrd18/4/hue18058.htm.

Ly Thi Luyen. 2003. Effect of the urea level on biomass production of water spinach (*Ipomoea aquatica*) grown in soil and in water; Retrieved, from MEKARN Mini-projects. http://www.mekarn.org/msc2003-05/miniprojects/webpage/luyen.htm.

Nguyen Huu Tam, Vo Thanh Tuan, Vo Lam, Bui Phan Thu Hang, Preston TR. 2008. Effects on growth of rabbits of supplementing a basal diet of water spinach (*Ipomoea aquatica*) with vegetable wastes and paddy rice. Livestock Research for Rural Development. Volume 21, Article # 174. Retrieved, from http://www.lrrd.org/lrrd21/10/hang21174.htm.

Nguyen Kien Cuong, Duong Nguyen Khang, Preston TR. 2008. Digestibility and growth in rabbits fed a basal diet of sweet potato vines replaced with cassava foliage meal. In: Preston TR, Nguyen Van Thu, editors. Organic rabbit production from forages. Proceedings MEKARN Rabbit Conference. Cantho University, Vietnam, 25-27 November 2008. http://www.mekarn.org/prorab/cuong.htm.

Nguyen Quang Suc, Dinh Van Binh, Preston TR. 1996. Effect of housing systems (cages vesus underground shelter) on performance of rabbits. Livest Res Rural Develop. Volume. 8 (4): http://www.lrrd.org/lrrd8/4/suc84.htm.

Nguyen Thi Duong Huyen, Nguyen Xuan Trach, Preston TR. 2010. Effects of graded levels of paddy rice supplemented to water spinach (*Ipomoea aquatica*) or sweet potato (*Ipomoea batatas*) vines as basal diets on feed utilization and growth performance of New Zealand White rabbits http://www.mekarn.org/workshops/pakse/abstracts/Huyen_hua.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu, Ogle RB, Preston TR. 2006b. Effect of supplementation level of water spinach (*Ipomoea aquatica*) leaves in diets based on Para grass (*Brachiaria mutica*) on intake, nutrient utilization, growth rate and economic returns of crossbred rabbits in the Mekong Delta of Vietnam. In: Proceedings of the MEKARN workshop on forages for pigs and rabbits. Phnom Penh, 22-24 August 2006. Phnom Penh (Cambodia): MEKARN.

Nguyen Thi Kim Dong, Nguyen Van Thu, Preston TR. 2006a. Effect of dietary protein supply on the reproductive performance of crossbred rabbits. In: Proceedings of the MEKARN Workshop on Forages for Pigs and Rabbits. Phnom Penh, 22-24 August 2006. Phnom Penh (Cambodia): MEKARN.

Pok Samkol, Preston TR, Leng RA. 2006b. Effect of offering leaves or stems of water spinach on patterns of eating, consumption of caecotropes and excretion of feces by growing rabbits. In: Proceedings of the MEKARN workshop on forages for pigs and rabbits. Phnom Penh, 22-24 August 2006. Phnom Penh (Cambodia): MEKARN.

Pok Samkol, Preston TR, Ly J 2006a. Effect of increasing offer level of water spinach (*Ipomoea aquatica*) on intake, growth and digestibility coefficients of rabbits. Livest Res Rural Develop. Volume 18, Article #25. Retrieved March 7, 2006, from http://www.lrrd.org/lrrd18/2/samk18025.htm.

Pok Samkol, Preston TR, Ly J. 2006. Digestibility indices and N balance in growing rabbits fed a basal diet of water spinach (*Ipomoea aquatica*) supplemented with broken rice. Livest Res Rural Developt. Volume 18, Article # 22. Retrieved June 8, 108, from http://www.lrrd.org/lrrd18/02/samk18022.htm.

Thi Giang D, Thi Hue K, Van Binh D, Thi Mui N. 2006. Effect of Guinea grass on feed intake, digestibility and growth performance of rabbits fed a molasses block and either water spinach (*Ipomoea aquatica*) or sweet potato (*Ipomoea batatas* L) vines. In: Workshop Seminar Forages for Pigs and Rabbits. Phnom Penh, 22-24 August 2006. Phnom Penh (Cambodia): MEKARN-CelAgrid.

Effects of Different Supplement of Catfish (*Pangasius hypophthalmus*) Oil in Para Grass Basal Diets on Feed Utilization, Nutrient Digestibility, Growth Rate and Meat Production of Crossbred Rabbits

Nguyen Thị Kim Dong

Faculty of Agriculture & Applied Biology, Cantho University, Vietnam
Campus II, 3/2 street, Ninh Kieu district, Can Tho city, Viet Nam
Corresponding e-mail: ntkdong@ctu.edu.vn

ABSTRACT

An experiment was carried out in the experimental farm and laboratory of Can Tho University to evaluate feed utilization, nutrient digestibility, growth performance of Crossbred rabbits supplemented by catfish oil. It was a completely randomized design with 5 treatments that were 5 supplement levels of 0, 5, 7, 9, and 11 g catfish oil per rabbit per day, three replications and 4 rabbits (balanced sex) per experimental unit. The results show that the intakes of DM, CP and NDF were similar among the treatments (P>0.05), however the EE and ME intakes significantly increased when increasing supplement levels of catfish oil in the diets and the highest values in the CFO9 and CFO11 treatments (P<0.05).The digestibility coefficients of DM, OM, CP and NDF were similar among the treatments (P>0.05), except for the EE digestibility that was clearly improved when supplementing catfish oil in the diets and the significantly highest (91.9%) (P<0.05) was found in the CFO9 treatment. The daily weight gain and final live weight were significantly higher for rabbits supplemented 9g CFO per animal per day (P<0.05). The significantly higher weight of carcasses, thigh meat and lean meat were for the rabbits given 9g CFO per day (P<0.05). It was concluded the Crossbred rabbits supplemented CFO in the diets enhanced the EE and ME intakes, and at level of 9g CFO per animal per day had better growth performance and gave higher benefit.

Key Words: Crossbred Rabbit, Catfish Oil, Nutrient Digestibility, Growth Performance

INTRODUCTION

Rabbit meat has been also considered as good meat for high protein of 21.3%, low fat content of 6.80% and low cholesterol of 45mg/kg (Owen 1992). In the Mekong delta of Vietnam, local and crossbred rabbits have been more popular due to high resistance to diseases, their feeding mainly based on natural grasses and agro-industrial by products (Dong & Thu 2009) so the cost for rabbit production is lower than the other animal species ones. Within these feeding strategies, green forages are used as the main protein and fiber sources, while for the improved performance of growing and reproductive rabbits, sources of energy feed supplementation are very important (Leng 2008).

In particular determining the optimal level of energy-supplied for growing rabbits makes the better rabbit production and gives the income for the rabbit keepers (Ren et al. 2003). In the Mekong delta, there is a large water surface area of the Tien and Hau rivers which are suitable for catfish cultivation. A number of large factories produce frozen white cobbler filet for export, and as a result there are large quantities of by-products available, the belly is pressed to give raw fish oil, which mainly consists of the fatty acids and has an energy content of 37.6 MJ/kg (Men 2003). Catfish oil has high nutrient value, due to primarily to its long-chain, polyunsaturated, omega-3 fatty acids that are valuable energy feed sources for livestock, especially fattening rabbits. Therefore the aim of this study was to determine optimum level of catfish oil supplement to para grass basal diets on growth performance of crossbred rabbits.

MATERIALS AND METHODS

Animals and experimental design

The study was carried out at the experimental farm in Cantho city from January in 2012 to May in 2012. Sixty crossbred rabbits (local × improved breeds) at 6 weeks of age with average initial weight from 457-491g, were arranged in a completely randomized design of a feeding trial with 5 treatments and 3 replications. Four rabbits with balance of sex were in a experimental unit. The treatments were catfish oil (CFO) supplementation to the para grass (PG) basal diet at levels of 0 (CFO0), 5 (CFO5), 7 (CFO7), 9 (CFO9) and 11g (CFO11) catfish oil/ day/one. Soya waste was offered at the level of 200g/day/animal and coconut cake was fed with the amount of 10g/day/animal for all experimental units. The feeding experimental period lasted 9 weeks.

In the digestibility trial, the experimental design was similar to that of the feeding trial, however, the 9-weeks old 30 rabbits with live weight around 1100g were used. The animals had two week for adaptation and another week for getting samples according to by fecal collection for 6 days. Feeds and refusals were daily measured. Urine was also collected for nitrogen analysis to calculate the nitrogen retention. DM, CP, EE, and NDF digestibility were employed according McDonald et al. (2002).

Feeds, feeding and management

Para grass was daily collected in the areas surrounding animal farm and soya waste was bought daily from soybean milk factory in the city. Catfish oil was bought in an occasion from catfish proccesing factory for using throughout the trials. The animals were fed three times a day at 7:30h, 14:00h and 18:00h. Fresh water was available for all rabbits almost all day and night time. The refusals and spillage were collected and weighed daily in the morning to calculate the feed intake. The animals were vaccinated to prevent some diseases, especially rabbit hemorrhagic and parasite diseases.

Measurements

The measurement taken were feed and nutrient intakes of dry matter (DM), organic matter (OM), ash, neutral detergent fiber (NDF), daily weight gain, feed conversion ratio, carcass values, economic returns, nutrient digestibility and nitrogen retention (McDonald et al. 2002).

The feeds and refusals were taken for analyses of DM, OM, CP, EE, CF, NDF and Ash following procedure of AOAC (1990) and Van Soest et al. (1991).

Statistical analysis

The data were analyzed using the General Linear Model (GLM) option in the ANOVA program of the Minitab (Version 16) software (Minitab 2010). The comparison of significant difference between two treatments was done by Tukey method of Minitab program (2010).

RESULTS AND DISCUSSION

Exp 1. Feeding trial

Feed characteristics

Feed chemical composition was shown in Table 1.

Table 1. Chemical composition of feed ingredients (%) in experiment

Feed	DM	OM	CP	EE	NDF	Ash	ME MJ/kg
Para grass	18.00	89.50	11.60	4.70	69.50	10.50	9.45
Catfish oil	94.00	99.50	-	99.00	-	0.50	27.80
Water spinach leaves	13.30	89.40	27.50	7.64	35.20	10.60	12.00
Soya waste	10.00	94.70	20.20	10.20	39.60	5.30	11.00
Coconut cake	89.40	95.70	19.60	8.18	62.20	4.28	11.00

DM: dry matter; OM: organic matter; CP: crude protein; EE: Ether extract; NDF: neutral detergent fiber; ME: metabolisable energy (Maertens et al. 2002)

Para grass (PG) was low in CP, but high in NDF and used for providing fiber component in the diets. Soya waste (SW) and coconut cake had high CP contents that were used as protein supplemental source in diets. Metabolizable energy of catfish oil (CFO) was higher than those of the other feeds and used for energy supplementation in the dietary treatments. The results of DM and CP of PG in this study are consistent with those indicated by Dong & Thu (2012a). The catfish oil used in a current study had similar ME content with the value stated by Thoai (2012).

Feed and nutrient intakes

The catfish oil (CFO) intake significantly increased from the CFO5 to CFO11 ($P<0.001$), and the highest values in the CFO9 CFO11 treatments. The total DM and CP intakes were similar among the treatments ($P>0.05$), while the EE and ME intakes linearly increased when rising levels of catfish oil supplement in the diets ($P<0.05$) (Table 2). The DM intake in a current trial was in a range of 56.8 to 61.8 g /day, stated by Nguyen Thi Kim Dong & Nguyen Van Thu (2012). The results are consisted with findings of a study in which the ME intake linearly increased with increasing graded levels of fresh sweet potato tuber supplement Dong & Thu (2013), but being higher than those (0.50-0.61ME MJ/rabbit/day) in a previous study of rabbits fed water hyacinth raplacing para grass in the diets (Nguyen Thu & Dong 2010).

Daily gain (DG), feed conversion ratio (FCR) and economic returns

Table 3 showed that the daily weight gain (DWG) and final live weight (FLW) of rabbits were improved when supplementing CFO in the diets, and the CFO9 treatment had the higher values (22.6 and 2079 g, respectively) ($P<0.05$). The results of DWG were consisted with those stated by Thanh (2011) in previous study on growing rabbits provided dried sweet potato and coconut cake (DWG being from 18,3-21,7 g/day and Dong & Thu (2012a) in study of rabbits fed different ratios of *Centrocenma* and para grass (18.4-21.2g). The feed conversion ratio ranged in 2.78-2.96 among the treatments ($P>0.05$), being similar to the values of 2.96-3.09 reported by Dong and Thu (2012a). The economic returns were similar to the pattern of the final live weight, with the highest profit for the animals supplemented 9 g CFO per day in the CFO9 treament. There were the linear relationship between EE and ME intakes and daily weight gain with $R^2 = 0.75$ and $R^2 = 0.78$, that were presented in following Figure 1.

Table 2. Daily intakes of feeds (gDM/animal) and nutrients (g/animal) of rabbits in the feeding trial

Item	Treatment					SE/P
	CFO0	CFO5	CFO7	CFO9	CFO11	
Para grass (DM)	22.600	20.300	20.100	20.600	19.800	0.720/1.000
Catfish oil (DM)	-	3.920^{a}	5.170^{b}	6.690^{c}	7.260^{c}	0.260/0.001
Total DM	57.500	60.400	61.100	62.700	61.500	2.670/0.720
OM	52.600	55.500	56.300	57.900	56.800	2.420/0.630
CP	11.000	10.800	10.700	10.700	10.400	0.420/0.910
EE	4.140^{a}	7.920^{b}	9.120^{bc}	10.600^{cd}	11.000^{d}	0.370/0.001
Ash	4.890	4.840	4.820	4.840	4.720	0.560/0.990
NDF	30.300	29.700	29.500	29.600	28.700	1.470/0.960
ME (MJ/animal)	0.620^{a}	0.717^{ab}	0.747^{ab}	0.787^{b}	0.787^{b}	0.030/0.020

CFO0: basal diet; CFO5; CFO7; CFO9; and CFO11: CFO supplementation at levels of 0.5, 7.9, and 11g, respectively. Means with different letters within the same rows are significantly different at the 5% level

Table 3. Daily gain (DG), feed conversion ratio (FCR) and economic returns of growing rabbits

Item	Treatment					SE/P
	CFO0	CFO5	CFO7	CFO9	CFO11	
Initial weight (g)	457.000	472.000	491.000	496.000	474.000	15.82/0.443
Final live weight (g)	1,829.000^{a}	1,913.000^{ab}	1,986.000^{ab}	2,079.000^{b}	1,958.000^{ab}	48.42/0.045
Daily weight gain (g)	19.600^{a}	20.570^{ab}	21.330^{ab}	22.600^{b}	21.230^{ab}	0.56/0.038
FCR	2.960	2.940	2.870	2.780	2.900	0.19/0.966
Feed cost (VND)	12.664	17.744	20.522	22.412	24.724	
Total cost (VND)	74.664	79.744	82.522	84.412	86.724	
Total income (VND)	118.885	124.345	129.133	135.135	127.292	
Profit (VND)	44.221	44.601	46.611	50.723	40.568	

Means with different letters within the same rows are significantly different at the 5% level

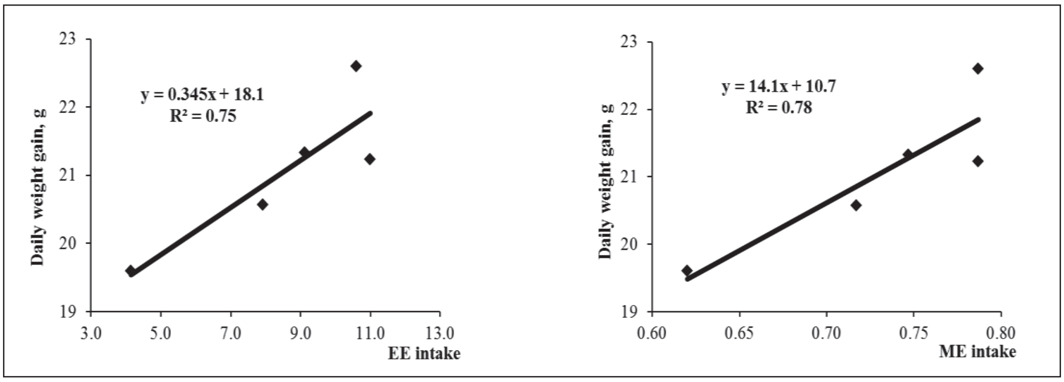


Figure 1. Effect of EE and ME intakes on DWG of rabbits

Mean values of slaughter weights and carcass traits of growing rabbits

The results of carcass, lean meat and thigh meat weights were significantly higher ($P<0.05$) for the animals offered 9g CFO per day (CFO9) (Table 4). The results in our study are in agreement with those in a trial of Crossbred rabbits supplemented dried cassava chips in diets that the carcass weight (852-1143g), lean meat weight (630-881g), thigh weight (242-333g) of growing rabbits supplemented dry cassava chips (Dong & Thu 2012b). The percentage of carcasses in our study are slightly higher than the findings of 43.5 to 48.5% reported by Elamin et al. (2012). The contents of crude protein and ether extract of rabbit meat in the present experiment were from 19.9 to 20.5% and from 4.17 to 4.51%, respectively. These values could be compared to 21% and 8%, respectively, found by Lebas et al. (1986). The differences could be caused by different breeds and nutrition.

Exp 2. Digestibility trial

The results of the digestibility trial were shown in table 5 and 6. The intakes of DM and CP, EE and ME in this digestibility trial had the same tendency with the feeding one. The results of DM intake were higher, but lower CP intake than the report of (Hiep & Man 2008) in which rabbits fed guinea grass basal diets with Kudzu leaves replacing soybean residues (17.8-20.5 g CP/rabbit/day).

Daily intakes of feeds and nutrients of rabbits in the digestibility trial

Apparent nutrient digestibility (%) and nitrogen retention (g/kg $W^{0.75}$) of rabbits were showed in Table 6. The digestibility of DM, OM, CP and NDF tended increase with supplementing CFO in the diets (P>0.05), however EE digestibility was significantly higher for the rabbits provided 9 g CFO per day (CFO9) (P<0.05). The results indicate that supplementation energy feed from CFO in the diets could improve nutrient digestibility resulting in better growth performance of rabbits. The digestibility values of DM and OM in present study are in agreement with, but CP and NDF values are higher than the findings in the trial of rabbits fed different ratios of *Centrocema pubescens* and Para grass in basal diet (DMD: 66.6-72.7%, OMD: 66.7-72.9%, CPD: 81.2-84.6% and NDFD: 48.4-55.4%, respectively) (Dong & Thu (2012a). However, the results of some nutrient digestibility were higher than reports by Cuong et al. (2008) 57.8-81.0% CPD and 33.1-78.8% NDFD, respectively). The results of CP apparent digestibility in the present experiment was better than the data found (74.9-77.9%), reported by El-Tahan (2012).

Nitrogen intake and nitrogen retention were closed (P>0.05) among the dietary treatments. It seemed to be graded supplement levels of CFO in the diets being not influence nitrogen retention.

Table 4. Mean values of slaughter weights, carcass traits and meat quality of rabbits

Item	Treatment					SE/P
	CFO0	CFO5	CFO7	CFO9	CFO11	
Live weight (g)	1,845.00^{a}	1,918.00^{a}	2,005.00^{ab}	2,115.00^{b}	1,987.00^{ab}	40.8/0.004
Carcass weight (g)	937.00^{a}	991.00^{a}	1,039.00^{ab}	1,106.00^{b}	1,046.00^{ab}	27.6/0.015
Carcass (%)	50.80	51.70	51.80	52.30	51.10	0.77/0.671
Lean meat weight (g)	703.00^{a}	753.00	794.00^{ab}	853.00^{b}	800.00^{ab}	23.1/0.010
% Lean meat	75.00	76.00	76.40	77.10	76.40	0.66/0.332
Thigh meat weight (g)	277.00^{a}	301.00^{b}	314.00^{b}	353.00^{c}	325.00^{bc}	6.16/0.001
% Thigh meat	29.70	30.40	30.30	32.00	31.10	0.96/0.501
Stomach W/Live W	5.60	5.83	5.65	5.59	5.90	0.18/0.655
Caecum length (cm)	60.70	59.80	58.20	60.90	60.20	0.87/0.267
Caecum weight (g)	146.00	139.00	146.00	149.00	147.00	5.35/0.480
Nutrient composition (%) of rabbit meat (fresh matter)						
Dry matter	26.60	25.90	26.10	26.20	26.60	0.25/0.252
Organic matter	97.80	97.30	98.00	97.60	97.80	0.54/0.913
Crude protein	19.90	20.20	20.50	20.10	20.00	0.40/0.845
Ether extract	4.17	4.23	4.44	4.41	4.51	0.11/0.224

Means with different letters within the same rows are significantly different at the 5% level

Table 5. Daily intakes of feeds (gDM/animal) and nutrients (g/animal) of rabbits in digestibility experiment

Item	Treatment					SE/P
	CFO0	CFO5	CFO7	CFO9	CFO11	
DM	52.30	53.90	54.50	57.00	55.00	2.16/0.66
OM	48.30	50.10	50.70	53.10	51.00	2.02/0.59
CP	10.30	9.80	9.60	9.83	9.13	0.54/0.68
EE	3.83^{a}	8.87^{ab}	10.10^{ab}	12.30^{b}	11.60^{b}	1.53/0.02
Ash	4.03	3.77	3.83	3.83	3.93	0.15/0.75
NDF	24.10	22.40	22.60	22.90	22.90	0.85/0.66
ME (MJ/rabbit)	0.64	0.76	0.79	0.85	0.82	0.10/0.62

Table 6. Apparent nutrient digestibility (%) and nitrogen retention (g/kg $W^{0.75}$) of rabbits

Item	Treatment					SE/P
	CFO0	CFO5	CFO7	CFO9	CFO11	
Apparent nutrient digestibility (%)						
DMD	69.80	70.70	72.80	73.80	72.30	1.45/0.36
OMD	69.90	70.90	72.90	73.90	72.40	1.45/0.36
CPD	81.20	82.40	83.90	84.60	84.30	0.90/0.11
EED	85.60^{a}	88.20^{ab}	90.20^{bc}	91.90^{c}	88.40^{ab}	0.66/0.001
NDFD	57.60	58.30	63.10	65.70	65.70	4.19/0.51
Nitrogen balance (g/kgW0.75)						
N intake	1.38	1.29	1.30	1.28	1.25	0.05/0.50
N retention	0.88	0.91	0.93	0.96	0.95	0.08/0.95

Means with different letters within the same rows are significantly different at the 5% level

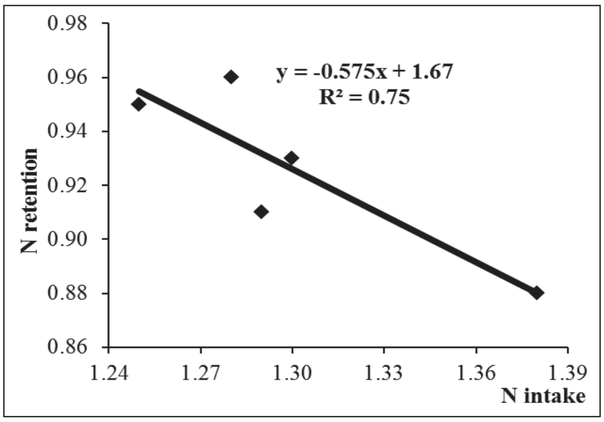


Figure 2. Relationship between N intake and N retention of growing rabbits

CONCLUSION

The conclusion was that catfish oil could be supplemented growing rabbits to improve nutrient intake and digestibility. The supplementation of catfish oil at level of 9 g/rabbit/day to para grass basal diet gave the highest daily weight gain, carcass performance and better profits.

REFERENCES

AOAC. 1990. Official methods of analysis (15th edition), Washington, DC, Volume 1:69-90.

Elamin KLE, Elkhairey MA, Bakhiet AO, Ahmed HB, Musu AM. 2012. Carcass and non-corcass traits of local rabbits fed different sources of fodder in Sudan. Asian J Anim Vet Adv. 7:341–345.

El-Tahan HM, Amber KH, Morsy WA. 2012. Effect of dietary starch levels on performance and digestibility of growing rabbit. In: Proceedings 10th world rabbit congress. Sharm El-Seikh, September 3-6, 2012. Sharm El-Seikh (Egypt): World Rabbit Science Association. p. 501-505.

Lebas F, Coudert P, Rouvier R, de Rochambeau H. 1986. Rabbit Husbandry, Health and Production. FAO Animal Production and Health Series No. 21. Rome (Italy): FAO.

Leng RA. 2008. Digestion in the rabbit a new look at the effects of their feeding strategies. In: International Workshop "Organic Rabbit Production from Forages", 25-27 November, 2008, Cantho University, Cantho City, Vietnam. Renlp_mod.pdf.

Maertens L, Peter JM, Villamide M, Cervera C, Gidenne T, Xiccato G. 2002. Nutritive value of raw materials for rabbit. World Rabbit Sci. 10:157-166.

McDonald P, Edwards RA, Greehalgh JFD, Morgan CA. 2002. Digestibility evaluation of foods. Animal Nutrition 6th Edition. New York (USA): Longman Scientific and Technical. p. 245-255.

Men LT. 2003. Utilization of catfish oil in diets based on dried cassava root waste for crossbred fattening pigs in the Mekong delta of Vietnam. Livest Res Rural Dev. 15:4.

Minitab. 2010. Minitab reference manual release 16.1.0. Minitab Inc.

Nguyen Kien Cuong, Duong Nguyen Khang, TR Preston 2008 Digestibility and growth in rabbits fed a basal diet of sweet potato vines replaced with cassava foliage meal. In: TR Preston, Nguyen Van Thu, editors. Proceedings MEKARN Rabbit Conference: Organic rabbit production from forages. Cantho University, Vietnam, 25-27 November 2008 http://www.mekarn.org/prorab/cuong.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2012a. Effect of mixed or separate feedings and ration of *Centrocema pubescens* and paragrass on feed utilization, nutrient digestibility and growth performance of crossbred rabbits. In: MEKARN Proceedings. Da Lat, Vietnam. August 12, 2012. http://mekarn.org/workshops/dalat2012/html/kimdong.ctu3.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2012b. Effects of dried chip casava supplementation in diets of crossbred rabbits intake and digestibility, meat production and economic return. J Anim Sci Technol. 36:77.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2009. The use of agro-industrial by productsfor raising crossbred rabbits in the Mekong delta of Vietnam. Conference on Asian Rabbit Production Development. Changchun, China, September 10-11 2009. p. 156.

Hiep NV, Man NV. 2008. Utilization of tropical kudzu leaves (*Pueraria phaseoloides*) as protein source for growing rabbits. In: International Workshop “Organic Rabbit Production from Forages”. 25-27 November 2008, Cantho University, Cantho City, Vietnam.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2009. A study of water hyacinth as a feed resource for feeding growing rabbits. In: Proceeding of International Workshop Livestock, Climate Change and the Environment. MEKARN Project. An giang University 11-2009. VIETNAM. http://www.mekarn.org/workshops/environ/proenv/.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2010. Study of water hyacinth (Eichhornia crassipes) as a feed resource for feeding growing rabbits. Mekarn Workshop “Livestock, Climate Change and the Environment”. 16-18 November 2009, An Giang University, Long Xuyen City, Vietnam.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2013. A respond of energy intakes, growth rate and carcass values of Crossbred rabbits to the supplementation of sweet potato tuber in the Mekong Delta of Vietnam. Paper presented at the 2nd International Conference on Rabbit production in Indonesia and Third Conference of Asian Rabbit Production Association. August 27-29, 2013. Bali (Indonesia): Asian Rabbit Production Association.

Owen JB.1992. Genetic aspects of appetite and food choice. Anim J Agric Sci. 119:151-155.

Thoai PTH. 2012. Effect of catfish oil supplement in diets on reproductive performance of Californian rabbits does. [Thesis]. [Cantho (Vietnam)]: Agricultural Sciences Animal Science, Cantho University.

Ren KL. Li YP, Ren JL, He DC, Liang QZ. 2003. Study of dietary energy and protein levels for reproducing Rex rabbits. In: Proceedings of the 8th World Rabbit Congress http://www.dcam.upv.es/8wrc/docs/Feeding%20and% 20Nutrition/Short%20Papers/959-963.

Thanh TM. 2011. Effect of different coconut meal supplements on growth performance and nutrient digestibility of Californian rabbits [Thesis]. [Cantho (Vietnam)]: Faculty of Agriculture and Applied Biology, Cantho University.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle: methods for dietary fiber, and nonstarch polysaccharides in relation to animal nutrition. J Dairy Sci. 74: 585-3597.

Feeding Strategies of Green Forages Associated with Local Supplement Resources Increasing Income for Rabbit Producers and Benefits for Environment in Rural Areas in Vietnam

Nguyen Van Thu

Faculty of Agriculture and Applied Biology, Can Tho University, Vietnam
Campus II, 3/2 street, Ninh Kieu district, Can Tho city, Viet Nam
Corresponding e-mail: nvthu@ctu.edu.vn

ABSTRACT

In many countries the rabbit production industries are mainly relied on the pellets produced by the feed companies which result in the high cost, while in the villages the small holder farmers economically raise rabbits for incomes and home consumption by the utilization of local green forages and diversified supplementation. The sustainability of animal production in tropical developing countries becomes more important in the 21st century due to limitation of grains and other supplements caused by the increase of human population, biofuel production and climate changes. Rabbit production could be considered as the animal meat source which has a good contribution to the protein consumption in the world because of its quick reproductivity, forage feeding, low capital input and green house gas emission. Particularly, in the rural poor areas of the tropical developing countries where green forages and local protein and energy supplements are available in organic farming systems, in which the peasants could easily collect or produce them with low cost. In this paper the author present and discuss the research results and experiences on rabbits fed green forages and local supplement resources which have been produced under Vietnam's conditions over ten years. The effects of feeding natural forages including grasses and legumes and supplementing tubers, stalks and agro-industrial byproducts on nutrition, nutrient digestibility, growth and reproductive performance and economic return are stated. The roles of energy, fiber and protein intakes relating to rabbit productivity and economic returns are also mentioned as the main issues of the presentation. The objective of this paper is to introduce the rabbit feeding strategies which are benefited by producers and environment in the tropical developing countries.

Key Words: Global Crises, Starvation, Fossil Fuel Depletion, Greenhouse Gas, Livestock Production

INTRODUCTION

Rabbits are hindgut fermentors and have a relatively high maintenance energy requirement. They efficiently utilise fibrous feed by courtesy of their feeding and digestive strategies. They are highly selective when given forage, free choice and in quantity. Their digestive strategies include initial enzyme digestion in acidic followed by alkaline medium of the stomach and small intestines respectively, followed by fermentation of feed residues in the caecum large intestines (Leng 2008). The world is faced with a global triple crisis including food, energy and climate change, which are interrelated and interactive. There will be great changes to content with in the future in order to produce and deliver food to maintain the present world population. The implications for world food stocks and prices are enormous, potentially creating major cereal food/feed grain shortages as land is diverted to fuel production. The expectation is that world cereal grain availability for livestock will be highly restricted and the case is made for the forage-fed ruminant as a major source of animal protein for the future. Herbivores in general are likely to be used more extensively with time, particularly the rabbit with its dual capabilities of high reproduction rates and the capacity to utilize efficiently forage resources produced locally. The caecum of rabbit is relatively large and the products of fermentation are similar to the products produced in the rumen of cattle and sheep- that is volatile fatty acids (VFA) and microbial cells. A number of reasons are put forward for the microbial growth being highly efficient in the caecum of rabbits on forage-based diets yielding a higher ratio of cells to VFA than may occur in fermentation in the fore stomach of ruminants. Considerable VFA are apparently absorbed by the rabbit but the availability of the essential amino acids of microbial protein depends on the subsequent consumption of soft faeces or caecotropes, while lower methane production in non-ruminant animals reported by Crutzen et al. (1986) and Belenguer et al. (2008) confirmed that the detriment of methanogenesis, acetogenesis might be one of the major H_2 sinks in rabbit caecal environment unlike other fermentation compartments.

In Vietnam rabbit production has been developed very well in recent years and brought good jobs and income to the producers. In rabbit industries feeds used are mainly the pellets, which are high in price and not available in the rural areas. There the producers rely on the green forages available with the low cost for raising rabbits. By that way they could make their living from the existing farming systems in many tropical developing countries. Thus the development of the rabbit feeding systems based on available green forages could be useful for farmers. However to improve rabbit performance the well balanced-nutrient diets should be considered, particularly on the dietary protein, energy and fiber contents. Therefore this paper aims to introduce the possibilities of rabbit feeding strategies in Vietnam adapting to climate change and food and energy crisis with some alternatives, which are relevant for the existing resources of the tropical developing countries.

Food and energy crisis

Latest official current world population estimate, for mid-year 2011, is 7,021,836,029. The pressure of the world population is the main factor which has caused the crisis of food and energy crisis. At the present time due to the human population pressure and food production there are 925 million people that are underfed and/or on imbalanced diets lacking essential micro nutrients that are provided by animal protein (FAO 2010). There is a great demand of animal production development and products for the World. Water is the major resource required for agriculture, which has also been depleted. Optimistic estimations of peak production forecast the global decline will begin by 2020 or later, and assume major investments in alternatives will occur before a crisis, without requiring major changes in the lifestyle of heavily oil-consuming nations. These models show the price of oil at first escalating and then retreating as other types of fuel and energy sources are used. As oil reserves are depleted it is predictable that, just as with any other commodity, prices will rise with increasing scarcity.

Green house gas emissions and climate changes

Global warming has been caused by the greenhouse gases emissions. These gases occur naturally, such as water vapor, carbon dioxide, methane, nitrous oxide and ozone. Human activities also add significantly to the level of naturally occurring greenhouse gases: carbon dioxide is released into the atmosphere by the burning of solid waste, wood and wood products, and fossil fuels; Nitrous oxide emissions occur during various agricultural and industrial processes, and when solid waste or fossil fuels are burned. Methane is emitted when organic waste decomposes, whether in landfills or in connection with livestock farming *i.e.* enteric fermentation of livestock and animal wastes. Methane emissions also occur during the production and transport of fossil fuels. As the concentration of greenhouse gases grows, more heat is trapped in the atmosphere and less escapes back into space. This increase in trapped heat changes the climate and alters weather patterns, which may hasten species extinction, influence the length of seasons, cause coastal flooding, and lead to more frequent and severe storms. All these factors will have the negative effects to human activities, life and environment such as agricultural production, outbreaks, disasters, etc.

Climate change and sea level rise by green house gas emissions effect is now accepted as occurring and cannot be ignored in any discussion on future agriculture. Increasing sea levels will undoubtedly remove considerable areas of fertile delta and weather patterns will certainly change, leading to at times more intense drought and or flooding rains. The crop and animal production systems are changed adapting to the drought, flooding and saline water effects in number of areas in Vietnam, Bangladesh, *etc*.

Livestock production issues

It is suggested that we must now enter a stage in the world where grain-based animal production will become increasingly expensive as the competition for resources for food, feed and fuel, develops. The animal production industries based on herbivores may need to develop extensively for exploiting a wide range of byproducts of agriculture or from land not dedicated to food or biofuels production. In general intensive animal production systems produce high levels of nitrogen and phosphorus wastes and concentrated discharges of toxic materials. Yet those systems are often located in areas where effective waste management is more difficult. The regional distribution of intensive system is usually determined not by environmental concerns but by ease of access to input and product markets, and relative costs of land and labor. In developing countries, industrial units are often concentrated in peri-urban environments because of infrastructure constraints. It recommends reintegration of crop and livestock activities, which calls for policies that drive industrial and intensive livestock to rural areas with nutrient demand (FAO 2006). More than 1/3 of all the world's methane emissions is considered to be generated by gut bacteria in farm animals such as cattle, buffaloes, sheep and goats. Methane is a twenty times more powerful greenhouse gas than carbon dioxide - this caused researchers to look for ways to reduce this 900 billion ton annual release of methane (Innovative News 2009). Although much evidence has been amassed on the negative impacts of animal agricultural production on environmental integrity, community sustainability, public health and animal welfare, the global impacts of this sector have remained largely underestimated and underappreciated. In a recent review of the relevant data, Steinfeld et al. (2006) calculated the sector's contributions to global greenhouse gas (GHG) emissions and determined them to be so significant that measured in carbon dioxide equivalent the emissions from animal agricultural sector surpass those of the transportation sector.

In animal production of the tropical developing countries, the impact of climate change on the emergence and re-emergence of animal diseases has been confirmed by a majority of the World Organization for Animal Health (OIE) Member Countries and Territories in a worldwide study conducted by the OIE among all its national Delegates (Pigprogess 2009). Climate change is widening viral disease among farm animals, expanding the spread of some microbes that are also a known risk to humans (Physorg 2009). Vector borne diseases are especially susceptible to changing environmental conditions due to the impact of temperature, humidity and demographics of vectors. Climate change eliminates ecological barriers and constraints for pathogen transmission and timing of seasonal migration. Because information health systems are limited, changes in disease may have occurred but are not yet been detected. As better information systems are put in place capable of measuring change in disease patterns, vector distribution and environmental conditions, we may be surprised by the number of diseases directly or indirectly already affected by climate change. In Europe, more than 80,000 outbreaks of bluetongue were reported to the World Animal Health Organization between 1998 and 2010, and millions of animals died as a result of the disease. Bluetongue was previously restricted to Africa and Asia, but its emergence in Europe is thought to be linked to increased temperatures, which allows the insects that carry the virus to spread to new regions and transmit the virus more effectively. FAO (2011) reported that during the past decades there has been an unprecedented increase in high-impact transboundary animal diseases (TADs) at a global scale. These include food-and-mouth disease (FMD), porcine reproductive and respiratory syndrome (PRRS), highly pathogenic avian influenza (HPAI), etc. They cause the negative effects on productive, economic and social consequences in many countries such as Vietnam, China, Cambodia, Thailand, etc.

RABBIT PRODUCTION – AN OPPORTUNITY FOR BETTER INCOME AND ENVIRONMENT

Rabbits are herbivores and are classified as hindgut fermentors. In nature they are highly selective feeders and they can efficiently digest a wide range of simple and complex carbohydrates by curtsey of their digestive strategy. The rabbit has an efficient monogastric mode of digestion that is followed by fermentation of 'selected' cellulose feed and endogenous materials in the caecum through the action of a resident bacterial ecosystem comprised primarily of *Bacteroides* spp (Leng 2008). Rabbit raised is an important source of primary income in small farms in many tropical developing countries, once it can be conducted in reduced places, with a relatively short production cycle and a minimum financial investment, in comparison to other commercial species (Thu 2011). In Vietnam due to the bird flu outbreaks, rabbit meat production has been more developed recently in order to meet the meat demand of human population. Rabbit production is good for commercial farm income and also being a tool of the poor producers for erasing starvation and alleviating poverty. Crossbred rabbits (Local and improved pure breeds) are popularly raised in the Mekong delta because of a good adaptation to the local climate and feeds. In recent years the pure New Zealand, Californian and Hyla breeds have been raised by the green forages and local supplementation in the Mekong delta of Vietnam giving the proper meat and reproduction performance with income improvement for producers. Also, the organic rabbit farming based on locally available feeds resources, particularly natural grasses and legumes and wild vegetables have a very important role for production in villages.

Beside the natural grasses, the planted ones with higher biomass yields such as *Paspalum atratum*, *Penisetum purpureum, Brachiaria ruziziensis, Panicum maximum*, etc. are successfully fed to rabbits in Vietnam. Carbon sequestration is the capture and storage of CO_2 that would otherwise reach the atmosphere. DOSUS (2011) indicated that there are a variety of carbon sequestration options being investigated including terrestrial CO_2 sequestration. Terrestrial sequestration is the enhancement of CO_2 uptake by soils and plants, both on land and in freshwater. Early terrestrial efforts include tree-plantings, no-till farming, wetlands restoration, land management on grasslands and grazing lands. One hectare (2.47 acres) of tropical grass can capture as much as 60,000 kg (133,000 lbs) of CO_2 per year. So planting grass can be very beneficial in making the world a better place. Not only capturing CO_2, covering the tropical world with grass, provides a place for animals to eat, increase biodiversity, decreases temperature, controls erosions, protects and improves the quality of the soil (DOSUS 2011). Similarly, Holdridge (2011) stated that carbon sequestration in well-managed pastures has tremendous potential for fighting global warming. Each of us who practices grass farming could benefit financially from a well-designed carbon trading system. The United States and the world could benefit, as well. However we need a standard method of measuring organic matter and thus the carbon in the soil. Questions include the depth at which a soil sample should be taken and methods of chemical analysis used to test soil samples (Holdridge 2011).

RABBIT FEEDING STRATEGIES OF GREEN FORAGES AND SUPPLEMENTS

Availability of local green forages

Although there are many advantages of feeding pellet feed merely for rabbits such as limited amount fed, easy feeding, use of feeding automatic systems, more feed and nutrient intakes and higher performance, however the feed cost is high and in many cases they are not available in rural areas. Feeding green forages give more chances for the producers to utilize the locally available feed resources without payment and rabbits seem to prefer the fresh feeds. Thus the green forage feeding would generate more profits and environmental benefits based on the resources within the family and farming systems and these could also encourage the producers to utilize lands for growing more grasses and other plants. In tropical developing countries forages are unlimited resources, which can be used for feeding the herbivore species. Preston

& Murgueitio (1992) stated that the only sustainable alternative is to derive energy from renewable resources. In the tropics have an untapped potential, once it is accepted that solar-derived energy can be the basic for future development and the appropriate uses of biomass produced from this source for energy and food of human being and animals. In there green forages are always available, abundant and cheap in different seasons and eco-farming systems by nature or planting due to the unlimited photosynthesis for producing the biomass, while rabbit can be naturally fed the green forages in every condition. These sources can be also cultivated in the farmers' plots to provide diets with high contents of digestible energy and protein without the need for cash resources to buy off-farm supplemental feeds. Feed sources from forages, vegetables and aquatic plants (*e.g.* Cassava, Mulberry, Leucaena, Gliricidia, Sweet Potato vines, Water Spinach, and Stylo) can be used in diets to replace or in combination with a protein source from conventional feed ingredients (soybean and fish meals). Therefore, poor families with limited resources could benefit through increased income and increased consumption of rabbit meat to meet the families' nutritional needs (Samkol & Lukefahr 2008). It is clear that rabbit production based on green-forage feeding could be used as a tool for improving the social-economic and environmental benefits in developing countries.

Chemical Composition and Metabolizable Energy of Forages

In a study of nutritive values of forages as rabbit feed resources by using *in vitro* digestibility and gas production techniques Thu & Mo (2008) concluded that in the Mekong delta of Vietnam, there were wide ranges of forage nutrients for the rabbits due to the diversity of their eating behaviors, the *in vitro* digestibility and gas production techniques by inoculum from caecal fluid of rabbits had high potential to evaluate nutritive value of forages for rabbit. The values of *in vitro* organic matter digestibility by inoculum from caecal fluid of rabbits had the linear relationships to metabolizable energy and neutral detergent fiber content.

Table 1 showed that forages had a wide range of chemical composition, the NDF content ranged from 21.6 to 69.5%, CP content ranged from 9.50 to 28.9% and ME concentration ranged from 6.58 to 13.7 MJ/kgDM. The grasses were higher in NDF and CF content than the legumes and others. The NDF content of grasses (*Brachiaria multica, Paspalum atratum, Brachiaria ruziziensis, Pannicum maximum)* were of 67.1-69.5%, while legumes (*Mucana pruriens*) had 48.5-49.1% NDF and other plants had 21.6-45.3% NDF. The *in vitro* OMD values by caecal inoculum of forages were widely variable, ranged from 36.7 to 88.2% at 48 hours and from 41.8 to 91.4% at 96 hours. It seems that the high fiber fodders were lower in the *in vitro* OMD value (*Pannicum maximum, Paspalum atratum, Brachiaria ruziziensis* and *Brachiaria multica*) than those obtained by the low fiber fodders (*Impomoea quatica, Brassica oleracea, etc.*). The *in vitro* OMD 48h of grasses by caecal inoculum were of 36.7-49.7% while those were higher in legumes (69.4-70.6%) and other plants (72.3-89.0%). the gas production volume values (GPV) from digestion of forages by ceacal inoculum were widely variable, ranged from 60.2 to 230 ml/gOM at 24 hours, from 68.2 to 274 ml/gOM at 48 hours and 87.2 to 298 ml/gOM at 96 hours. These GPV were lower than those reported by Mo & Thu (2007) due to the effects of lower activity of caecal microorganisms in nutrient digestion comparing to ruminal microbes. El-Adawy et al. (2008) showed that the GPV 24hs of some forages in Egypt by caecal inoculum were ranged from 68 to 114 ml/gOM. Stanco *et al*. (2003) reported the GPV 96hs of rabbit feeds with 35.1-46.0% NDF and 18.5-20.7% CP by caecal inoculum was ranged from 185 to 221 ml/gOM.

Some problems of feeding rabbit by green forages are the high moisture content of greens and the wide-range variation of nutrient composition by seasons, ages, fertilization and cultivation and harvest techniques. Therefore it is necessary to adjust dry matter intake and the dietary components following the nutrient-changed forages for an adaptation to the nutrient requirements of rabbits.

Table 1. Chemical composition (%DM) of forages as rabbit feeds

Forages	DM	OM	CP	EE	CF	NDF	ME, MJ/kg DM
Brachiaria multica	18.50	89.90	9.50	3.70	25.70	67.10	8.23
Paspalum atratum	20.10	92.40	9.50	3.80	32.80	69.50	6.58
Brachiaria ruziziensis	19.60	89.70	9.90	4.10	29.50	67.50	7.44
Pannicum maximum	18.30	89.20	10.20	2.70	31.20	69.30	6.78
Mucana pruriens 1	17.80	88.10	20.90	7.10	27.60	48.50	9.13
Mucana pruriens 2	15.70	89.10	19.30	7.00	24.10	49.10	9.83
Operculina turpethum	11.90	87.90	15.50	6.50	21.20	38.80	10.20
Phyllanthus niruri	20.20	92.40	11.90	8.70	24.90	42.30	9.55
Wedilia trilobata	10.40	83.90	12.70	8.90	15.50	38.20	11.80
Brassica oleracea 1	7.60	84.50	14.80	5.30	15.30	21.60	11.30
Brassica oleracea 2	8.80	82.10	17.00	6.10	13.40	24.30	12.00
Impomoea quatica	10.90	86.90	28.90	8.30	11.30	25.90	13.70
Amaranthus caudatus	12.90	82.20	24.80	3.00	26.50	42.10	8.80
Ipomoea batatas	9.10	86.20	19.70	9.40	15.00	32.10	12.50
Commelina palidusa	9.80	84.90	16.60	5.50	18.80	45.30	10.60

DM: dry matter; OM: organic matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ME: metabolizable energy

Source: Thu & Mo (2008)

Green forages as a basal diet

Some examples of using the new green forages sources for rabbits such as water hyacinth (*Eichhornia crassipes*), *Wedelia trilobata, Operculina turpethum*, *etc*. as the basal diets are presented.

Water hyacinth

In an experiment of water hyacinth (*Eichhornia crassipes*) as a feed resource for feeding growing rabbits, Thu & Dong (2009a) concluded that water hyacinth could be used for feeding growing rabbits for improving nutrient digestibility and nitrogen retention. The replacement of water hyacinth from 40 to 60% (DM basis) to Para grass improved the feed utilization, growth performance and economic returns.

Table 2 shows that the daily weight gain of the WH0, WH20, WH40 and WH60 treatments was significantly higher than that of the WH80 and WH100 ($P<0.05$). The WH40 treatment gave highest value (19.6 g/day). The final live weights were also significantly different ($P<0.05$) among the treatments and corresponding with daily weight gain. The feed conversion ratio ranged between 3.63-4.37, and being better than that reported by Thu & (2008c). The economic returns were similar to the pattern of the daily weight gain, with the highest value of the WH40 treatment.

Apparent nutrient digestibility (%) and nitrogen retention (g/kg W0.75) of rabbits are shown in Table 3. There was no significant difference in the pattern of apparent digestibility of DM, OM, CP, except for NDF digestibility. The digestibility coefficient was higher in the diet included 60% of water hyacinth. The CP digestibility ranged in 58.8-70.1% that was lower than those reported by Dong et al. (2006) being from 82.0 to 84.5%. There was significant increase of NDF digestibility among the treatments ($P<0.05$). The higher values were found when rabbits were fed the diets contained 40% and 60% water hyacinth (45.7% and 49.9%, respectively) as compared to the remains. Nitrogen intake and nitrogen retention slightly increased with increasing water hyacinth level from 0 to 60%, while these values significantly decreased ($P<0.05$) when rising water hyacinth in the diets up to 80-100%.

Table 2. Daily weight gain (DWG), feed conversion ratio (FCR) and economic return of rabbit fed different levels of water hyacinth (Thu & Dong 2009a)

Item	Treatment						SEM/P
	WH0	WH20	WH40	WH60	WH80	WH100	
Initial live weight (g)	822.00	802.00	827.00	813.00	809	813	40.5/0.991
Final live weight (g)	2,012^{ab}	2,020^{ab}	2,059^{a}	2,011^{ab}	1,827^{bc}	1,695^{c}	73.9/0.005
DWG (g)	18.90^{a}	19.30^{a}	19.60^{a}	19.00^{a}	16.20^{c}	14.00^{c}	0.955/0.001
FCR	3.75^{ab}	3.68^{a}	3.63^{a}	3.76^{ab}	4.37^{b}	4.25^{ab}	0.196/0.009
Total cost (VND)	59,989	60,226	60,182	60,046	59,902	57,936	-
Total income (VND)	84,510	84,845	86,460	84,454	76,720	71,201	-
Economic return (VND)	24,521	24,620	26,279	24,409	16,819	13,265	-

WH: water hyacinth, WH0: basal diet, WH20, WH40, WH60, WH80 and WH100: WH replace Para grass at levels of 20,40,60,80 and 100% , respectively, of the amount of Para grass consumed in WH0. Means with different letters within the same rows are significantly different at the 5% level.

Table 3. Apparent nutrient digestibility (%) and nitrogen retention (g/kg $W^{0.75}$) of rabbits fed different levels of water hyacinth (Dong & Thu 2009a)

Variable	Treatment						SEM/P
	WH0	WH20	WH40	WH60	WH80	WH100	
Apparent nutrient digestibility(%)							
DM	54.8	56.8	57.9	65.9	61.7	59.8	4.74/0.292
OM	55.3	57.4	58.3	66.1	61.9	60.9	4.71/0.317
CP	64.6	66.6	67.7	70.1	61.5	58.8	4.73/0.246
NDF	40.8^{ab}	44.4^{ab}	45.7^{ab}	49.9^{a}	42.2^{ab}	40.0^{b}	3.63/0.044
Nitrogen balance (g/kg W0.75/day)							
Intake	1.32^{a}	1.32^{a}	1.40^{a}	1.40^{a}	1.27^{a}	1.09^{b}	0.043/0.001
Retention	0.82^{ab}	0.87^{ab}	0.91^{a}	0.95^{a}	0.75^{ab}	0.61^{b}	0.080/0.011

WH: water hyacinth, WH0: basal diet, WH20, WH40, WH60, WH80 and WH100: WH replace Para grass at levels of 20,40,60,80 and 100% , respectively, of the amount of Para grass consumed in WH0. Means with different letters within the same rows are significantly different at 5%

Wedelia trilobata

A study of using *Wedelia trilobata* in diets for growing crossbred rabbits including a feeding trial and digestibility has been conducted (Dong & Thu 2009a). Two experiments were designed in a completely randomized arrangement of 6 treatments in which Para grass was replaced by *Wedelia trilobata* (WT) at levels of 0, 20, 40, 60, 80 and 100% (DM) and 3 replications. Seventy two female rabbits were used for the study. The digestibility trial was done in the same rabbits at 15 weeks old. The results found that there was a remarkable improvement in feed DM intake, retention of nitrogen and energy, growth rate and profit of the WT diets with the highest values of WT80, but those criteria were decreased at the W100 diet (P<0.05). There was no effect of the replacement for Para grass by Wedelia on haematology of the rabbits (P>0.05). The recommendation was that the *Wedelia trilobata* should be used to replace from 60-80% Para grass in diets to enhance the economic returns.

Table 4. Feed and nutrient intake (gDM/day/rabbit) and daily weight gain of rabbit fed different levels of *Wedelia trilobata* to replace Para grass (Dong & Thu 2009a)

	WT0	WT20	WT40	WT60	WT80	WT100	SEM	P
DM	77.0^{a}	79.9^{a}	81.0^{a}	83.9^{a}	83.6^{a}	69.4^{b}	1.80	0.001
OM	68.3^{a}	69.7^{a}	69.7^{a}	71.7^{a}	71.3^{a}	58.6^{b}	1.51	0.001
CP	10.8^{a}	10.7^{a}	10.6^{a}	10.6^{a}	10.4^{a}	8.49^{b}	0.21	0.001
NDF	36.5^{a}	36.2^{a}	33.9^{a}	33.1^{ab}	31.3^{b}	20.1^{c}	1.20	0.001
ADF	20.3^{a}	20.5^{a}	20.0^{a}	20.4^{a}	19.9^{a}	14.7^{b}	0.65	0.001
Final weight (g/rabbit)	1,863^{a}	1,913^{ab}	1,987^{ab}	2,097^{b}	2,112^{b}	2,008^{ab}	44.0	0.010
Daily weight gain (g)	16.7^{a}	17.6^{ab}	18.6^{ab}	20.1^{b}	20.7^{b}	18.7^{ab}	0.684	0.013
FCR	4.61^{a}	4.55^{ab}	4.39^{ab}	4.19^{ab}	4.05^{ab}	3.71^{b}	0.177	0.030
Feed cost (VND/rabbit)	12,678	15,109	15,468	15,936	16,044	15,002		
Profit (VND/rabbit)	20,581	21,857	24,065	27,447	27,864	25,289		

WT0, WT20, WT40, WT60, WT80 and WT100: *Wedelia trilobata* replacing Para grass at the levels of 0, 20, 40, 60, 80, and 100%; DM: dry matter; OM: organic matter; CP: crude protein; EE: Ether extract; CF: crude fibber; NDF: neutral detergent fiber; ADF: acid detergent fibber; NFE: nitrogen free extract; FCR: feed conversion ratio, $^{a, b, c, d, e, f}$: values with different letters were statistically significant difference at 5%

The results (Table 4) showed that DM intake of rabbit increased gradually from WT0 to WT60, while at WT100 the DM intake was significantly reduced (P<0.05) compared to the others. CP intake was similar among the treatments except the lowest value of the W100 one. The NFE intake increased gradually, while the NDF and ADF were reduced with the increasing WT in the diets. Daily weight gain was significantly improved by the increase of WT in the diets with higher values of WT 60 and 80. As a result the profit was higher at the WT60 and WT80 diets. In the experiment of digestibility and nitrogen and energy retention, the nutrient digestibility values were significantly different among the treatments (P<0.001). DMD and OMD were the highest values at WT80 and the lowest one at WT0 diet. The CP digestibility of WT0, WT20, WT40, WT60 and WT80 diets was not significantly different among them but different significantly to WT100 (P<0.05).

The WT80 diet had the highest values of ME intake, ME retention and CP retention without significant difference to WT40 and WT60. Overall the results from the present study indicated that WT80 had the highest values of weight gain. Increasing of WT up to 80% in Para grass diet improved nutrients intake, growth performance and nutrient digestibility but these improvements was reduced at 100%WT diet. There was no effect of the replacement for Para grass by Wedelia on haematology of the rabbits (P>0.05) (Dong & Thu 2009a).

It was reported that a conclusion of the feeding trial of different *Wedelia trilobata* levels replacing Para grass for the does in three litters was that the *Wedelia trilobata* could be used a basal diet and at the level of 80 % replacing Para grass (DM basis) to improve reproductivity and economic returns (Chau & Dong 2010). The feed and nutrient intakes and reproductive performance of does in litter 3 were presented in Table 5 and 6.

Dietary association among green forages

In a study of effect of water spinach and sweet potato vine associated with 2 other natural plants, on growth performance and economic return of growing crossbred rabbits in the Mekong delta of Vietnam, Thu & Dong (2008a) indicated that local available green feeds such as water spinach, sweet potato vine, Mom grass (*Hymenachne acutigluma)* and Cuc (*Wedelia* spp.) could be used for feeding growing rabbits. Water spinach and sweet potato vine associated Mom grass or Cuc in the diet at the ratio of 1:1 would be economically fed and increase economic return.

Mom grass had the highest DM content (15.7%) compared to those of Cuc, water spinach and sweet potato vine (12.1, 9.63 and 8.56%, respectively) (Table 7). Crude protein content was higher for sweet potato vine and water spinach. The NDF content was high in Mom grass (66.3%), while that was similar in the others. The ADF content of Mom grass and Cuc was higher than those of sweet potato vine and water spinach. Paddy rice supplement had DM and CP content of 87.4 and 6.68%, respectively.

The DM intake (g/rabbit/day) was not significantly different (P>0.05) among different diets, however, the lower figures were for the WS and SP diets, due to the low DM content of the SP and WS. The OM and CP intakes were not significantly different among treatments, however, the CP intake of the WS and SP diets was numerically higher than the rest of diets (Table 8). The NDF intakes of the WS+M and SP+M diets were significantly higher than other because of higher NDF content of the Mom grass.

Table 5. Daily feed and nutrient intakes (g DM/doe) of does of litter 3 fed different levels of *Wedelia trilobata* to replace Para grass (Chau & Dong 2010)

	Treatment*						SEM	P
	WT0	WT20	WT40	WT60	WT80	WT100		
Wedelia trilobata	-	12.30^{a}	24.70^{b}	36.30^{c}	45.10^{d}	39.00^{d}	4.340	0.001
Para grass	59.00^{a}	54.00^{ab}	41.30^{b}	31.90^{b}	28.50^{b}	0.00^{c}	3.100	0.001
Concentrate	61.40	61.40	61.40	61.40	61.40	61.40	-	-
Total DM	120^{ab}	128^{ab}	127^{a}	130^{a}	135^{a}	100^{b}	4.340	0.006
CP	21.90^{a}	22.20^{a}	22.20^{a}	22.50^{a}	22.10^{a}	17.00^{b}	0.452	0.001
NDF	51.30^{a}	53.60^{a}	50.30^{a}	47.50^{a}	49.80^{a}	28.80^{b}	2.830	0.003
ME, MJ	1.30^{ac}	1.40^{abc}	1.43^{ab}	1.46^{ab}	1.54^{b}	1.25^{c}	0.043	0.005

*: WT0, WT20, WT40, WT60, WT80 and WT100: *Wedelia trilobata* replacing Para grass at the levels of 0, 20, 40, 60, 80 and 100%; DM: dry matter; OM: organic matter; CP: crude protein; EE: Ether extract; CF: crude fibber; NDF: neutral detergent fibber; ADF: acid detergent fibber; NFE: nitrogen free extract; FCR: feed conversion ration; $^{a, b, c, d, e, f}$: values with different letters in the same row were statistically significant difference at 5%

Table 6. The reproductivity of does of litter 3 fed different levels of *Wedelia trilobata* to replace Para grass (Chau & Dong 2010)

	Treatment*						SEM	P
	WT0	WT20	WT40	WT60	WT80	WT100		
Litter size at birth	7.00	6.33	6.33	6.00	7.00	5.33	0.782	0.664
Weight of litter at birth (g)	348	263	340	312	318	260	35.400	0.397
No. of alive rabbit at birth	7.00	6.00	6.33	6.00	7.00	5.33	0.805	0.670
No. of alive rabbit at weaning	7.00	6.00	6.33	5.33	7.00	5.33	0.782	0.497
Weight of kitten at weaning (g)	295	325	335	353	354	379	39.500	0.748
Milk production of litter (g/d)	76.70	72.20	83.80	87.40	83.40	76.10	5.910	0.474
Daily weight gain of kitten (g)	8.20	9.40	9.36	11.40	10.30	11.00	1.260	0.506
Feed cost (VND)	18,137	18,763	18,955	19,277	19,730	17,699	-	-
Income from kitten (VND)	245,000	210,000	221,667	186,667	262,500	186,667	-	-
Difference (VND)	226,863	191,237	202,712	167,390	242,770	168,968	-	-

Values with different letters in the same row were statistically significant difference at 5%

Table 7. Chemical composition (% DM) of feeds in Exp (Thu & Dong 2008a)

Raw feed	DM	OM	CP	NDF	ADF	Ash
Water spinach	9,63	89,10	18,10	37,20	25,00	10,90
Sweet potato vine	8,56	87,60	18,80	41,40	29,60	12,40
Mom grass (*H. acutigluma)*	15,70	90,70	12,40	66,30	36,90	9,32
Cuc (*Wedelia* spp.)	12,10	84,50	10,00	41,80	34,30	15,50
Paddy rice	87,40	93,60	6,68	29,10	15,80	6,37

Table 8. Average feed and nutrient intakes (g DM/rabbit/day) of rabbits in experiment (Thu & Dong 2008a)

Intake	Treatments						SEM/P
	WS	SP	WS+M	WS+C	SP+M	SP+C	
Sweet potato vine	-	44.50[a]	-	-	26.40[b]	24.20[b]	1.74/0.001
Water spinach	43.90[a]	-	29.50[b]	26.70[b]	-	-	2.22/0.001
Mom grass	-	-	18.60	-	20.50	-	0.65/0.001
Cuc	-	-	-	19.40	-	21.90	1.15/0.001
DM	60.70	61.40	65.00	63.20	64.00	63.00	0.18/0.220
OM	55.00	54.90	58.90	58.10	57.60	55.50	0.48/0.200
CP	9.07	9.47	8.77	7.90	8.63	7.83	2.11/0.700
NDF	21.20[a]	23.30[a]	30.30[b]	22.90[a]	31.80[b]	24.10[a]	1.09/0.001

WS: Water spinach; SP: Sweet potato vine; M: Mom grass; C: Cuc. Means with different letters within the same rows are significantly different at the 5% level

Table 9. Daily weight gain, feed conversion ration and economic return of rabbits in experiment (Thu & Dong 2008a)

Variable	Treatments						SEM/P
	WS	SP	WS+M	WS+C	SP+M	SP+C	
Initial weight (g)	790	780	730	760	730	758	38.7/0.836
Final weight (g)	1,985[a]	1,818[ab]	1,780[ab]	1,825[ab]	1,725[b]	1,767[b]	47.0/0.030
Daily weight gain (g)	17.70[a]	15.80[ab]	15.00[ab]	15.20[ab]	14.20[b]	14.40[b]	0.67/0.032
Feed conversion ration	3.35[a]	3.91[a]	4.34[b]	4.15[b]	4.50[b]	4.39[b]	0.17/0.005
Income (VND/rabbit)	59,550	54,550	53,400	54,750	51,750	53,000	-
Profit (VND/rabbit)	13,165	12,281	12,679	14,853	15,043	16,509	-

WS: Water spinach; SP: Sweet potato vine; M: Mom grass; C: Cuc. Means with different letters within the same rows are significantly different at the 5% level

In Table 9 the daily weight gain was significantly different among the treatments ($P<0.05$) with the highest value of the WS diet, while the significantly lower values were for SP+M and SP+C diets. The results of daily weight gain of crossbred rabbits fed local green foliages in present experiment ranged from 14.2 to 17.7g. They are consistent with those (from 11.0 to 19.0 g) reported by Linh (2005). Ha et al. (1996) stated that the weight gain of the pure New Zealand rabbits fed grasses and concentrate and legume leaves were 15.5 g and 20.6 g per day. Feed conversion ratio of the rabbits was from 3.35 to 4.50 and the WS and SP diets were significantly lower than the rest of the diets. The economic analysis showed that the profit got from the WS+M, SP+M and SP+C diets were higher than the rest of the diets due to acceptable growth rate and lower cost of feed, despite growth rate and feed conversion ratio of the WS and SP diets were better.

Crude protein (CP) supplementation

Proteins are compounds comprised of amino acids. They make up an animal's DNA and enzymes. Proteins play a role in most cellular functions. In addition, proteins have an important structural role in the body. They make up muscle, hair, toenails, and skin. Rabbits use lower quality proteins than humans. Bacteria in a rabbit's colon produce protein, which the rabbit can use to meet its nutrient needs by practicing cecotrophy. Rabbit's protein requirements increase during times of growth, pregnancy or lactation (milk production). Protein needs are lowest for adults at maintenance (American's Research-Based Learning Network 2012).

Replacing grass by higher CP forages in diets

The increasing CP in the diets by replacement of legumes or water spinach leaves to grass in diets for rabbits would improve nutrient intakes, digestibility, performance and profits, which are presented in several experiments.

One experiment was carried out to evaluate the effects of levels of fresh *Psophocarpus scandens* (PS) replacing fresh para grass (*Brachiaria mutica)* in the diets on feed and nutrient utilization, growth performance and economic return of crossbred rabbits. Rabbits received in addition 15 g/d of concentrate during the experiment. A complete randomized design with five treatments and three replicates was used. Two female rabbits at 60 days of age (799 g on average) were allocated in one experimental unit for 70 days. The treatments were levels of 0, 20, 40, 30 and 80% (DM basis) of *Psophocarpus scandens* replacing para grass in the diets corresponding to the treatments named PS0, PS20, PS40, PS60 and PS80, respectively. The results were reported in Table 10 and 11.

In Table 10, the DM of Para grass was 19,1% and higher than *Psophocarpus scandens* of 14%. While the CP content of *Psophocarpus scandens* was of 23.1%, while it was 9.92% in para grass. NDF content of *Psophocarpus scandens* was lower than Para grass (41.8% vs. 61.6%).

The DM intake of rabbit was lower in the treatments, which increased the PS replacement. The DM intake of PS80 was significantly lower than the PS0 and PS20 diets due to the lower DM of the PS compared to the PG (Table 11). The CP intake proportionally increased in the diets to the increase of the SP replacement and they are significantly different among the treatments ($P<0.01$), while opposite pattern occurred for the NDF intake, due to lower NDF content in the SP.

Table 12 indicated that the daily weight gain of the rabbits were higher in the diets with PS replacement, however the daily weight gain of the PS40 treatment was significantly higher ($P<0.05$) than the PS0 one. The feed conversion ratio of the PS0, PS60 and PS80 was significantly lower ($P<0.05$) than that of PS0. The economic analysis showed that the PS40 diet gave the best benefit from the experiment.

The results also showed that the digestibility of dry matter (DMD), organic matter (OMD) and crude protein (CPD) were improved with the increase of Psophocarpus scandens leaves in the diets. The DMD were significantly higher for the PS60 and PS80 diets, while The lowest DMD was for the PS0 diet (42.1%).

Table 10. Chemical composition of feeds (% DM) used in the experiment (Thu & Dong 2008[b])

Feed	DM	OM	CP	NDF	Ash
Para grass	19.10	89.60	9.92	61.60	10.40
Psophocarpus scandens	14.00	90.40	23.10	41.80	9.60
Concentrate	87.00	91.10	20.00	23.60	8.90

DM: dry matter; CP: crude protein; OM: organic matter; NDF: neutral detergent fiber

Table 11. Feed and nutrient intake of rabbits in the experiment (g/rabbit/day) (Thu & Dong 2008b)

Intake (g/rabbit/day)	Treatment					SEM/P
	PS0	PS20	PS40	PS60	PS80	
Para grass	77.70a	64.90b	51.50c	39.00d	28.70e	1.52/0.01
Psophocarpus scandens (PS)	0.00a	12.20b	25.30c	30.20d	39.90e	0.71/0.01
DM	93.50a	93.00ac	92.70ab	85.00bc	84.50b	1.82/0.01
OM	84.00a	83.60ab	83.50ab	76.70ab	76.30b	1.63/0.01
CP	10.90a	12.40b	14.00cd	13.80c	15.00d	0.32/0.01
NDF	51.60a	48.80ab	46.10b	40.40c	38.10c	1.04/0.01

DM: dry matter; CP: crude protein; OM: organic matter; NDF: neutral detergent fiber. PS0: no *Psophocarpus scandens* (PS); SP20: PS replace 20% PG; SP40: PS replace 40% PG; SP60: PS replace 60% PG; SP80: SP replace 80% PG. Means with different letters within the same rows are significantly different at 5%

Table 12. Daily weight gain, feed conversion ratio and economic return of the rabbits in the experiment (Thu & Dong 2008b)

Criteria	Treatments					SEM/P
	PS0	PS20	PS40	PS60	PS80	
LW at initial (g)	807	784	798	803	805	6.44/0.16
LW at finishing (g)	1,860a	1,955ab	2,075b	1,943ab	2,027ab	42.1/0.04
Daily weight gain (g/rabbit)	15.10a	17.30ab	18.20b	16.30ab	17.50ab	0.62/0.04
Feed conversion ratio	6.20a	5.40ab	5.10b	5.27b	4.83b	0.62/0.04
Cost of feeds and rabbits (VND/rabbit)	40,948	41,810	42,747	42,537	43,209	-
Income (VND/rabbit)	55,800	59,850	62,250	58,290	60,810	-
Benefit (VND/rabbit)	14,852	18,040	19,503	15,753	17,601	-

LW: live weigh; PS0: no *Psophocarpus scandens* (PS); PS20: PS replace 20% PG; PS40: PS replace 40% PG; PS60: PS replace 60% PG; SP80: PS replace 80% PG. Means with different letters within the same rows are significantly different at 5%

The increasing OMD pattern was similar to that of the DMD. There was an increase of CPD corresponding to the increased *Psophocarpus scandens* in the diets with a significantly higher CPD for the PS80 diet (84.4%) compared to that of the PS0 one. The digestibility of NDF in different diets was not significantly different, however there was proportionally an improvement of NDFD numerically (from 35.3 to 40.9%) with the increase of *Psophocarpus scandens* leaves in the diets. Similar patterns of nitrogen intake and retention were obtained in diets, however, they were significantly different ($P<0.01$) among the treatments with the highest values of the PS80 diet (2.99 and 2.42 g/kg $W^{0.75}$, respectively). This indicated that there was better utilization of plant foliated protein in rabbits when increasing legume leaves in the diets.

Water spinach leaves (waste) as a good protein source

In the Mekong Delta of Vietnam water spinach (*Ipomoea aquatica*) stems are used for making pickles for human consumption, while the leaves (WSL) are normally discarded. In a study of effect of supplementation levels of WSL in diets based on Para grass (*Brachiaria mutica*) of crossbred rabbits, Dong et al. (2008) indicated that water spinach leaves have a high nutritive value for rabbits, as confirmed by high protein content and the improved apparent digestibility of most nutrients in the diets including water spinach leaves. Increasing levels of water spinach leaves (WSL) in the diets of growing crossbred rabbits increase feed utilization and growth rate and levels of from 50 to 75% of water spinach leaves supplemented to Para grass diets give higher economic benefits for small farmers. Feed chemical composition of Para grass, Water spinach leaves and Paddy rice is shown in Table 13.

In Table 14 the daily intake of Para grass (PG) decreased significantly as the WSL supply increased (P<0.001). However, the total DM intake in rabbits fed PG only (control diet, WSL0) was significantly higher (P<0.001) than for those fed the diets that included WSL, possibly due to the low DM content in WSL, although total DM intake was unaffected by the inclusion level of WSL in the offered feed, and was similar for WSL25, WSL50 and WSL75. CP intake was least on the PG only (WSL0) and WSL25 diets, and increased with increasing WSL intakes, being highest on the WSL75 diet, as a result of high CP content in WSL. The intakes of OM, NDF, ADF and ME in the WSL supplemented diets were lower than those in the control diet. The growth performance and economic analysis were presented in Table 15.

It was also indicated that the apparent DM digestibility coefficients were significantly higher (P<0.05) in the diets with inclusion of WSL than that in the control diet. However, no significant difference in CP digestibility was found among the treatments. Digestibility of OM and EE was lower in the control diet (WSL0) than in the diets with WSL (P<0.05). The probable explanation is the high fiber content in PG, and Gidenne et al. (1998) stated that a high level of fiber in the diet leads to a decrease of retention time and an increase of caecotrophe production because of increasing bacterial fibrolytic activity, which in turn results in a reduction of diet digestibility (De Blas & Gidenne 1998). Both the nitrogen intake and nitrogen retention increased corresponding with increasing levels of WSL in the diet, but differences were significant only for the nitrogen intake (P<0.001).

Table 13. Chemical composition (% in DM) of Para grass, WSL and paddy rice (Dong et al. 2008)

Ingredient	DM	OM	CP	EE	NFE	NDF	Ash	ME, MJ/kg*
Para grass	16.600	87.600	12.900	6.000	76.700	36.900	12.400	9.230
Water spinach leaves	10.800	90.600	36.300	7.600	40.200	24.200	9.400	10.200
Paddy rice	87.100	95.600	6.740	1.400	25.100	13.800	4.400	11.800

Table 14. Effect of level of offer of water spinach leaves (WSL) on feed and nutrient intakes (DM basis) of growing rabbits (Dong et al. 2008)

Item	WSL0	WSL25	WSL50	WSL75	SEM/P
Daily intake, g/rabbit					
Para grass (PG)	73.80^{a}	37.30^{b}	28.90^{bc}	19.60^{c}	2.41/0.001
Water spinach leaves	0.00	11.20^{a}	19.20^{b}	30.30^{c}	1.29/0.001
Paddy rice	26.10	26.10	26.10	26.10	na
Dry matter	99.90^{a}	74.60^{b}	80.80^{b}	76.00^{b}	1.58/0.001
Organic matter	89.60^{a}	67.80^{b}	73.50^{b}	69.60^{b}	1.39/0.001
Crude protein	11.30^{a}	10.60^{a}	13.90^{b}	15.30^{c}	0.24/0.001
Neutral detergent fiber	63.20^{a}	39.60^{b}	40.50^{b}	33.80^{c}	1.17/0.001
Acid detergent fiber	30.80^{a}	20.10^{b}	21.00^{b}	18.20^{b}	0.56/0.001
ME, MJ/day/rabbit	0.99^{a}	0.76^{b}	0.83^{b}	0.79^{b}	0.02/0.001

WSL0: no WSL supplemented; WSL25, WSL50 and WSL75: WSL supplemented at levels of 25, 50, 75% of the amount of the control diet consumed, respectively. Means with different letters within the same row are significantly different at 5%

Table 15. Effect of level water spinach leaves (WSL) on live weight and daily gains of growing rabbits

Item	WSL0	WSL25	WSL50	WSL75	SEM/P
Initial weight, g	870	800	892	788	57.4/0.53
Final weight, g	1,508^{ab}	1,432^{a}	1,738^{ab}	1,820^{b}	77.4/0.03
Daily gain, g/day	13.00^{a}	12.90^{a}	17.30^{b}	19.00^{b}	0.60/0.01
FCR, kg feed DM/kg gain	7.67^{a}	5.85^{b}	4.71^{c}	4.03^{c}	0.15/0.01
Feed cost, VND/rabbit	20,826	17,596	17,152	18,333	na
Income, VND/rabbit	45,255	42,945	52,125	54,600	na
Difference, VND/rabbit	24,429	25,349	34,973	36,267	na

WSL0: no WSL supplemented; WSL25, WSL50 and WSL75: WSL supplemented at levels of 25, 50, 75% of the amount of the control diet consumed. Means with different letters within the same row are significantly different at 5%. **Source:** Dong et al. (2008)

Table 16. Chemical composition of Para grass, brewery waste, soya waste and concentrate pellet

Item	DM	OM	CP	NDF	Ash
Para grass (PG)	20.20	88.20	10.80	70.00	11.80
Brewery waste (BW)	27.60	94.80	25.30	48.90	5.20
Soya waste (SW)	10.40	93.90	20.70	44.50	6.12
Concentrate pellet	88.00	91.20	19.90	29.10	8.80

DM: dry matter; OM: organic matter; CP:crude protein; NDF: neutral detergent fiber. **Source:** Dong & Thu (2009a)

Table 17. Effect of different brewery waste supplementation on daily gain, FCR and economic returns of growing rabbits

Item	Treatment					SEM/P
	BW0	BW100	BW150	BW200	BW250	
Initial weight (g)	783	772	755	757	787	44,3/0,98
Final weight (g)	1,856^{a}	2,051^{ab}	2,064^{ab}	2,144^{b}	2,190^{b}	55,8/0,02
Daily gain (g)	15.3^{a}	18.3^{ab}	18.7^{b}	19.8^{b}	20.0^{b}	0.68/0.01
FCR (kg DM/kg gain)	5.40	4.96	5.24	5.36	5.31	0.15/0.32
Tot. Expenses VND/rabbit)	59,389	62,238	62,672	64,790	68,056	na
Tot. income (VND/rabbit)	83,520	92,295	92,880	96,480	98,550	na
Difference (VND/rabbit)	24,131	30,057	30,208	31,690	30,494	na

BW: brewery waste; BW0, BW100, BW150, BW200, BW250, BW supplemented at levels of 0, 100, 150, 200, and 250 g/rabbit/day. Means with different letters within the same rows are significantly different at P<0.05. **Source:** Dong & Thu (2009a)

Brewery and soya wastes

It was concluded by Dong & Thu (2009a) that with the basal diets of Para grass, brewery and soya waste could be supplemented to improve feed and nutrient intake and digestibility; growth and reproduction performance; and economic return of rabbit production. The optimum level of fresh brewery waste for growing rabbit diets was 200 g/day/rabbit, while this was from 300 to 400 g/day/rabbit of fresh soya waste for growing rabbit and does (Dong & Thu 2009a). The chemical composition of brewery waste and soya waste as compared to Para grass and concentrate pellet, and growing rabbit performance and economic return were presented in Table 16 and 17.

When economic analysis was done, although the feed cost was higher for the BW diets, however, the income was higher for them with highest value of the BW200 (96,480 VND/rabbit). It was also indicated that the organic matter digestibility (DMD) was proportionally increased, when increasing BW supplementation in the diets (R^2= 0.995) and the CPD and NDFD had similar pattern of the DMD for the BW supplements. Although the nitrogen retention numerically had an increasing tendency when enhancing the BW supplementation in diets, however, this increase was up to the BW200 treatment.

In the feeding and digestibility trials of growing rabbits fed with the dietary treatments were fresh soya waste (SW) supplementation to the diets at levels of 0, 100, 200, 300 and 400g/rabbit/day corresponding the SW0, SW100, SW200, SW300, and SW400 treatments, while Para grass (*Brachiaria mutica*) was fed *ad libitum*. Pellet supplementation was supplied at the same level of 10-20g per day per rabbit for all treatments (Dong & Thu 2009a). The higher final live weight (1,345-1,704 g) and daily gain (14.5-22.7 g) were found for rabbits fed high levels of SW in the SW400 and SW300 diets as compared to those fed PG only with the highest values (P<0.05) for rabbits supplied 300g SW per day per animal. This was probably due to higher CP intake from SW. The results of the present study were very promising for growth rate in the crossbred rabbit (14.5-22.7 g/day), while Ha et al. (1996) stated that the weight gain of the pure New Zealand rabbits fed grasses and concentrate and legume leaves were 15.5 g and 20.6 g per day. Feed conversion ratio was poorest for animals fed PG alone (SW0), and being better (P<0.01) with inclusion of SW in the diets, as a result of better daily gain. The economic analysis was done for 8 weeks, showed that the cost for feeds was lower with increasing the level of SW included in the diets, furthermore, due to the better rabbit growth rate of the increasing SW in the diets which gave more benefit. The results indicated that the promising diets for the rabbit could be SW300 and SW400. The close linear relationship (R^2= 0.91) between the daily weight gain and CP intakes of rabbit was also found in the experiment.

The results of the feeding experiment on does supplemented soya waste showed that the DM, CP and NDF intakes of does for three litters were generally increased when increasing the SW offered, particularly higher values for the diet SW300 and SW400. Responsibly the reproductive criteria such as the average of number of alive rabbit at birth and weaning, weight litter at weaning, daily milk production, daily gain of kittens and weight of does in pregnancy were also improved by the SW supplementation with the higher values for the diet SW300 and SW400. There were also gradual increase of litter size at birth, number of alive rabbit at weaning, weight at weaning, daily milk yield from the litter 1 to litter 3, contrastingly weight gain of does in pregnancy was reduced (Dong & Thu 2009a).

Soluble carbohydrate supplements

Organic rabbit farming based on green forages is an opportunity for the poor farmers for producing to erase starvation and to evaluate poverty in villages of Vietnam. Within these feeding strategies, green forages are used as the main protein sources and fiber, while for improving performance of growing and reproductive rabbits, sources of soluble carbohydrate supplementation are very important. This is a cause of low performance of the forages-fed rabbits in the villages as compared to the concentrate/pellet-fed rabbits in the industries (Dong & Thu 2009b).

In an experiment of supplementing dry cassava chips in diets of growing crossbred rabbits, Dong & Thu (2010) reported that increasing the offer level of dried cassava chips in a basal diet of Para grass for growing rabbits led to linear increases in total DM intake, live weight gain and coefficients of apparent digestibility. It is proposed that the determinant of rabbit growth rate in forage-based diets is the overall apparent digestibility of the diet rather than the composition of the diet in terms of the relative proportions of soluble and structural carbohydrates. The chemical composition of feeds, growth and income was shown in Table 18.

Paddy rice and sweet potato vine

Two experiments with 2 × 4 factorial designs and three replications and four rabbits per experimental unit was carried out. The first factor was supplement feed with 0.43 MJ/day/

animal (45 g paddy rice or 115 g fresh sweet potato tuber) and the second one was the level of sweet potato vine (SP) (DM basis) offered (5, 6, 7, and 8% of LW). The first trial was done on growing rabbits at 8 weeks of age to evaluate feed intake, growth performance and economic returns, while the second experiment of feed digestibility and nitrogen retention of rabbits was determined at twelve weeks of age. The chemical composition of SP and SPT was showed in Table 20.

In Experiment 1, the dry matter (DM) and organic matter (OM) intakes were similar between supplements and among the four levels of feed offered (5, 6, 7, and 8% of LW) ($P>0.05$). Crude protein (CP) intake was significantly higher for the paddy rice ($P<0.001$) and numerically it increased with higher levels of feed offered ($P= 0.07$). ME intakes were significantly higher ($P<0.01$) for the PR diet supplement and for the 8% feed offered. The daily gain and values of carcass were significantly higher for the diets supplemented PR ($P<0.01$) and 8% feed offered ($P<0.01$). The higher profits were found for the diet supplemented SPT and for the level of DM feed offered at 8% of live weight (Table 21). In Experiment 2 the apparent digestibility (%) of DM, OM were significantly higher in the supplemented PR diet ($P<0.01$) and in the diet of 8% feed ($P<0.001$).

Table 18. Chemical composition of feeds (% in DM except for DM which is on fresh basis, and ME in the feeding trial

Feed	DM	OM	CP	EE	CF	NDF	Ash	ME MJ/kg
Para grass	17.40	89.60	12.30	5.09	28.90	67.10	11.20	8.72
Dried cassava chips	94.30	97.10	2.70	1.59	3.39	15.60	3.09	13.40
Soya waste	12.00	95.30	21.30	15.40	3.50	35.00	4.96	13.10
Extracted soybean	87.90	90.10	42.80	3.22	3.70	27.40	11.30	12.40

ME: calculated according to Maertens et al. (2002). **Source:** Dong & Thu (2010)

Table 19. Mean values for changes in live weight, feed conversion and economic return

Item	Treatment					SEM/P
	DC0	DC10	DC20	DC30	DC40	
Initial weight (g)	737	735	738	727	738	5.53/0.567
Final weight (g)	1755^{a}	1848^{ab}	2047^{abc}	2083^{bc}	2255^{c}	67.5/0.003
Daily gain (g)	16.2^{a}	17.7^{ab}	20.8^{abc}	21.5^{bc}	24.1^{c}	1.09/0.002
FCR	3.33	3.13	3.28	3.18	3.35	0.14/0.761
Total cost (VND)	61,268	63,194	67,534	69,393	72,709	
Total income (VND)	78,975	83,175	92,100	93,750	101,475	
Net income (VND)	17,707	19,981	24,566	24,357	28,766	

Source: Dong & Thu (2010)

Table 20. Chemical composition of feed ingredients (% in DM, except for DM which is on fresh basis)

Feed	DM	OM	CP	EE	NDF	ADF	Ash	ME*, MJ/kgDM
Sweet potato vines (SP)	11.80	90.00	22.10	7.44	42.10	29.80	10.00	9.48
Paddy rice (PR)	87.70	95.90	7.37	3.25	25.50	13.80	4.10	10.80
Sweet potato tuber (SPT)	31.20	96.90	2.80	1.05	31.20	5.00	3.11	12.20

*: Calculated by Maertens et al. (2002). **Source:** Dong & Thu (2010)

Table 21. Live weight, daily gain (g/rabbit) and economic returns of growing rabbits in the Experiment 1

Item	Feed supplement (FS)		Supplementation level (SPL) (%)				SEM/P	
	PR	SPT	5%	6%	7%	8%	FS	SPL
Final weight (g)	2.115	2.060	2.028[a]	2.091[ab]	2.084[ab]	2.147[b]	17.900/0.040	25.3/0.04
Daily gain (g/day)	20.000	19.100	18.900[a]	19.400[ab]	19.600[ab]	20.300[b]	0.180/0.002	0.26/0.01
FCR	4.120	4.180	4.220	4.130	4.130	4.120	0.050/0.430	0.06/0.70
Feed cost (VND)	36,202	30,829	32,414	32,994	33,529	35,124		
Tot. cost (VND)	79,202	73,829	75,414	75,994	76,529	78,124		
Tot. income (VND)	95,194	92,681	91,275	94,088	93,788	96,600		
Profit (VND)	15,992	18,852	15,861	18,093	17,259	18,476		

It was concluded that the diets including paddy rice (PR) and offering 8% feed had higher growth performance, however, the sweet potato tuber (SPT) supplementation gave better economic returns

Source: Dong & Thu (2010)

Molasses and sugarcane stalk residue

An experiment was conducted to determine the effect of different levels of molasses on nutrient utilization, growth performance, profits and digestive tract content of crossbred rabbits. The experiment was a complete randomized design with five treatments and three replicates. Two female and two male rabbits at 50 days of age were allocated in one experimental unit (Dong & Thu 2012c). The rabbits were fed with the levels of 0, 6, 12, 18, and 24 g molasses per day respectively. They were corresponding to the treatments named M0, M6, M12, M18 and M24, respectively. The results showed in Table 22 that the molasses was higher in ME as compared soya waste and sweet potato vine.

The results indicated that daily weight gain and carcass weight were significantly different (P<0.05) among the treatments with the highest values for the M12 treatment.

The highest economic return was also for the M12 treatment. There was not significantly different (P>0.05) of chemical composition of stomach and intestine content, however there were lower values of pH and higher VFAs concentrations found in the caecum content of the rabbit fed molasses. There was no difference of chemical composition of stomach and intestine contents, however there were lower values of pH and a higher VFAs concentration found in the caecum content of the rabbit fed molasses. The conclusion was that molasses could be supplied in the growing crossbred rabbit diets as an enegry source and supplying a level of 12 g molasses/rabbit/day (DM basis) gave better daily weight gain, lean meat weight and economic return.

An experiment was carried out to evaluate feed utilization, nutrient digestibility and growth rate of crossbred rabbits supplemented by sugarcane stalk residue. It was a factorial

Table 22. Chemical composition (%DM) of molasses, soya waste and sweet potato vine

Feed	DM	OM	CP	EE	CF	NFE	NDF	ADF	Ash	ME* (MJ/kg)
Molasses	69.10	93.00	3.51	-	-	-	-	-	6.99	15.40
Soya waste	11.90	96.20	21.40	9.87	18.00	65.00	36.60	27.20	3.76	11.20
Sweet potato vine	9.72	90.20	19.10	8.40	17.70	62.70	43.00	33.80	9.78	9.55

DM: Dry matter; OM: Organic matter; CP: Crude protein; EE: Ether extract; CF: Crude fiber; NFE: Nitrogen free extraction; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ME: Metabolisable energy *: calculated by Maertens et al. (2002). **Source:** Dong & Thu (2012c) design in which the first factor was length of sugarcane stalk residue (SSR) (3 and 10 cm length) fed *ad-libitum*, and second factor was different supplement levels of *Operculina turpethum* (OT) (0, 100, 200 and 300g/rabbit/ day) with three replications and 4 rabbits per experimental unit. Dong & Thu (2012b) stated that the chemical composition (%) of sugarcane stalk residue is 25.9, 97.5, 3.6, 4.44, 22.0 and 2.58% and 9.2 MJ/kg DM for OM, CP, EE, NDF and ash and ME, respectively. The results show that the intakes of sugarcane stalk residue were slightly higher (P>0.05) for rabbits fed 3 cm length and gradually decreased with increasing supplement of OT in the diets (P<0.05), while OT intakes were remarkably increased (P<0.05) (Table 23). The total DM, CP, EE and ME intakes were higher for rabbits given sugarcane stalk residue at 3 cm length (P<0.05) and when increasing the levels of OT supplement (P<0.05).

It was also presented that the digestibility coefficients of DM and CP were higher for animals offered 3 cm length sugarcane stalk residue (P<0.05), and NDF values were clearly improved with increasing OT supplement in the diets (P<0.05). The higher nitrogen intake and retention were found for rabbits fed 3 cm sugarcane residue (P<0.05) and supplemented 300 g OT/rabbit/day. The daily gain and final live weight were significantly higher for rabbits fed 3 cm length sugarcane stalk residue and supplemented 300 g OT per animal per day (P<0.05). The conclusion was that rabbits fed 3 cm length sugarcane stalk residue and supplemented 300 g OT per animal per day in the diet had better growth rate and gave higher economic returns.

Catfish oil as an energy source

Catfish oil has high nutrient value, due to primarily to its long-chain, polyunsaturated, omega-3 fatty acids that are valuable energy feed sources for livestock production, especially for the fattening stage. Due to the Mekong river, there is a large water surface area are suitable for catfish cultivation. Number of large factories produce frozen white cobbler filet for export, and as a result there are large quantities of by-products available, the belly is pressed to give raw fish oil. Therefore the aim of this study was to determine optimum level of catfish oil supplement to Para grass basal diets on growth performance of crossbred rabbits. Its chemical composition (%) is 94.0, 99.5, 99.0 and 0.5 for DM, OM, EE, and ash, respectively and the ME value of 27.8 MJ/kg (Dong & Thu 2012a).

An experiment was carried out to evaluate feed utilization, nutrient digestibility, growth performance of crossbred rabbits supplemented by catfish oil. It was a completely randomized design with 5 treatments that were 5 supplement levels of 0, 5, 7, 9, and 11 g catfish oil per rabbit per day, three replications and 4 rabbits (balanced sex) per experimental unit.

Table 23. Daily intakes of feeds and nutrients (g DM/rabbit/day) of growing rabbits supplemented sugarcane stalk residue

Item	SSR length (SSRL)		OT level (OTL)				SEM/P	
	3 cm	10 cm	OT0	OT100	OT200	OT300	SSRL	OTL
O. turpethum	15.50	15.50	-	10.30^{a}	20.60^{b}	30.90^{c}	-	-/0.001
Sugarcane stalk	17.70	16.00	22.00^{a}	17.60^{b}	14.10^{bc}	13.70^{c}	0.660/0.090	0.940/0.001
DM	62.80	61.20	57.40^{a}	61.30^{b}	63.00^{c}	66.20^{d}	0.230/0.001	0.320/0.001
OM	59.00	57.50	54.80^{a}	58.00^{b}	59.00^{b}	61.30^{c}	0.220/0.001	0.320/0.001
CP	7.66	7.47	6.92^{a}	7.49^{b}	7.75^{bc}	8.09^{c}	0.060/0.05	0.870/0.001
EE	2.60	2.57	2.09^{a}	2.41^{b}	2.76^{c}	3.10^{d}	0.020/0.19	0.020/0.001
NDF	18.40	18.10	15.60^{a}	17.50^{b}	19.00^{c}	20.80^{d}	0.090/0.06	0.130/0.001
ME (MJ/rabbit)	0.69	0.68	0.63^{a}	0.67^{b}	0.70^{c}	0.74^{d}	0.010/0.001	0.002/0.001

OT: *Operculina turpethum*, SSR: sugarcane stalk residue. OT0, OT100, OT200, OT300: *Operculina turpethum* supplemented in diets at levels of 0, 100, 200, and 300 g/rabbit/day.

Sorce: Dong & Thu (2012b)

The results show that the intakes of DM, CP and NDF were similar among the treatments (P>0.05), however the EE and ME intakes significantly increased when increasing supplement levels of catfish oil in the diets, and the highest values (P<0.05) in the CFO9 and CFO11 treatments (Dong & Thu 2013). The digestibility coefficients of DM, OM, CP and NDF were similar among the treatments (P>0.05), except for the EE digestibility that was clearly improved when supplementing catfish oil in the diets, and the significantly highest (91.9%) (P<0.05) was found in the CFO9 treatment (Table 24).

The results also showed that the daily weight gain and final live weight were significantly higher for rabbits supplemented 9 g CFO per animal per day (P<0.05). The significantly higher weight of carcasses, thigh meat and lean meat were for the rabbits given 9 g CFO per day (P<0.05). It was concluded the Crossbred rabbits supplemented CFO in the diets enhanced the EE and ME intakes, and at level of 9 g CFO/rabbit/day had better growth performance and gave higher benefit.

Another experiment of the fish oil was conducted to evaluate the effects of different supplement levels of Carp fish oil (*Pangassius hypophthalmus*) in basal diet on the reproductive performance of Californian rabbits in two parities. The experiment had a completely randomized design, with 5 treatments as 5 diets and 6 replicates. The 5 diets were different supplement levels of Carp fish oil (CFO) of 0 g (CFO0), 10 g (CFO10), 20 g (CFO20), 30 g (CFO30) and 40 g (CFO40) per rabbit per day, respectively. Dong & Thu (2012a) reported that in two litters the results indicated that ME intake significantly increased (P<0.05) when increasing CFO supplement levels in the diets. Significantly higher litter sizes at birth (P<0.05) was found for rabbits supplemented 20 g CFO/day for litter one. Litter sizes at birth and at weaning were significantly higher (P<0.05) in the CFO20 diet for both two litters. Milk yield of female rabbit was significantly higher for the does supplemented 20 g CFO/ day. A comparison of results between the two parities showed that litter size at weaning and milk yield were significantly higher for the second litter (P<0.05). It was concluded that at supplement level of 20 g Carp fish oil had better reproductive performance.

CONCLUSION

It can be concluded that feeding strategies of green forages associated with local supplements could improve nutrient intakes and performance of rabbits, profits for producers and benefits for environment in rural areas in Vietnam. More studies of utilization of local available feed resources based on the given farming systems should be considered to make rabbit production adapting to the global crises in tropical developing countries.

Table 24. Apparent nutrient digestibility (%) and nitrogen retention (g/kg $W^{0.75}$) of rabbits by consuming catfish oil

Item	Treatment					SEM/P
	CFO0	CFO5	CFO7	CFO9	CFO11	
Apparent nutrient digestibility (%)						
DMD	69.80	70.70	72.80	73.80	72.30	1.450/0.360
OMD	69.90	70.90	72.90	73.90	72.40	1.450/0.360
CPD	81.20	82.40	83.90	84.60	84.30	0.900/0.110
EED	85.60^{a}	88.20^{ab}	90.20^{bc}	91.90^{c}	88.40^{ab}	0.660/0.001
NDFD	57.60	58.30	63.10	65.70	65.70	4.190/0.510
Nitrogen balance (g//kg$W^{0.75}$)						
N intake	1.38	1.29	1.30	1.28	1.25	0.050/0.500
N retention	0.88	0.91	0.93	0.96	0.95	0.080/0.900

Means with different letters within the same rows are significantly different at the 5% level

Source: Dong & Thu (2013)

REFERENCES

American's Research-Based Learning Network. 2012. Nutrients Required by Rabbits. http://www.extension.org/pages/64500/nutrients-required-by-rabbits.

Belenguer A, Fondevila M, Balcells J, Abecia L, Lachica M, Carro MD. 2008. *In vivo* and *in vitro* study of caecal fermentation pattern and methanogenesis in rabbits. In: Xiccato G, Trocino A, Lukefahr SD, editors. Proceedings of the 9th World Rabbit Congress. 9th World Rabbit Congress. Verona, June 10-13, 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche e Zootecniche. p. 184.

Binh LT. 2009. Effects of tofu waste supplementation and energy feed sources in diets on growth, nutrient digestibility and economic analysis. [MSc Thesis]. [Can Tho (Vietnam)]: Can Tho University, Vietnam.

Crutzen PJ, Aselmann I, Seiler W. 1986. Methane production by domestic animals, wild ruminants, other herbivorous fauna, and humans. Tellus. 388:271-284.

Danh Mo, Nguyen Van Thu. 2007. Results of studies on applications of in vitro digestibility techniques to evaluate ruminant feeds at Can Tho University, Vietnam. In: Proceedings of The 5th Vietnamese-Hungarian Conference on Animal Production and Aquaculture. Can Tho, August 13-14, 2007. Can Tho (Vietnam): Can Tho University. p. 102-122.

De Blas E, Gidenne T. 1998. Digestion of starch and sugars. In: De Blas C, Wiseman J, editors. The Nutrition of the Rabbit. Wallingford (England): CABI Publishing. p. 17-38.

DOSUS. 2011. Carbon sequestration through grass. Available from: http://www.helpdosus.org/posts/co2-sequestration-through-grass.

El-Adawy MM, Salem AZM, Borhami BE, Gado HM, Khalil MS, Abo-Zeid A. 2008. In vitro caecal gas production and dry matter degradability of some browse leaves in presence of enzymes from anaerobic bacterium in NZW rabbits. In: Xiccato G, Trocino A, Lukefahr SD, editors. Proceedings of the 9th World Rabbit Congress. 9th World Rabbit Congress. Verona, June 10-13, 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche e Zootecniche. p. 643-647.

FAO. 2006. Livestock impacts on the environment. http://www.fao.org/ag/magazine/0612sp1.htm.

FAO. 2011. A rationale for FAO to tackle transboundary animal diseases. http://www.fao.org/ag/againfo/programmes/en/empres/news_150711.html.

FAO/IAEA. 2010. Sustainable livestock production & health. Odongo NE, Garcia M, Viljoen GJ, editors. Rome (Italy): Food and Agriculture Organization.

Gidenne T, Pinheiro V, Facao E, Cunha L. 1998. Conséquences d'une déficience en fibres alimentaires sur la digestion et le transit; premiers résultats chez le lapin adulte. 7èmes Journ Rech Cunic. p. 147-150.

Holdridge M. 2011. What grass farmers have known all along—research shows grass sequesters carbon. Published by the American Grassfed Association. http://soilcarboncoalition.org/holdridge.

Innovative news, 2010. Cows fight global warming. http://www.sikantis.org/sikantis.org/site/pix/content/cow.jpg& imgrefurl=.

Le Thu Ha, Nguyen Quang Suc, Dinh Van Binh, Le Thi Bien, Preston TR. 1996. Replacing concentrates with molasses blocks and protein rich tree leaves for production and growth of rabbits. Livest Res Rural Dev 8:39-43.

Leng RA. 2008. Digestion in the rabbit – a new look at the effects of their feeding and digestive strategies. In: MEKARN Proceedings of International Workshop. "Organic Rabbit Farming Based on Forages" Cantho Univ, Cantho City, Vietnam. http://www.mekarn.org/prorab/dongt.htm.

Linh NTX. 2005. Effect of sweet potato vines replacing Para grass (*Brachiaria mutica*) on feed and nutrient digestibility and nitrogen retention of growing crossbred rabbits. [BSc thesis]. Faculty of Agriculture and Applied Biosciences. p. 4-12, 17.

Nguyen Thi Kim Dong, Nguyen Van Thu, Ogle B, Preston TR. 2006. Effect of supplementation level of water spinach (*Ipomoea aquatica*) leaves in diets based on Para grass (*Branchiaria mutica*) on intake, nutrient utilization, growth rate and economic returns of crossed rabbit in the Mekong Delta of Vietnam, Workshop-seminar, Mekarn-CelAgrid. Available from: http://www.mekarn.org/proprf/kimd2.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu, Ogle B, Preston TR. 2008. Effect of supplementation level of water spinach (*Ipomoea aquatica*) leaves in diets based on para grass (*Brachiaria mutica*) on intake, nutrient utilization, growth rate and economic returns of crossbred rabbits in the Mekong Delta of Vietnam Livest Res Rural Dev 20 (9). http://www.lrrd.org/lrrd20/9/kdon20144.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu, Preston TR. 2010. Sweet potato tuber and paddy rice as energy supplements for growing rabbits in the Mekong Delta of Vietnam. In: MEKARN International Conference on Live Stock Production, Climate Change and Resource Depletion. November, 9-11, 2010 in Pakse, Laos. http://www.mekarn.org/workshops/ pakse/html/content.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2009a. A study of using *Wedelia trilobata* in diets of growing and reproductive crossbred rabbits in the Mekong Delta of Vietnam. Proceedings of the Second International Conference on Sustainable Animal Agriculture for Developing Countries (SAAC 2009). Kuala Lumpur, November 8-11, 2009. Kuala Lumpur (Malaysia): SAAC. p. 156.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2009b. The use of agro-industrial byproducts for raising crossbred rabbit (New Zealand x local rabbits) in the Mekong delta of Vietnam. Proceedings of the First Conference on Asian Rabbit Production Development. Sep 10-11 2009. Changchun, China. Pp 156.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2010. The supplementation of dried cassava chips in growing rabbit diets to improve growth performance and economic returns. MEKARN International Conference on Live stock production, climate change and resource depletion. Nov. 9-11, 2010. In Pakse, Laos. http://www.mekarn.org/workshops/pakse/html /content.htm.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2012a. Effects of different supplement of Catfish oil (*Pangassius hypophthalmus* oil) in diets on reproductive performance of Californian rabbits. In: International Proceedings of Animal Production and Environment. Can Tho, December 12, 2012. Can Tho (Vietnam): Can Tho University. p. 232.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2012b. Effect of different sizes of sugarcane stalk residue in the basal diet with Operculina turpethum supplement on feed utilization, nutrient digestibility and growth rate of crossbred rabbits. In: Proceedings of the International Conference. Livestock-Based Farming Systems, Renewable Resources and the Environment. 6-9 June 2012, Dalat, Vietnam. http://www.mekarn.org/workshops/dalat2012/ html/kimdongsc.htm

Nguyen Thi Kim Dong, Nguyen Van Thu. 2012c. A response of nutrient digestibility, growth rate and carcass values of crossbred rabbits to dietary molasses supplementation. In: Proceedings of Animal Production and Environment. CTU, Vietnam. Dec-12, 2012. p. 238.

Nguyen Thi Kim Dong, Nguyen Van Thu. 2013. Effects of different supplement of Catfish oil (Pangassius hypophthalmus oil) in para grass basal diets on feed utilization, nutrient digestibility, growth rate and meat production of Crossbred rabbits. Paper presented at the 2nd International Conference on Rabbit Production in Indonesia and 3rd Conference of Asian Rabbit Production Association. Aug 27-29, 2013. Bali, Indonesia.

Nguyen Thi Van Chau, Nguyen Thi Kim Dong. 2010. A study of using *Wedelia trilobata* as a forage source for reproductive crossbred rabbits in the Mekong delta. In: Proceedings of the Conference of Climate Changes and Sustainable Agriculture Production (Vietnamese). Can Tho, Nov. 26th 2010. Can Tho (Viet Nam): Can Tho University. p. 345-351.

Nguyen Van Thu, guyen Thi Kim Dong. 2008c. A study of associated fresh forage for feeding growing crossbred rabbit in the Mekong delta of Vietnam. In: MEKARN Proceedings of International Workshop of Organic Rabbit Farming based on Forages from 25-27 Nov 2008 at Cantho University. http://www.mekarn.org/prorab/dong.htm.

Nguyen Van Thu, Mo D. 2008. A study of nutritive values of forages as rabbit feed resources by using in vitro digestibility and gas production techniques. In: MEKARN Proceedings of International Workshop. "Organic Rabbit Farming Based on Forages" Cantho University, Cantho City, Vietnam. http://www.mekarn.org/ prorab/dongt.htm.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2008a. Effect of water spinach and sweet potato vine associated with 2 other natural plants, on growth performance, carcass values and economic return of growing crossbred rabbits in the Mekong delta of Vietnam. Proceedings of the 9th World Rabbit Congress. Verona, June 10-13, 2008. Verona (Italy): World Rabbit Congress. p. 763-767.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2008b. Effect of Psophocarpus scandens replacing Para grass in the diets on feed utilization, growth rate and economic return of growing crossbred rabbits in the Mekong delta of Vietnam. Proceedings of the 9th World Rabbit Congress. Verona, June 10-13, 2008. Verona (Italy): World Rabbit Congress. p. 759-762.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2009a. A study of water hyacinth (Eichhornia crassipes) as a feed resource for feeding growing rabbits. In: MEKARN Proceedings of Conference on Livestock, Climate Change and the Environment. From 16 to 18 November 2009, An Giang University, Long Xuyen City, Vietnam. http://www.mekarn.org/workshops/environ/proenv/thuctu.htm.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2009b. The role of green forages for small and medium commercial scales of rabbit production in developing countries. In: Proceedings of the First Conference on Asian Rabbit Production Development. September, 10-11 2009. Changchun, China. p. 119.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2013. A response of energy intakes, growth rate and carcass values of crossbred rabbits to the supplementation of sweet potato tuber (Ipomoea batatas) in the Mekong delta of Vietnam. Paper presented at the 2nd International Conference on Rabbit Production in Indonesia and 3rd Conference of Asian Rabbit Production Association. Bali, August 27-29, 2013. Bali (Indonesia): ARPA.

Nguyen Van Thu. 2011. Rabbit production in response to the global energy and food crisis, and climate change in tropical developing countries – A review. In: Proceedings of the 2nd Asian Rabbit Production Association (APRA). Hanoi, December 5-6, 2011. Hanoi (Vietnam): ARPA. p. 6-18.

Physorg. 2009. Climate change amplifying animal disease. http://www.physorg.com/news162486984.html.

Pigprogress. 2009. Animal diseases linked to climate change. http://www.pigprogress.net/news/oie-animal-diseases-linked-to-climate-change-3010.html.

Preston TR, Murgueitio E. 1992. Strategy for sustainable livestock production in the tropics. Consultorias Para el Desarrollo in en Tropico et da Cali (Colombie). p. 89.

Samkol P, Lukefahr SD. 2008. A challenging role for organic rabbit production towards poverty alleviation in South East Asia. In: Proceedings of the 9th World Rabbit Congress, Verona, ITALY. http://world-rabbit-science.com/WRSA-Proceedings/Congress-2008-Verona/Verona-2008-a.htm#management.

Stanco G, Di C, Calabro S, Nizza A. 2003. Prediction of nutritive value of diets for rabbits using an in vitro gas production technique. World Rabbit Sci. 11:199-210.

Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, de Haan C. 2006. Livestock's Long Shadow: Environmental Issues and Options. Rome (Italy): Food and Agriculture Organization of the United Nations.

Effects of Dietary Neutral Detergent Fiber Levels on Feed Intakes, Production Performance and Nutrients Utilization of Growing Crossbred Rabbits Reared in Mekong Delta of Vietnam

Nguyen Thi Vinh Chau[1], Nguyen Van Thu[2]

[1] Agricultural and Environmental Department, Kiengiang Economic and Technology College, 425 Maccuu, Rachgia city, Kiengiang province, Vietnam; [2] Animal science Department, College of Agriculture and Applied Biology, Cantho University, 3/2 street, Cantho city, Vietnam
Corresponding email: nvthu@ctu.edu.vn

ABSTRACT

A study was conducted to determine the effects of different dietary neutral detergent fiber (NDF) levels on growth performance, nutrient digestibility, caecal fermentation and carcass value of crossbred (New Zealand × local) rabbits reared in Mekong delta of Vietnam. Seventy two rabbits at 8 weeks of age were randomly allocated to six treatments and three replications (2 males and 2 females per each experimental unit). The treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% (DM basis), respectively. The experimental period was 12 weeks, in which the samples collected for digestibility trial was for one week at the age of 13th week. The results showed that The DM, CP and ME intakes was numerically higher for the NDF36 and NDF39 treatments, however only their values of the NDF36 treatment were significantly higher ($P<0.05$) than the NDF42, NDF45 and NDF48 treatments. As a result the higher values of DWG and profit were higher for the NDF36 and NDF39 treatment. There were significant differences ($P<0.05$) of DMD and OMD among different treatments, but these were not found for CPD, EED, NDFD and ADFD ($P>0.05$). The DMD, OMD, NDFD and ADFD decreased with increasing dietary NDF. The nitrogen retention values decreased when increasing the dietary NDF. The conclusion was that the proper levels of dietary NDF concentration for growing crossbred rabbits from 8 to 20 weeks of age was from 36 to 39 %. Feed and nutrient intakes, growth and meat production were significantly affected by the dietary NDF levels.

Key Words: Rabbit, Fiber, Performance, Digestion, Growth Rate, Caecal Environment

INTRODUCTION

In recent years rabbit production and meat have been popular in the Mekong delta of Vietnam due to the human demands after the bird flu outbreak occurred. Rabbit production is good for commercial farm income and also for the poor producers. Crossbred rabbits (New Zealand × local) are widely raised in the Mekong delta because of a good adaptation to the local climate and feed resources. In this region researchers have studied on the utilization of available local feedstuffs for crossbred rabbits since year 2000 (Thu & Dong 2011), but studies on nutrient requirements of crossbred meat rabbits were lagged behind in the development process.

Crude fibre (CF) is an important structural matter of feed, a material of supplying energy and assuring rabbit health. The dietary CF levels not only affect feed consumption and nutrient supply, but also influence the nutrient digestion and absorption, production performance and health status of rabbits. NRC (1977) recommended that the dietary CF requirement of growing rabbits was 10-12%. AEC (1987) prescribed that the dietary CF requirement of pre-weaning rabbits was 12% and that of post-weaning rabbits was 14%. Similarly, Wang et al. (2012) indicated that the appropriate CF requirement of growing rabbits from weaned to 2.5 month-old was 14%. Currently, dietary neutral detergent fiber (NDF) or acid detergent fibre (ADF) substituting traditional CF has become a trend of fibre nutrition research, particularly for the herbivores. De Blas & Mateos (2010) suggested that the appropriate dietary NDF level for does was 32%, while this for growing rabbits varied from 20% to 35% (Gidenne et al. 2002; Tao & Li 2006; de Blas & Mateos 2010). However, studies of suitable NDF level for growing crossbred rabbits in the Mekong delta of Vietnam have been limited. Therefore the objectives of this study were to investigate the effects of different dietary NDF levels on feed and nutrient intakes, meat production and ceacum content of crossbred rabbits for the dissemination of results to producers.

MATERIALS AND METHODS

Animals and experimental design

Seventy two crossbred rabbits (New Zealand × local) at 8 weeks of age (624±5.79 g), were randomly allocated in an experiment of complete randomized design with six treatments and three replications (2 male and 2 female rabbits per each experimental unit). Rabbits in each experimental unit were individually housed in self-made metabolism cages which can separate urine from faeces. Each cage contained a feeder and water trough to provide free access to feed and water. Table 1 gave the ingredients and chemical composition of experimental diets. The experimental diets in different treatments were formulated with crude protein of 15.6% (DM basis) and metabolizable energy (ME) of 12.1 MJ/kg. The NDF levels of six experimental diets were 33, 36, 39, 42, 45 and 48% corresponding to NDF33, NDF36, NDF39, NDF42, NDF45 and respectively. The animals were vaccinated to prevent some diseases, especially rabbit hemorrhagic diarrhea and parasite diseases.

Experimental procedures

For the feeding and digestibility trials of the study the feeds including Para grass, water spinach leaves, broken rice and oil-extracted soybean were daily offered at 8:00, 11:00 and 17:00. The experimental period was 12 weeks in which the faeces and urine samples collected for measuring nutrient digestibility and nitrogen retention was one week at the age of the 13^{th} week. Feeds and refusals were daily collected for the chemical analysis.

Measurement taken and chemical analysis

All experimental rabbits were monthly weighed for calculating the daily gain (DWG). The daily feed consumed was weighed and recorded for measuring feed and nutrient intakes and feed conversion ratio. After finishing the study all rabbits were slaughtered to evaluate the carcass values. Then meat was analyzed for the chemical composition (DM, OM, CP, EE and ash).

The feeds and refusals were taken for analyses of DM, OM, CP, EE, NDF, ADF, and Ash following the procedures of AOAC (1990) and van Sorest et al. (1991).

Table 1. Ingredients and chemical composition of experimental diets

Ingredients, % dietary DM	Dietary treatments[1]					
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48
Para grass	0.00	11.90	27.70	51.10	59.90	72.00
Water spinach leaves	82.30	70.70	48.70	16.50	10.20	0.00
Broken rice	9.32	7.97	11.40	16.80	13.80	11.00
Oil-extracted soybean	8.38	9.45	12.20	15.50	16.10	17.00
Chemical composition[2] (% DM)						
DM	7.25	7.39	8.12	9.58	9.48	9.54
OM	87.30	87.60	88.50	89.80	89.50	89.30
CP	15.60	15.60	15.70	15.60	15.60	15.60
EE	6.80	6.75	6.60	6.33	6.45	6.54
NDF	33.00	36.20	38.70	41.80	45.00	48.30
ADF	23.40	27.40	28.80	30.40	32.60	35.30
Ash	7.25	7.39	8.12	9.58	9.48	9.54
ME (MJ/kgDM)	12.10	12.10	12.10	12.10	12.10	12.10

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] DM: Dry matter; OM: Organic matter; CP: Crude protein; EE: Ether extract; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ME: Metabolizable energy

Metabolizable energy (ME) was calculated by suggestion of Maertens et al. (2002). At the beginning of the experiment two rabbits per experimental unit were weighed individually and thereafter weekly. Daily feed intakes, growth rate, and feed conversion ratios were measured and calculated. After finishing the experiment all rabbits were slaughtered for evaluating the carcass values. After slaughtering, the caecum was removed and weighed with and without its content. The pH value of caecal content was determined by a pH meter. Then these samples were filtered with three layers of muslin cloth for analyzing ammonia-nitrogen (AOAC 1990) and total volatile fatty acids (VFA) concentration suggested by Barnett & Reid (1957).

Statistical analysis

All data were primarily calculated in Excel software, then analyzed for variance using the One-way model of the Minitab software (Minitab 2010). In comparison of the treatments, these mean values were analyzed using Tukey's test (Minitab 2010).

RESULTS AND DISCUSSIONS

Feed and nutrient intakes, growth performance and income

The effects of different dietary NDF levels on feed and nutrient intake and growth performance of experimental rabbits is shown in Table 2 and 3, respectively.

The DM, CP and ME intakes was numerically higher for the NDF36 and NDF39 treatments, however only their values of the NDF36 treatment were significantly higher ($P<0.05$) than the NDF42, NDF45 and NDF48 treatments. The EE and NDF intakes were significantly different among the treatment with the highest values for the NDF36 treatment. As a result the higher values of DWG and profit were higher for the NDF36 and NDF39 treatment.

Table 2. Feed and nutrient intake (gDM/day) of rabbits fed different level of NDF

Item	Dietary treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Total DM	76.700^{b}	83.100^{a}	78.600^{b}	69.600^{c}	67.300^{cd}	63.700^{d}	0.911	0.001
CP	12.000^{c}	12.900^{a}	12.400^{b}	10.800^{d}	10.500^{e}	9.930^{f}	0.062	0.001
EE	5.210^{b}	5.610^{a}	5.180^{b}	4.410^{c}	4.340^{c}	4.170^{c}	0.053	0.001
NDF	25.300^{a}	30.400^{b}	30.300^{b}	29.100^{b}	30.300^{b}	31.100^{b}	0.578	0.001
ME, MJ/day	0.924^{b}	1.000^{a}	0.950^{ab}	0.845^{c}	0.816^{cd}	0.773^{d}	0.011	0.001

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] DM: Dry matter; CP: Crude protein; EE: Ether extract; NDF: Neutral detergent fiber; ME: Metabolizable energy
The data with different superscript letters in the same row differ significantly ($P<0.05$)

Table 3. Growth performance and economic return of experimental rabbits

Item[2]	Treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Initial live weight (g)	628.00	623.00	628.00	622.00	625.00	618.00	16.700	0.998
Final live weight (g)	2062.00^{bc}	2253.00^{a}	2178.00^{ab}	1993.00^{cd}	1903.00^{d}	1690.00^{e}	32.500	0.001
DWG (g/day)	17.10^{bc}	19.40^{a}	18.50^{ab}	16.30^{c}	15.20^{c}	12.80^{d}	0.411	0.001
Feed conversion ratio	4.50	4.29	4.26	4.26	4.42	5.00^{b}	0.100	0.002
Total cost (VND)	132,734	137,111	136,242	131,443	127,761	123,215	-	-
Income (VND)	164,933	180,267	174,267	159,467	152,267	135,200	-	-
Profit, VND	32,199	43,155	38,024	28,023	24,505	11,985	-	-

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45, and 48% DM, respectively
[2] DWG: daily weight gain; the total cost consisted of feeds, rabbits costs; profit = Income - total cost

However only the DWG of the NDF36 treatment was significantly higher (P<0.05) than that of the treatments of NDF33, NDF42, NDF45 and NDF48. The daily DM intake and DWG increased when the increasing dietary NDF from 33 to 36%, then they were reduced when increasing the dietary NDF from 39 to 48 %. This study also showed that there was a close relationship between DM intakes and dietary NDF levels (x, %) with

$$y = -16.8 + 5.71x - 0.085x^2 \ (R^2 = 0.857)$$

Similarly there were also close relationships between DWG and FCR, and dietary NDF levels with

$$y = 50.9 + 3.74x - 0.050x^2, R^2 = 0.94$$
$$y = 18.8 + 0.7474x + 0.0096x^2$$
$(R^2 = 0.951)$, respectively

In a study of dietary NDF for growing rabbit de Blas et al. (1985) indicated that there were significant differences in DWG in growing rabbits from 28 to 49 days of age between 30% and 21% NDF treatment. In suckling rabbits from 21 to 30 days of age a linear decrease of DWG with increasing level of fibre in the diets (de Blas et al. 1985). Gutierrez et al. (2002) reported that an increase of dietary NDF concentration from 30% to 36% led to a decrease in DWG and feed efficiency in rabbits from 25 to 39 days of age. Gidenne et al. (2002) observed the effect of a dietary fibre on the rabbit around weaning and indicated that DWG of group fed 31% NDF diet was lower than that of 19% NDF one. Rabbits at 2 to 3 months of age when feeding diets of NDF concentration from 24% to 30% led to an increase in DWG and feed efficiency and then having a decrease of DWG of NDF diets from 30% to 36% (Tao & Li 2006).

Nutrients digestibility and nitrogen balance

The effects of different dietary NDF on the total tract apparent digestibility of nutrients and nitrogen balance of experimental rabbits was shown in Table 4.

There were significant differences (P<0.05) of DMD and OMD among different treatments, but these were not found for CPD, EED, NDFD and ADFD (P>0.05). The DMD, OMD, NDFD and ADFD decreased when increasing the dietary NDF. There were significant differences (P<0.05) in nitrogen intake (NI) and nitrogen retention (NR) among the treatments. The NI and NR decreased when increasing dietary NDF. The regression function between DMD (y, %) and dietary NDF levels (x, %) was

$$y = -1.06x + 112 \ (R^2 = 0.980),$$

NDFD (y, %) and dietary NDF levels (x, %) was

$$y = -0.695x + 83.3 \ (R^2 = 0.946)$$

and ADFD (y, %) and dietary NDF levels (x, %) was

$$y = -0.967x + 77.4 \ (R2 = 0.915)$$

Table 4. Total tract apparent digestibility of nutrients (%) and nitrogen retention of experimental rabbits

Item[2]	Treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
DMD	77.500[a]	73.200[ab]	70.600[ab]	67.300[ab]	65.500[ab]	60.100[b]	2.890	0.015
OMD	77.800[a]	73.800[ab]	71.500[ab]	68.700[ab]	61.100[ab]	62.200[b]	2.910	0.024
CPD	79.700	79.900	79.600	80.500	79.500	79.300	2.640	0.999
EED	93.900	93.700	93.900	93.100	93.200	93.300	0.513	0.745
NDFD	60.700	57.000	56.500	54.100	53.700	48.400	4.460	0.536
ADFD	43.600	42.500	41.500	36.700	36.000	28.000	6.290	0.535
N intake (g)	1.370[b]	1.530[a]	1.510[a]	1.410[b]	1.280[c]	1.220[c]	0.008	0.001
N retention (g)	0.791[a]	0.791[a]	0.725[ab]	0.550[ab]	0.439[ab]	0.389[b]	0.083	0.013
N retained percentage	57.600	51.700	47.900	39.000	34.200	31.900	5.900	0.055

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] DMD, OMD, CPD, EED, NDFD and ADFD: total tract digestibility of DM, OM, CP, EE, NDF and ADF
The data with different superscript letters in the same row differ significantly (P<0.05)

and NR percentage (y, %) and dietary NDF levels (x, %) was

$$y = -1.74x + 114.6$$
$$(R^2 = 0.966)$$

In the study, when increasing dietary NDF, generally the DMD, OMD, NDFD and ADFD decreased. These results were similar to those showed by other authors such as de Blas et al. (1985) indicated that nutrient digestibility was dropped when dietary NDF level was from 31 to 41% and Rodriguez et al. (2011) also reported that DMD, OMD and NDFD were dropped when increasing dietary NDF level from 37 to 46%.

Carcass values and meat quality

The effect of different dietary NDF on meat production and quality were shown in Table 5.

There were no significant differences in carcass, lean meat and thigh meat percentages, and fresh meat nutrients composition among different treatments (P>0.05). However, weights of carcass, meat and thigh meat weight of NDF36 and NDF39 were numerically somewhat higher than the NDF42, NDF45 and NDF48 treatments.

Caecal development and fermentation activity

The effects of different dietary NDF levels on caecum development and fermentation of experimental rabbits is shown in Table 6.

Caecum content weight (y) significantly decreased when increasing dietary NDF (x) with regression function

$$y = 331 – 5.12\,x$$
$$(R^2 = 0.864, SE = 13.7, P = 0.009)$$

and there were a significant difference among different treatments (P<0.001). The digestive system of the rabbit is characterized by the relative importance of the caecum when compared with other species.

The capacity of the caecum is approximately 49% of the total capacity of the digestive tract (Carabano et al. 2010). The caecum plays an important role in the digestion of fiber. Garcia et al. (1999) and Gidenne *et al.* (2002) also indicated that the caecal content weight dropped when dietary NDF increased. However, it should be considered that the live weight of rabbits also contributed to this reduction of the ceacal weight in the present study.

Table 5. Carcass value and meat quality of experimental rabbits

Variable[2]	Dietary treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Live weight (g)	2043[ab]	2227[a]	2073[ab]	1907[b]	1933[b]	1863[b]	57.2	0.007
Carcass weight (g)	973	1030	1015	937	927	860	36.3	0.056
Carcass percentage (%)	47.6	46.3	49.0	49.1	48.0	46.2	1.26	0.458
Lean meat weight (g)	722	766	738	580	667	600	72.8	0.408
Lean meat percentage (%)	74.2	74.4	72.7	60.5	71.9	69.8	6.38	0.652
Thigh meat weight (g)	387	417	376	357	370	339	21.9	0.272
Thigh meat percentage (%)	39.7	40.4	37.0	38.4	39.9	39.4	1.73	0.760

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45, and 48% DM, respectively
[2] DM: Dry matter; OM: Organic matter; CP: Crude protein

Table 6. Fermentation activities in ceacum of experimental rabbits

Variable[2]	Dietary treatments[1]						SE	P
	NDF33	NDF36	NDF39	NDF42	NDF45	NDF48		
Ceacal weight (g)	167^{a}	160^{ab}	114^{bc}	105^{c}	101^{c}	96.7^{c}	10.5	0.001
pH	6.18	5.90	6.27	5.81	6.02	6.00	0.121	0.157
NH_3-N (mg/100ml)	59.6^{d}	63.7^{d}	69.3^{cd}	91.6^{a}	86.7^{ab}	75.4^{bc}	3.14	0.001
VFA (mM)	114^{b}	122^{b}	133^{ab}	153^{a}	128^{b}	117^{b}	4.53	0.001

[1] Dietary treatments were dietary NDF levels of 33, 36, 39, 42, 45 and 48% DM, respectively
[2] NH_3-N, ammonia-nitrogen; VFA, total volatile fatty acid
The data with different superscript letters in the same row differ significantly ($P<0.05$)

The pH value of caecal content was not significantly different ($p>0.05$) among different treatments. The pH of caecal content may evaluate the extent of caecal fermentation and was negatively correlated to the diarrhea rate of rabbit. There were significantly different in the NH_3-N and VFA concentration of caecum among different treatments ($p < 0.001$). The NH_3-N and VFA concentration of caecum gradually increased when increasing the dietary NDF increased from 33 to 42%, then they decreased when increasing the dietary NDF from 42 to 48%. Volatile fatty acids were main products of carbohydrate fermented by micro-organism, so the concentration of VFA may evaluate fermentation extent and activity of micro-organism. Volatile fatty acids were rapidly absorbed by hindgut and supplied energy.

CONCLUSION

The conclusion was that the proper levels of dietary NDF concentration for growing crossbred rabbits from 8 to 20 weeks of age was from 36 to 39 %. Feed and nutrient intakes, growth and meat production were significantly affected by the dietary NDF levels. Increasing dietary NDF levels from 39 % could decrease the feed intake, nutrient digestibility, nitrogen retention and daily weight gain. The ceacal N-NH_3 and VFAs values in the present study did not support for the results of nutrient intakes, growth rate and meat production.

ACKNOWLEDGEMENT

The authors kindly thank to the facilitation of Department of Animal Sciences, Fac. of Agriculture and applied Biology, Cantho University and this work was partly financed through the Supported Project for Doctoral students of Cantho University.

REFERENCES

AEC. 1987. Recommendations for Animal Nutrition, 5th ed. Commentry (France): Rhone-Poulenc. p. 86.

AOAC. 1990. Official methods of analysis, 15th ed. Washington DC (USA): Association of Official Analytical Chemists.

Barnett AJG, Reid RL. 1957. Studies on the production of volatile fatty acids from grass by rumen liquor in an artificial rumen: The volatile fatty acid production from grass. J Agric Sci. 48:315-321.

Carabano R, Piquer J, Menoyo D, Badiola I. 2010. The digestive system of the rabbit. In: De Blas C, Wiseman J, editors. Nutrition of the rabbit, 2nd edition. Wallingford (UK): CAB International. p. 1-18.

De Blas JC, Fraga MJ, Rodrıguez M. 1985. Units for feed evaluation and requirements for commercially grown rabbits. J Anim Sci. 60:1021-1028.

De Blas C, Mateos GG. 2010. Feed formulation. In: De Blas C, Wiseman J, editors. Nutrition of the rabbit, 2nd edition. Wallingford (UK): CAB International. p. 222-232.

Garcıa J, Carabano R, de Blas JC. 1999. Effect of fiber source on cell wall digestibility and rate of passage in rabbits. J Anim Sci. 77:898-905.

Gidenne T, Jehl N, Segura B, Michalet-Doreau B. 2002. Microbial activity in the caecum of the rabbit around weaning: impact of a dietary fiber deficiency and of intake level. Anim. Feed Sci Technol. 99:107-118.

Gutierrez I, Espinosa A, Garcıa J, Carabano R, de Blas JC. 2002. Effect of levels of starch, fibre, and lactose on digestion and growth performance of early-weaned rabbits. J Anim Sci. 80:1029-1037.

Maertens L, Perez MT, Villamide M, Cervera C, Gidenne T, Xiccato G. 2002. Nutritive value of raw materials for rabbits: Egran tables 2002. World Rabbit Sci. 10:157-166.

Minitab. 2010. Minitab reference manual release 16.1.0.0. Minitab Inc.

NRC. 1977. Nutrient requirements of rabbits, Second revised edition. Washington DC (USA): National Academy of Sciences.

Rodríguez-Romero RN, Abecia L, Fondevila M, Balcells J. 2011. Effects of levels of insoluble and soluble fiber in diets for growing rabbits on faecal digestibility, nitrogen recycling and in vitro fermentation. World Rabbit Sci. 19:85-94.

Tao ZY, Li FC. 2006. Effects of dietary neutral detergent fibre on production performance, nutrient utilization, caecum fermentation and fibrolytic activity in 2- to 3-month-old New Zealand rabbits. J Anim Physiol Anim Nutr. 90:467-473.

Thu NV, Dong NTK. 2011. Monographical book of rabbit: Feeding and product processing technology. Ho Chi Minh City (Vietnam): Agricultural Publishing House.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle: methods for dietary fiber, and nonstarch polysaccharides in relation to animal nutrition. J Dairy Sci. 74:3585-3597.

Wang X, Ma M, Sun L, Wang C, Zhu Y, Li F. 2012. Effects of different protein, fiber and energy levels on growth performance and the development of digestive organs in growing meat rabbit. In: Proceedings 10th World Rabbit Congress. September 3-6, 2012. Sharm El - Sheikh (Egypt): World Rabbit Congress. p. 641-645.

The Use of Coco Peat as a Source of Fiber with Or without Multienzyme Supplementation for Rabbits

Yono C Raharjo[1], Haryati T[1], Mudaris A[2], Sweet[2]

[1]Indonesian Research Institute for Animal Production Bogor, PO Box 221, Bogor 16002
[2]Faculty of Animal Husbandry. University of Pajajaran Bandung
Corresponding e-mail: raharjoyc2009@yahoo.com

ABSTRACT

Coco peat is a waste product of coconut oil industry and sometimes is considered to causing pollution to the environment. It contains a very high content of fiber, especially lignin, hence is hardly utilized as an economically valued product. Rabbits, on the other hand, requires a certain amount of indigestible fiber, including lignin to facilitate the normal digestion in the gastrointestinal tract. An experiment was carried out to study the lignin inclusion in the rabbit diet supplemented with or without enzymes on the performance of the rabbits including the digestibility of coco peat. A factorial 2 × 3, in which 2 levels of enzyme (0 and 30g/100 kg) and 3 levels of cocopeat (0, 6, 1, and 12,2%, which contribute 0, 4 and 8% crude fiber to the diet, respectively) was applied. Each treatment combination consisted of 6 replicates, each of 3 weanling rabbits. All treatments were formulated to contain 18% crude protein, 2550 kcal/kg DE and 14% crude fiber. Trial was carried out for 10 weeks. Therefater, 1 animal from each replicate was slaughtered for carcass percentage. A digestibility study was carried through a total collection method in 5 strains of rabbit (Rex, Satin, Reza, NZW and Meat-type crossed). For digestibility purpose, coco peat was mixed 50 : 50 with the basal diet. Fecal collection was carried out for 10 days following a 3 days adaptation. All results were subjected to an Anova analysis which was followed by DMRT (Duncan Multiple Range Test) for any significant differences among treatment means. Results indicated that there was no significant interaction of level of cocopeat with level of enzymes among all measured parameters. No significant differences were noted in feed consumption, carcass percentage, FCR, meat and pelt production among levels of dietary coco peat or among levels of enzyme. It is observed however, that higher levels of coco peat consistently decreased the performance, which was significant in bodyweight and bodyweight gain, when 8% dietary coco peat fiber was included. Inclusion of enzyme slightly but not significantly improved the performance of measured parameters. When basal diet was used, body weight gain of the NZW was significantly higher than other treated rabbits. However no differences were noted on feed consumption and dry matter digestibility (DMD). On the other hand, when coco peat was included at 50% in the basal diet, BWG was negative for all rabbits and feed consumption was lower compared with those at basal diet. The DMD was poorer ($P<0.05$) in Rex, Satin and Reza compared with faster growing rabbits (Cross and NZW). In Conclusion, coco peat can be included at a very low level (4%) in the diet. It however could be used as a source of lignin to balance the ratio of cellulose: lignin when the indigestible lignin is limitedly available.

Key Words: Cocopeat, Digestibility, Fiber

INTRODUCTION

Coco peat is abundantly available in many areas that produce coconut oil or coconut products in Indonesia. Coco peat, which is almost similar to soft wood, contains high levels of fiber. Chemical analyses from Balitnak showed crude fibers 30%, cellulose and lignin 65-70%, hemicellulose 8.50%. Coco peat is also reported to contain pentosans, tar, and tannins and that to some extent contribute to a rather sticky property of coco peat. It is hardly used for any purpose, except as a filler in compost to loosen soil solidity, and very few, if any, has been used as part of animal diet. In contrast, as a herbivore animals, rabbits require a certain amount of indigestible fiber, including lignin, in their diet to ensure a digestive health (Gidenne 1992), hence support the optimal gowth of the animal. Requirement of fiber fractions for rabbits needs an appropriate ratio of cellulose to lignin, *e.g.* 3-3.5 : 1 (Gidenne 2013). For commercial rabbit pellet in Indonesia, some commonly used ingredients such as rice bran, wheat bran, copra meal and palm kernel meal contribute a certain amount of fiber (Raharjo 2007). However the most substantial amount of fiber comes from available dried sugar cane tops or dried grass (Nasrullah & Raharjo 2013). As the sugar cane tops is now exported, while production of grasses, is low at dry season and need a drying facilities at rainy season, therefore its availability is uncertain. Moreover, lignin content of these forages are moderately low. One of few available sources in the tropics is cocopeat, which contain high level of indigestible fiber, lignin content in particular.

High levels of crude fiber and tannin in calliandra caused adverse effect to rabbit performance as it reduces the nutrient digestibility (Raharjo et al. 1986). Similar situation may apply to the use of coco peat. The use of enzyme or multi enzymes to improve digestibility has been reported elsewhere (Danicke et al. 1999; Hubener et al. 2002) and hence its used in coco peat containing diet is hypothesized to some extent reduce the negative effect of high levels of fiber and tannins. This experiment was to explore the possibility of using cocopeat as a source of fiber for rabbit and was combined with various levels multienzyme to optimize such use of cocopeat. A study on the digestibility of coco peat in different strains of rabbits was also conducted.

MATERIALS AND METHODS

A 2 × 3 factorial design applying 2 levels of enzyme (0 and 0.03%) and 3 levels of cocopeat (0, 6.01, and 12.02%) was used in the experiment. A commercial enzyme used was a cocktail of enzymes containing protease, carbohydrase, oligosaccaharidase and phytase. Contribution of crude fiber from cocopeat was 4,01 (treatment 3 and 4) and 8,02% (treatment 5 and 6) , while total dietary dietary crude fiber level was about 14%. Chemical composition of cocopeat and of treatments is presented in Table 1. Other main feed ingredients in the diet were corn, soybean meal, rice bran, wheat bran, copra meal and cane tops. Molasses, vitamin-mineral premix, limestone, and bone meal were also added to fit the nutrient requirements (NRC 1977). Each treatment combination consisted of 6 replicates, each of 3 weanling Rex rabbits. All treatments were formulated to contain 18% crude protein, 2550 kcal/kg DE and 14% crude fiber. Trial was carried out for 10 weeks. One animal from each replicate was slaughtered for carcass percentage. A digestibility study was also carried out through a total collection method in 5 strains of rabbit (Rex, Satin, Reza, NZW and Meat-type crossed). In this digestibility trial, coco peat was mixed 50 : 50 with the basal diet. Basal diet contains 16% crude protein, 2500 kkal/kg DE and 9% crude fiber. Fecal collection was carried out for 7 days following a 3 days adaptation. All results were subjected to an Anova analysis which was followed by DMRT (Duncan Multiple Range Test) for any significant differences among treatment means.

Table 1. Calculated chemical composition of diets used in the trial

Nutrient	Treat-1	Treat-2	Treat-3	Treat-4	Treat-5	Treat-6
Level of coco peat (%)	0.00	0.00	6.01	6.01	12.02	12.02
Fiber contribution from cocopeat (%)	0.00	0.00	4.01	4.01	8.02	8.02
Level of enzyme (%)	0.00	0.03	0.00	0.03	0.00	0.03
Digestible energy (kcal/kg)	2520.00	2520.00	2544.00	2544.00	2589.00	2589.00
Crude protein (%)	18.02	18.02	18.05	18.05	18.08	18.08
Crude fiber (%)	14.20	14.20	14.03	14.03	14.08	14.08
Cacium (%)	0.82	0.82	0.72	0.72	0.69	0.69
Phosphorus, total (%)	0.79	0.79	0.93	0.93	0.98	0.98
Lysine (%)	0.89	0.89	0.89	0.89	0.89	0.89
Methionine (%)	0.58	0.58	0.60	0.60	0.60	0.60

RESULTS AND DISCUSSION

Growth performance

Effects of coco peat and enzyme inclusion in the diets on rabbit performance are presented in Table 2. Statistical analysis indicated that there were no interaction detected between levels of coco peat and levels of enzyme used and therefore further analyses were performed between means of treatments within variables (level of coco peat and level of enzyme). Increasing level of coco peat in the diet decreased all parameters measured. However, differences among treatments were significant only in level of coco peat treatments on bodyweight (BW), bodyweight gain (BWG) and meat production. Increasing levels of coco peat decreased the BW, BWG and meat production. However, inclusion of 6% of coco peat is statistically similar to those of 0%. Therefore, the use of coco peat up to 6% is tolerable and in fact, as the diet price is lower (coco peat is of no price, while replaced cane tops is almost 60-70% of corn price), hence any level of the use of dietary coco peat inclusion up to 6% will reduce diet cost while maintaining the animal production. Feed consumption in this trial were somewhat low (56-65 g/rabbit/d) compared with those (70-80 g/rabbit/d) reported by Raharjo and Sartika (1992) on Rex rabbits raised in the cool room. It is therefore not surprising that their BWG was also low (12.0-15.2 g/r/d). Common results of BWG of Rex in Bogor was about 20-25 g/h/d (Raharjo 2008).

Improvements, but not statistically significant, were noted on all parameters measured when the rabbits are fed with the enzyme containing diet. This indicated that the enzyme used had positive effect but was not sufficiently effective to work on the coco peat. The inclusion of 12% coco peat decreased digestibility of the diet by 9.03%, while the addition of enzyme improved its digestibility by 5.07%. This fact suggests that coco peat may be of useful mostly as a source of indigestible fiber for rabbit, to help the health of digestive tract.

Digestibility of dry matter in different rabbit breed

Digestibility of dry matter of coco peat was performed in the growing and mature animal. In the growing animal, coco peat was included in the diet at 6 and 12% with or without enzyme supplementation. Results clearly indicated that inclusion of coco peat in the diet caused a decrease of DM digestibility from 72.4 to 66.4%. The decrease however was not statistically significant. The use of multi enzyme also increased the digestibility from 67.0 to 70.4%. However, the increase did not cause significant difference (P>0.05).

Table 2. Effects of levels of cocopeat and enzymes on the parameters measured.

Parameter	Levels of dietary Cocopeat (%)			Levels of enzyme (%)	
	0.00	6.01	12.02	0.00	0.030
CF from Cocopeat in diet (%)	0.00	4.00	8.00	4.00	8.00
Feed consumption (g/h/d)	65.00	65.00	56.00	58.0	63.00
Bodyweight (g/head)	2116.00^{a}	2039.00^{ab}	1886.00^{b}	1996.00	2060.00
Bodyweight gain (g/h/d)	15.20^{a}	14.60^{ab}	12.00^{b}	12.80	14.80
Carcass percentage (%)	52.00	54.00	51.00	52.00	54.00
Feed Conversion Ratio	4.30	4.45	4.67	4.30	4.20
Meat production (g/head)	887.00^{ab}	916.00^{a}	796.00^{b}	845.00	887.00
Pelt Production	205.00	206.00	185.00	197.00	199.00
Dry matter digestibility of diet (%)	72.40±5.40	67.30±5.50	66.40±2.20	67.00±3.70	70.40±5.80

^{a,b,c} in the same row differ significantly

The decrease of DM digestibility in coco peat containing diet is predicted because of the nature of coco peat that contains very high fiber fraction and also contains tannin/phenolic group, which contribute to the undigestion of dietary nutrient component (Raharjo et al. 1986).

Dry matter digestibility of basal, mixed diet and calculated coco peat in different breed of rabbits is presented in Table 3. Feeding basal, irrespective of breeds, to the mature male rabbits gave small but positive gain. This indicated adequate nutrient intake to meet the need for growth maintenance. This probably supported by the fact that feed consumption of basal diet by these 5 breeds were normal, about 71 g/h/d (rex) - 90 g/h/d (crossed bred rabbit. In addition, a diet containing 18% crude protein and 2550 kcal digestible energy plus addition of energy (fat), vitamins and minerals, provides somewhat adequate nutrients and that, reduce the negative effect of the coco peat. A somewhat high variation in the replication among treatments, on the BWG was also noted and contributed to the non-statistical difference, eventhough the improvement by enzyme addition was almost 15%.

Dry matter digestibility of the basal diet was similar to those in young rabbits (68.9-74.6%). On the other hand, feed consumption of coco peat containing diet, were surprisingly low. Range of intake of coco peat diet were 44 g/h/d (Reza) to 60 g/h/d (crossed rabbit). This results indicated that coco peat was less palatable to the rabbit. Not only it was less palatable, coco peat mixed diet also very low in their digestibility value (19.3-35.2%) and consequently it caused negative weight gain to the rabbit, regardless of the breed.

When those digestibility data from basal and mixed diet were calculated, the DMD of coco peat in 5 breeds of rabbits were extremely poor and were negatives in the Reza, Satin and Rex rabbits (-7.63, -7.98, and -11.69, respectively). This results suggest that coco peat binds the nutrients of basal diet and makes those nutrients undigested by the rabbits. It is particularly true, because coco peat is very high in lignin and other indigestible fiber fractions and also tannin, whose properties is their ability to bind nutrients and cause them undigested (Gidenne 2013). The binding effect occurred more with the drying process in forage materials (Raharjo et al. 1986).

Between breeds (Reza, Rex and Satin), in terms of BW, BWG, feed consumption, and their DMD, were comparable. Those 3 breeds are medium type breeds and each has exotic fur. Digestibility results of crossed bred and NZW were also very small (7.23 and 6.20%,

Table 3. Digestibility of basal diet solely or mixed with coco peat included solely or is mixed with basal diet in different strains of rabbits

Breed	Basal				Mixed diet (basal : coco peat = 50 : 50)				Coco peat (%)
	Initial weight (g/head)	Weight gain (g/head)	Feed Intake (g/head)	DM Digest (%)	Initial weight (g/head)	Weight gain (g/head)	Feed Intake (g/head)	DM Digest (%)	DM Digest coco (%)
Reza	2583.00	28.00[a]	567.00[ab]	70.30	2571.00	-195.00	306.00[a]	21.60[a]	-7.63
sd	185.00	76.00	56.00	6.30	135.00	113.00	74.00	21.80	7.09
Satin	2309.00	57.00[a]	552.00[ab]	69.20	2377.00	-144.00	317.00[a]	22.80[a]	-7.98
sd	264.00	37.00	63.00	5.00	266.00	64.00	55.00	15.00	4.93
Rex	2313.00	61.00[a]	497.00[b]	68.90	2354.00	-164.00	335.00[a]	19.30[a]	-11.69
sd	408.00	117.00	89.00	3.80	316.00	71.00	56.00	14.60	1.64
Cross	3478.00	32.00[a]	627.00[a]	71.70	3451.00	-130.00	419.00[b]	35.20[b]	7.23
sd	157.00	67.00	28.00	4.40	195.00	87.00	35.00	8.10	4.24
NZW	3201.00	110.00[b]	575.00[ab]	74.60	3254.00	-205.00	373.00[ab]	32.50[ab]	6.20
sd	74.00	158.00	58.00	5.00	224.00	96.00	41.00	11.00	8.09

[a,b,] in the same column differ significantly

respectively) yet were comparable between these breeds. The NZW and crossed bred rabbit are meat-type rabbit, have been more selected to multiplying and growing fast. So probably their digestive system mechanism is better than the Rex/Satin/Reza group.

These results suggested that coco peat is highly indigestible to the rabbit and its use at more than 6% may cause adverse effect to the efficiency of nutrient metabolism and to the growth of animal.

CONCLUSION

Since rabbits do need certain indigestible in their diet and also to make use of this waste product, the level of coco peat is not more than 3% in rabbit diet.

REFERENCES

Danicke S, Vahjen W, Simon O, Jeroch H. 1999. Effects of dietary fat type and xylanase supplementation to rye-based broiler diets on selected bacterial groups adhering to the intestinal epithelium. on transit time of feed, and on nutrient digestibility. Poult Sci. 78:1292-1299.

Gidenne T. 2003. Fibres in rabbit feeding for digestive troubles prevention: respective role of low-digested and digestible fibre. Livest. Prod. Sci. 81:105-117.

Gidenne T. 2013. Dietary fiber: their analysis in animal feeding and their role in rabbit nutrition and health. 2nd International Conference on Rabbit Production in Indonesia. Bali, 27-29 August 2013.

Hubener K, Vahjen W, Simon O. 2002. Bacterial responses to different dietary cereal types and xylanase supplementation in the intestine of broiler chicken. Arch Tierernahr. 56:167-87.

Nasrullah, Raharjo YC. 2013. Recent Advances in Rabbit Research in Indonesia. 2nd International Conference on Rabbit Production in Indonesia. Bali, 27-29 August 2013.

Raharjo YC. 2008. Strategy on the development of small- and medium-scale rabbit farming based on farmers cooperation. A case of rabbit production in Indonesia. In: Xiccato G, Trocino A, Lukefahr SD, editors. Proceedings of the 9th World Rabbit Congress. 9th World Rabbit Congress. Verona, June 10-13, 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche e Zootecniche. p. 1609-1614.

Raharjo YC, Sartika T. 1992. Effects of environmental temperatures and restricted feeding on the performance, carcass percentage and fur quality of the Rex rabbit. J Appl Rabbit Res. 15:1590-1598.

Raharjo YC, Cheeke PR, Patton NM, Supriyati K. 1986. Evaluation of tropical forages and by-product feeds for rabbit production. 1. Nutrient digestibility and effect of heat treatment. J Appl Rabbit Res. 9:56-66.

Effect of Various Fiber Sources on the Growth of Weaned Rabbit

Susana IWR

Indonesian Research Institute for Animal Production, Jl. Veteran III, Ciawi-Bogor, Indonesia 16720
Corresponding e-mail: susanawijaya@yahoo.com.au

ABSTRACT

Four fiber sources (cane-top, rice straw, saw dust and rice hull) were observed in this study. Digestibility trial was carried out using 12 male satin rabbit (3 replicates, each of 4 rabbits). Each of test fiber source was mixed with a basal diet at 1:1 ratio and then were pelleted. Three days adaption period was applied and followed with 7 days feeding and fecal collection. Protein digestibility was 30.78% (basal+canetop) and 57.22% for basal diet. Energy digestibily showed positive value, however NDF, ADF and lignin digestibilities showed negative values for basal and basal + canetop, rice straw and saw dust. The result showed that rice hull gave positive values for all digestibility subjects. Feeding trial was conducted to 100 weaned rabbit (6 week-old) with 5 treatments (1)Control, 2) Basal+canetop, 3) Basal+ rice straw, 4) Basal+ saw dust and 5) Basal+ rice hull. The crude protein content was between 17.6 % and 18.27% and gross energy was between 3834 and 4499 kcal/ kg. Feed consumption, weight gain, feed consumption ratio was measured. The average of total mortality in the 6th week reached 27% with the highest for basal+canetop treatment (45%) and followed with saw dust (30%), for rice straw and rice hull (both 25%). Average daily feed consumption of each rabbit for control basal (B), basal+canetop (BCT), basal+rice straw (BRS), basal+saw dust (BSD) and basal+rice hull (BRH) treatments were 100.02; 72.65; 69.54; 65.76 dan 63.95 g respectively. The average of feed consumption ratio for B, BCT, BRS, BSD and BRH were 4.68, 6.87; 6.15; 6.88 and 7.40 respectively and average of daily weight gain for B, BCT, BRH, BRS and BSD were 17.2; 11.11; 5.62; 14.34 and 8.19 g respectively. Rice straw could be a promising fiber source that can be used for rabbit diet.

Key Words: Fiber Sources, Rice Hull, Cane Tops, Saw Dust, Rice Straw

INTRODUCTION

Fiber is an important component in a rabbit ration and it is recommended that 12-16% of rabbit feed should be crude fiber (de Blas 2004). While fiber is not considered to be an "essential" nutrient, however it is certainly important to the rabbit to maintain a healthy gut function, motility and transit of feed ingested (Belenguer et al. 2002; Garcia et al. 1993). Low fiber intake has been reported to decrease the volatile fatty acid (VFA), increase pH and ammonia levels in the caecum (Gidenne et al. 2004). Indonesia is one of the intensive agriculture countries in South East Asia with rice as the most priority crop. Byproduct from agriculture is abundant in Indonesia such as of rice (rice bran, straw, hull /husk), sugarcane (sugarcane top, bagasse, molasses) and wood (sawdust).

Rice straw is usually used as alternative feedstuffs for the animals in most rice-based farm areas in Indonesia, especially during dry season. Rice straw has low content of essential nutrients like protein, energy, minerals and vitamins as well as poor palatability and digestibility. The main components of rice straw are fibrous cell wall substances consisting of cellulose, hemicellulose, lignin and silica. With the proportion of 20% husk and 50% straw in rice weight (Lim et al. 2012), the production of rice husk and straw may reach 14 million and 34.5 million ton per year, respectively (Ministry of Agriculture 2013). Rice straw is commonly used for cattle feed by farmers, while rice hull was rarely used as animal feed.

Sugar cane top is a major side-product of the sugar industry and obtained after the harvesting of the sugarcane plant. Indonesian sugarcane area had reached 418,000 hectares in 2010 with sugarcane production was 34 million tons and approximately produced 16.7 million tons of waste products as cane top and bagasse (Directorate General of Crops Plantations 2011). Cane top and bagasse are familiar to farmers and used as feed for cattle or other ruminant animals.

Meanwhile saw dust as a waste from wood industry although is abundant but is not used as animal feed. Those agricultural wastes are rich in crude fiber component and since fiber is essential in rabbit feed, their digestibility, chemical composition and their effect on rabbit growth rate were evaluated and reported.

MATERIALS AND METHODS

Digestibility trial was performed using 12 weaned rabbit. Tested ingredients were cane top (CT), rice hull (RH), rice straw (RS) and saw dust (SD), each was mixed (1 : 1w/w) with basal diet (Table 1). Feeding was conducted for 3 days adaptation period and 7 days collection periods. Intake, feed refusal, fecal produced were recorded. Proximate analysis (crude protein, CP; Crude fiber, CF; fiber fractions (NDF, neutral detergent fiber and ADF, acid detergent fiber) and energy was measured. Crude protein, CF, NDF. ADF and lignin digestibility were calculated.

Feeding trial was conducted using 100 weaned rabbit for 6 weeks. Basal diets consist of fish meal, soybean meal, coconut kernel cake, rice bran, corn, elephant grass, vegetable oil, premix (Table 1).

Feeding was performed in five treatments as follows: (1) Control: basal diet (B, Table 1); (2) Basal diet containing cane top (BCT); (3) Basal diet containing rice hull (BRH); (4)Basal diet containing rice straw (BRS); (5) Basal diet containing saw dust (BSD).

Table 1. Basal diet composition

Feed Ingredient	%
Corn	27.0
Elephant grass	25.0
Soybean meal	16.2
Rice bran	15.3
Coconut kernel cake	7.5
Fish meal	3.0
CPO	2.0
Molases	2.0
$CaCO_3$	1.0
DCP	0.5
Topmix	0.3
Salt	0.2

When fiber material was added, elephant grass was omitted. All fiber feed materials were added to basal diet to meet the minimum fiber content for rabbit (12%). Feed offered, feed refusal, weekly body weight were recorded.

RESULTS AND DISCUSSION

Digestibility

Proximate analysis of fiber feed material, basal diet, and faecal samples were shown in Table 2. Basal diet (B) contained 17.66% protein and protein content in basal + fiber feed ingredient was between 11 and 15%. The dietary protein requirement of growing rabbits has been set at 15.5 to 16% (NRC 1977; De Blas & Wiseman 2010). However, Cheeke (1987) reported that 11% protein in the rabbit diet will support growth when casein was used as protein source.

Fiber content in basal diet was 13% and in the basal + fiber feed ingredient (1 : 1) between 15 and 32%. Fiber content of cane top (CT) was higher than rice straw (RS) but much lower when compared with saw dust (SD) and rice hull (RH) that reached up to 52%. Fiber component in CT mostly is cellulose and the crude protein content of CT was the lowest than the three other fiber materials. In the shortage of elephant grass, CT was used as grass replacer to fulfill fiber need for rabbit feed. Typical nutritive value of sugarcane top had been reported wit CP content and digestibility was 5.5 and 27.5% (NSW Department of Primary Industries 2007).

The most general method for determining digestibility involves the collection of all feedd eaten and all excreta produced (total collection method). The apparent digestibility of basal diet, CT, RS, RH and SD is presented in Table 3. Crude protein, crude fiber, NDF, ADF and lignin digestibility were significantly different ($P<0.05$) among treatments. Basal and basal-rice straw were similar for CP digestibility (51 and 59%) while for other treatments were between 31 to 35%. It was reported that apparent digestibility of urea treated RS were between 64.42 and 73.62% (Hossain et al. 2010).

Table 2. Proximate analysis of basal diet, fiber sources feed ingredients and faecal samples for digestibility measurement of fiber sources feed ingredients

Sample	%CP	%C Fiber	Gross energy	%NDF	%ADF	%Lignin
Cane top (CT)	4.54	38.15	4157	45.50	40.75	16.65
Rice hull (RH)	12.28	52.23	5039	74.20	62.30	20.18
Rice straw (RS)	5.74	28.11	4153	37.15	16.50	12.48
Saw dust (SD)	9.70	52.15	6439	72.83	43.17	24.22
Basal diet (B)	17.66	12.71	2653	22.89	13.59	2.22
BCT (Basal+cane top)	11.10	15.43	3405	43.99	27.55	3.92
BRH (Basal+rice hull)	14.97	32.47	3846	40.83	39.98	10.00
BRS (Basal+rice straw)	11.70	20.41	3403	47.79	34.24	4.53
BSD (Basal+straw dust)	13.68	32.43	4546	53,17	38.47	9.18
Fecal composition						
FBCT (Basal+cane top)	11.53	25.32	3027	64.29	39.44	5.95
FBRH (Basal+rice hull)	14.42	24.39	3704	52.66	41.30	7.79
FBRS (Basal+rice straw)	8.64	35.01	3207	73.98	54.19	8.02
FBSD (Basal+straw dust)	7.83	53.60	3899	77.71	61.62	15.12

Table 3. Crude Protein, Crude Fiber, Neutral and acid detergent fiber and lignin Digestibility ofbasal diet and canetop, rice straw, rice hull and saw dust

Digestibility (%) of	B	BCT	BRS	BRH	BSD
CP	58.72 ± 3.87	30.78 ± 3.11	50.72 ± 3.77	34.38 ± 2.56	35.13 ± 2.40
CF	34.91 ± 7.97	34.91 ± 7.07	(4.02) ± 5.37	48.71 ± 1.72	(9.61) ± 2.66
NDF	21.11 ± 3.69	2.22 ± 1.14	(3.26) ± 1.92	11.37 ± 11.89	17.11 ± 3.65
ADF	14.58 ± 4.71	4.58 ± 14.71	(5.57) ± 1.97	29.11 ± 7.87	6.22 ± 2.48
Lignin	9.90 ± 4.06	10.90 ± 4.96	(8.09) ± 9.50	46.66 ± 3.95	(8.21) ± 4.02

Treatment BRS showed a negative digestibility value for CF, NDF, ADF and lignin (value shows in brackets) and BSD diets showed negative value for CF and lignin.

Lignin is commonly derived from woody plants and being an integral part of the cell wall of plants. Negative value on lignin digestibility such as in BRS and BSD diets could be caused by the formation of artifact lignin either in the gastrointestinal digestion and released through feces and triggered by drying method of faecal sample. Artifact lignin could alter on lignin determination and could result to higher value of lignin in feces than in intake. The digestibility of cane top in this experiment was lower than *in vitro* digestibility that had been reported (35.2%, Mohammadabadi & Chaji 2010).

Rabbit performance

Feeding trial was conducted for 6 weeks and basal diet as shown in Table 1. Chemical composition of treatment diets was presented in Table 4. Crude fiber content of diet which contained fiber materials tested were lower than 12% except for BSD (13.24%), while basal diet contained 12.71% of CF (Table 2). Crude protein content was similar among treatments, between 17.41 and 18.27%. The highest value of fiber fraction in the form of NDF and ADF was found in BRS diet (31.04 and 20.96% respectively) followed by BSD, BCT and BRH diets. The NDF fraction represents a cell wall content of feed forage, gives a close estimate of fiber constituents of feedstuffs as it measures cellulose, hemi-cellulose, lignin, silica, tannins and cutins.

Table 4. Proximate Analysis of treatment diets

Chemical composition		Fiber source			
		BCT (cane top)	BRH (rice hull)	BRS (rice straw)	BSD (saw dust)
DM	(%)	90.65	90.70	91.16	90.24
CP	(%)	17.90	18.27	17.60	17.41
Fat	(%)	8.10	9.73	9.52	6.74
CF	(%)	9.17	8.05	10.38	13.24
NDF	(%)	22.89	20.08	31.04	25.80
ADF	(%)	13.59	14.19	20.96	17.13
Lignin	(%)	2.22	4.00	2.69	4.50
Ash	(%)	8.40	9.05	13.32	6.48
Ca	(%)	0.89	0.86	0.89	0.94
P	(%)	0.77	0.78	0.61	0.79
Energy	(kcal/kg)	3979	4499	3834	4235

Fiber level in rabbit diet was recommended as between 33 and 40% NDF and approximately 17% ADF (De Blas & Mateus 1998) and a daily intake of 6 g lignin (Dalle Zotte 2002). In this experiment NDF and ADF content of BRS diet was almost similar to the recommended NDF and ADF content.

Average of daily feed consumption for basal diet (control) between 67 and 121 g/head/day, was significantly higher (P<0.05) with other treatments, while other treatments were similar in daily intake which was between 44 and 77 g/head/day (Figure 1). It was significant difference in feed consumption (P<0.05) between control and other treatments. Average daily feed intake for rabbit fed with different levels of protein was reported between 75 and 85 g/h/day (Wang et al. 2012).

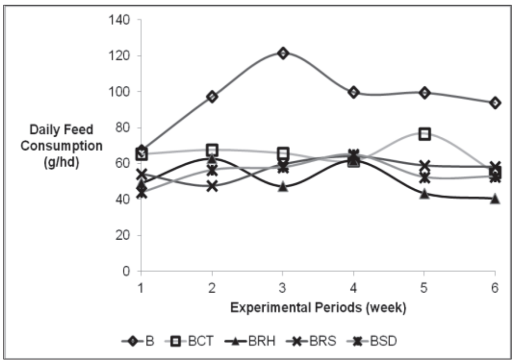


Figure 1. Daily feed consumption during 6 weeks experimental period

Average daily weight gain of rabbit during experimental period is presented in Figure 2. Control (B) and BRS treatments showed a similar pattern of weight gained with the highest weight was at the 3rd week of experiment period and then showed a reduction until the end of experiment. Other treatments showed a steady weighed gain.

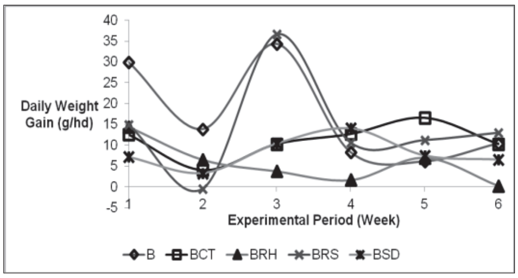


Figure 2. Daily weight gain of rabbit during 6 weeks period

Some of feed conversion ratio (FCR) of treatment feed was giving a negative value. It showed that some of the rabbits had a lower gain during experiment than in the initial period. Feed conversion ratio for control diet (B) was 2.34 to 7.72; BCT -5.96 to 7.13; BRH 3.65 to 12.06; BRS 3.83 to 10.54; BSD -1.98 to 8.12. Overall mortality reached up to 27% with the highest percentage of mortality (45%) was by BCT treatment (Table 4). Mostly the mortality of rabbit was due to reduction in weight gain. It was probably the palatability of the feed shared the reason in low intake and then low weight gain of animal.

Table 4. Percentage of Mortality of rabbit during experiment

Treatment	Dead	Percentage
B	2.0	10
BCT	9.0	45
BRH	5.0	25
BRS	5.0	25
BSD	6.0	30
Total	27.0	27
Average	5.4	27

CONCLUSION

The result from this study showed that rice straw could be a promising fiber source that can be used for rabbit diet. It gave a similar feed intake and average daily gain to control diet.

REFERENCES

Belenguer A, Balcells J, Fondevila M, Torre C. 2002. Caecotrophes intake in growing rabbits estimated either form urinary excretion of purine derivatives or from direct measurement using animals provided with a neck collar: effect of type and level of dietary carbohydrate. Anim Sci. 74:135-144.

Cheeke PR. 1987. Rabbit Feeding and Nutrition. Orlando (USA): Academic Press.

Dalle Zotte A. 2002. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Livest Prod Sci. 75:11-42.

De Blas F. 2004. Reflections on rabbit nutrition with a special emphasis on feed ingredients utilization. In: Proceedings of the 8th World Rabbit Congress. Ciudad de Puebla, 7–10 September 2004. Ciudad de Puebla (Mexico): World Rabbit Congress. p. 686-736.

De Blas JC, Mateous GG. 1998. Feed formulation. In: de Blas JC, Wiseman J, editors. The Nutrition of the Rabbit. Wallingford (UK): CABI International. p. 241– 253.

De Blas JC, Wiseman J. 2010. Nutrition of the Rabbit. 2nd edition. Madrid (Spain): CABI Publishing.

Directorate General of Crops Plantations. 2011. Swasembada gula nasional. Bimbingan teknis tebu. Direktorat Tanaman Semusim, Jakarta (Indonesia): Direktorat Jenderal Perkebunan.

Garcia G, Galvez JF, de Blas JC. 1993. Effect of substitution of sugarbeet pulp for barley in diets for finishing rabbits on growth performance and on energy and nitrogen efficiency. J Anim Sci. 71:1823-1830.

Gidenne T, Jehl N, Lapanouse A, Segura M. 2004. Inter-relationship of microbial activity, digestion and gut health in the rabbit: effect of substituting fiber by starch in diets having a high proportion of rapidly fermentable polysaccharides. Br J Nutr. 92:95-104.

Hossain MM, Khan MJ, Akbar MA. 2010. Nutrient digestibility and growth of local bull calves as affected by feeding urea and urease enzyme sources treated rice straw. Bangladesh J Anim Sci. 39:97-105.

Licht FO. 2009. World Sugar Statistics 2010. Kent (UK): Agra Informa Limited.

Lim JS, Manan ZA, Wan Alwi SR, Hashim H. 2012. A review on utilisation of biomass from rice industry as a source of renewable energy. Renew Sustain Energy Rev. 16:3084-3094.

Ministry of Agriculture. 2013. Agriculture Database. Jakarta (Indonesia): Ministry of Agriculture. http://aplikasi.deptan.go.id/bdsp/hasil_kom.asp assessed September 2nd 2013.

Mohammadabadi T, Chaji M. 2010. *In vitro* digestibility of sugarcane top treated with exogenous enzyme or sodium hydroxide. Proc Aust Soc Anim Prod. 28:45.

Muhammad D. 2012. Manisnya Pembangunan Pabrik Gula Hingga 'Disemuti' 20 Pengusaha. Republika On Line, Jumat, 27 Juli 2012, 20:23 WIB. [Internet]. [cited 12 September 2012]. Available at: http://www.republika.co.id/berita/nasional/umum/12/07/27/m7tmiz-manisnya-pembangunan-pabrik-gula-hingga-disemuti-20- pengusaha).

NRC. 1977. National Research Council: Nutrient Requirements of Rabbits. Washington DC (USA): National Academy Press.

NSW Department of Primary Industries. 2007. New South Wales (Australia): Prime fact. 314.

Wang XP, Ma MW, Sun LZ, Wang CY, Zhu YL, Li FC. 2012. Effects of different protein, fiber, and energy levels on growth performance and the development of digestive organs in growing meat rabbit. In: Proceedings 10th World Rabbit Congress. Sharm El- Sheikh, September 3-6, 2012. Sharm El- Sheikh (Egypt): World Rabbit Congress. p. 641-645.

The Effect of Dietary *Lythrum salicaria* on the Rabbit's Performance and Microbial Community

Kovitvadhi A[1], Gasco L[1], Ferrocino I[1], Cocolin[1], Malavasi C[2], Zoccarato I[1]

[1]Department of Agriculture, Forestry and Food Sciences, University of Torino, via Leonardo da Vinci 44, 10095 Grugliasco, Torino, Italy
[2]Biotrade s.n.c., via Pacinotti 21, 41037, Mirandola, Modena, Italy
Corresponding e-mail: attawitthai@hotmail.com

ABSTRACT

Medical plants with anti-microbial properties have been used as an animal diet supplementation, to improve the performance and health in commercial and organic livestock productions. One of the medical plant, *Lythrum salicaria* (LS; purple loosestrife), was discovered those activities from their extracted compounds. Balanced microbial community in rabbit gastrointestinal tract have important role to provide the healthy condition. Therefore, the effect from dietary LS on performance and on gut microbiota were the objective of this research. One hundred and sixty Hycole weaned rabbits (35-day-old) were randomly decided into four groups which included one control and three treatment groups. Respectively, 0.2%, 0.4% dry powder of LS and CUNIREL (CR; the commercial phyto-additive mixture from Biotrade®, Italy, contained the LS as the main ingredient) were added in the treatment diets. Performance data were recorded at 1, 21 and 49 days after experiment beginning. For microbial diversity analysis, hard feces from 10 systemic random sampling rabbits, were collected separately at 35, 42, 49, 56, 70 and 89 days of age, whereas caecal contents were taken at slaughter day (89-day-old). After that, samples which in the same group, collected site and collected date were pooled for further molecular analysis. The microbiota were assessed at species level by using Polymerase Chain Reaction-Denaturing Gradient Gel Electrophoresis (PCR-DGGE) analysis of 16S rRNA gene. There were not statistically significant differences on performances (weight, average daily weight gain, average daily feed intake, feed conversion ratio, morbidity, mortality and health risk index) between the control and treatment groups. The dendrogram generated by using DGGE profiles of 16S rRNA fragments show that the similarity between rabbit fed with LS and commercial product were higher if compared with conventional diet. On the other hand, we found high similarity between samples obtained from caecal content and hard feces at the end of the experiment whereas no any adverse effects from dietary LS were found on rabbit's performance.

Key Words: DGGE, *Lythrum salicaria*, Microbial Community, Performance, Rabbit

INTRODUCTION

Organic livestock farming have been interested by global viewpoint because products from this husbandry are known as organic products which more safety for the consumption, higher value than other common products and less environmental contamination (Sundrum 2001). Anyways, the organic farming still has chances to suffer from health problems because the antibiotic usage is strictly limit. There was the similar situation when the European Union banned the antibiotic usage as the growth promoter in livestock animals. From that prohibition, a product yield reduction, a sharp increment of morbidity and mortality rate were discovered (Casewell et al. 2003). Any supplements which have potentiality to achieve those requirements and allow to use in the organic farming, have been investigated. Medical plants with anti-microbial and anti-oxidant properties, are receiving considerable attention (Franz et al. 2010; Christaki et al. 2012).

Lythrum salicaria (LS) with common name is purple loosestrife, is in the Lythraceae family. LS were considered as the invasive and competitive plant in the ecosystem for the special ability on environmental adaptation and faster reproduction. On the other hand, medical functions (such as anti-diarrhea, anti-dysentery, anti-haemorrhagic) were discovered and used in folk medicine. *In vitro* studies, main action compounds (*e.g.* tannins and flavanoids) which were identified by extraction, had anti-microbial, anti-fungal, anti-inflammatory and anti-oxidant activities (Becker et al. 2005; Tunalier et al. 2007; Humadi & Istudor 2009).

From those properties, LS should have capacity to apply as the additive in rabbit feed to develop rabbit's health and performance.

The microorganism in rabbit's digestive tract have important role to develop the gut immunity and prevent the pathogen overgrowth. Therefore, the microbiota community can be the criteria which evaluate gut health status (Fortun-Lamothe & Boullier 2007). Molecular methods such as polymerase chain reaction denaturing gradient gel electrophoresis (PCR-DGGE) are optimized for an easy comparison of profiles from related microbial assemblages and are used in many ecological studies (Michelland et al. 2010). The study on the effect from LS supplement in rabbit diet on the microbial environment and performance is the aim of this research article.

MATERIAL AND METHODS

Animals and diets

The experiment was performed at the Department of Animal Science experimental rabbitry in Carmagnola, Turin, Italy. One hundred and sixty weaned, Hycole rabbits which were 35-day-old with 934.3±118 g of the initial weight, were randomly decided into four groups with equal sex and number (one control group and three treatment groups). Normal distribution and equal variance were confirmed before experimental beginning by statistic analysis. Each animals were separated in the individual standard cage with free access of clean water. The indoor housing temperature and light-dark photoperiod cycle were maintained at 22±2°C and 12-hour light/12-hour dark along the experiment, respectively. The ingredients of the experimental diets were reported in Table 1 and conserved for the control group. Diets for treatment groups supplemented by 0.2% LS and 0.4% LS powder which provided from dry LS leaves grinding by Biotrade®, Italy. CUNIREL (CR; Biotrade®, Italy) which are the commercial mixtured of medical plants with LS are the main composition, were added in another treatment diet. A feeding strategy was *ad libitum*.

Performance and hard feces collection

Weight, feed intake, morbidity (digestive disorders, respiratory disease, weight under 2 standard deviation: SD, from group mean and others) and mortality from individual rabbits at the first day, after 3 weeks and after 7 weeks of experiment, were recorded to compute the performances which were the average daily

Table 1. Ingredients of the experimental diets

Ingredients (%)	Control	0.2% LS	0.4% LS	CR
Dehydrated alfalfa meal	29.0	29.0	29.0	29.0
Barley	19.0	18.8	18.6	18.7
Dry beet pulp	14.0	14.0	14.0	14.0
Wheat bran	20.0	20.0	20.0	20.0
Soybean seed meal	6.0	6.0	6.0	6.0
Sunflower seed meal	6.0	6.0	6.0	6.0
Soybean oil	1.0	1.0	1.0	1.0
Molasses	1.5	1.5	1.5	1.5
Dicalcium phosphate	0.5	0.5	0.5	0.5
Vitamin-mineral premix[1]	1.0	1.0	1.0	1.0
Wheat straw	1.0	1.0	1.0	1.0
Corn gluten	1.0	1.0	1.0	1.0
Supplements	0.0	0.2	0.4	0.3

LS: dry *Lythrum salicaria* powder; CR: CUNIREL (Biotrade®, Italy) mixtured of medical plants with LS were the main composition; [1] Per kg of diet: Vit. A 200 IU; α-tocopheryl acetate 16 mg; Niacine 72 mg; Vit. B6 16 mg; Choline 0.48 mg; DL-methionine 600 mg; Ca 500 mg; Pt1:13 920 mg; K 500 mg; Na 1 g; Mg 60 mg; Mn 1.7 mg; Cu 0.6 mg gain (ADG), average daily feed intake (ADFI), feed conversion ratio (FCR) and health risk index (HRi). Necropsy were performed in dead rabbits. 10 systemic random rabbits from each group were selected for the hard feces collection at 35, 42, 49, 56, 70 and 89 days of age and samples kept in -20°C until analysis will perform.

Slaughter procedures and caecal content collection

The 89-day-old rabbits (54 days after the experiment beginning) with 3126±193 g of a final weight, were killed by concussion technique without fasting at the Department of Animal Science experimental slaughter house, Carmagnola, Turin, Italy. Immediately after the end of the slaughter process, a caecal content of the same rabbit which were selected for the hard feces collection, were collected and kept in -20°C for further analysis.

DNA extraction and PCR-DGGE analysis

For DNA extraction, feces and caecal content of 10 rabbits from the same group, collected site and collected date, as previously reported, were pooled together. Samples (10 g) were homogenized in a stomacher bag with 20 ml of quarter-strength Ringer's solution (Oxoid) for 1 min; a deposit was allowed to set for 1 min, and 1 ml of the supernatant was used for the DNA extraction. The protocol described from manufacturer's instructions of Powersoil DNA kit (MO-BIO, Carlsbad, CA) were used. The DNA solution was incubated at 37°C for 30 min with 5 µl of RNAse (Promega, Milano), and then stored at -20°C. DNA was quantified by using the NanoDrop 1000 spectrophotometer (Thermo Scientific) and was standardized at 50 ng μl^{-1}. The primers 338F-GC and 518R (Muyzer et al. 1993) were used to amplify the variable V3 region of the 16S rRNA gene, giving PCR products of about 300 bp. Amplifications were performed in a programmable heating incubator (Bio-Rad, Milan, Italy) as previously described (Muyzer et al. 1993). Aliquots (2 ml) of PCR products were routinely checked on 2% agarose gels. PCR products were analyzed by denaturing gradient gel electrophoresis (DGGE) by using a Bio-Rad Dcode apparatus. Samples were applied to 8% (wt/vol) polyacrylamide gels in 1 × TAE buffer. Parallel electrophoresis experiments were performed at 60°C using gels containing a 20 to 60% urea-formamide denaturing gradient (100% corresponded to 7 M urea and 40% (wt/vol) formamide). The gels were run for 4 h at 200 V, stained with SYBR® Gold Nucleic Acid Gel Stain (Invitrogen, Milano) for 30 minutes, visualized under UV-transillumination and photographed by Bio-Rad Gel Doc system (Bio-Rad, Milano, Italy).

A database of fingerprints was created by using the software Bionumerics version 5.1 (Applied Maths, Sint Marten Latem, Belgium). A dendrogram of similarity was retrieved by using the Dice coefficient and unweighted pair group method using arithmetic average (UPGMA) clustering algorithm (Vauterin & Vauterin 1992).

Statistical analysis

Continuous data were analyzed by using one-way analysis of variance (ANOVA). All of statistic analyses were performed with an SPSS 11.5.1 for Windows statistical software package (SPSS Inc., Cary, NC, USA). Categorical data (morbidity, mortality and health risk index), chi-square was used.

RESULTS AND DISCUSSION

Along the experiment, no statistic significant difference between treatment and control groups were observed from any observed parameters (Table 2).

However, Ayala et al. (2011) reported the growth parameter improvement in fattening rabbits when oregano was used as phyto-additive whereas others research did not find any effect on performance between control and treatment groups. (Botsoglou et al. 2004; Soultos et al. 2009; Szabóová et al. 2012). In general, active components from aromatic plants have potential to promote better flavour in feed that directly increase consumption from animals. Hence, the performance improvement should observe in phyto-additive animals but actually most of outcomes were given none or adverse effects (Franz et al. 2010; Christaki

Table 2. Performance of rabbit fed 0.2%LS, 0.4%LS and CR from 35 to 84 days of age[1, 2]

Performance parameters	Control	0.2%LS	0.4%LS	CR	RMSE
Weaning (35 days) to 56 days of age					
Initial weight (g)	933.78	938.78	929.38	935.25	119.09
Weight at 56 days (g)	1760.39	1761.79	1771.70	1754.69	253.58
ADG (g/day)	37.53	37.25	37.79	37.06	18.58
ADFI (g/day)	92.10	94.49	98.08	95.42	9.32
FCR	2.48	2.58	2.61	2.63	0.34
Morbidity (%)	17.50	20.00	15.00	15.00	
Mortality (%)	5.00	5.00	7.50	5.00	
56 to 84 days of age					
Weight at 84 days (g)	2925.55	2928.28	2849.75	2844.62	369.04
ADG (g/day)	41.61	41.66	38.50	38.93	23.28
ADFI (g/day)	146.25	149.41	145.95	144.29	7.75
FCR	3.54	3.69	3.99	3.91	1.04
Morbidity(%)	7.89	7.89	8.11	10.53	
Mortality(%)	0.00	0.00	0.00	0.00	
Weaning to 84 days of age					
ADG (g/day)	39.82	39.72	38.19	38.11	18.77
ADFI (g/day)	122.43	125.25	124.89	122.79	6.42
FCR	3.10	3.17	3.32	3.28	0.40
Morbidity (%)	25.00	27.50	22.50	25.00	
Mortality (%)	5.00	5.00	7.50	5.00	
HRi (%)	30.00	32.50	30.00	30.00	

LS: dry *Lythrum salicaria* powder; CR: CUNIREL (Biotrade®, Italy) mixtured of medical plants with LS were the main composition; ADG: Average daily weight gain; ADFI: Average daily feed intake; FCR: Feed conversion ratio; HRi: Health risk index= mortality+morbidity rates; [1] 40 animals in each group; [2] No statistically significant ($P<0.05$) differences were noted

et al. 2012). On the other hands, positive outputs on performances were found in the rabbit, poultry and swine production when the commercial product, mixture of essential oils or mixture of herbs, were used (Krieg et al. 2009; Franz et al. 2010; Christaki et al. 2012). Synergistic effect from different plant's essential oil provides probably stronger actions or any effects that supports on the animal performances. Anyways, more evidences from future research studies must perform.

The incidence of mortality were only found at the first three week of fattening period which no difference between any groups. After the necropsy, main gross lesions were completely without normal faecal production, gastrointestinal impaction and no inflammation in internal organs. Gastrointestinal hypomotility or gut stasis were the main suspected disorder in this experiment. Watery or mucous diarrhea and weight under 2SD from the group mean were observed and recorded as the morbidity animals. On the same pace, there were not any difference on illness and dead animals between any study groups which as similar as other articles (Ayala et al. 2011; Botsoglou et al. 2004; Soultos et al. 2009; Szabóová et al. 2012).

In this study, the overall outcome on bacterial community from PCR-DGGE analysis of DNA extracted directly from hard feces and caecal content was generated to visualize by the dendrogram (Figure 1). The age increment influenced the dynamic of the microbiota which was observed in this study. The fingerprints of control group with old age (56 and 70 days) were different if compared to the younger groups. Moreover, the relationship between age and microbial community were reported because the development of intestinal microbiota had mission to support the fiber digestion. (Combes et al. 2011).

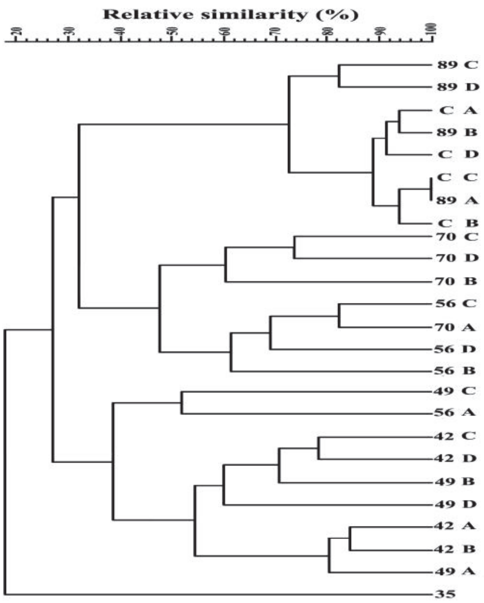


Figure 1. Dendrogram of similarity generated by the digitized DGGE fingerprints. Ages of the rabbits from beginning of the experiment (35 days) to slaughter day (89 days) are reported in the left column. C letter in the left column mean caecal content samples which collected at 89 days of age. Types of diet (right column) are also reported: control (A), CR (B), 0.2% of LS (C) and 0.4% of LS (D)

On the other hand the dendrogram showed that the similarity of microbial community between rabbits, fed with LS and CR, were higher if compared with rabbits fed with conventional diet. In addition at the end of the experiment the dendogram showed an higher similarity between samples obtained from caecal content and hard feces.

The microorganism have important role to develop the gut immunity and prevent the pathogen overgrowth. Hence, the quickly adaptation to reach the appropriate microbial ecosystem, when animals were impacted by diverse factors, was significant to provide the healthy condition in rabbits (Fortun-Lamothe & Boullier 2007). Caecum is the one of the important organ of rabbit's digestive tract and has bacterial species variety. The caecal content were collected at the slaughter day and performed the same protocol as hard feces samples. The results from this study, the bacterial community structure between caecal contents and hard feces were nearly similar. On the one hand, no significantly difference were published on the diversity index of bacterial community between caecal content and hard feces (Michelland et al. 2010).

Generally, the effect on anti-bacterial functions were originated from the essential oil in medical plants (Franz et al. 2010; Christaki et al. 2012). From this report results, LS supplement influenced on the bacterial environment transition in rabbit's gastrointestinal tract. Many types of essential oil, mainly flavanoids, tannins and terpenes, were found in LS which had the anti-bacterial activities (Becker et al. 2005). Moreover, high amount of tannins was discovered from LS extraction (Humadi & Istudor 2009) and the hexahydroxydiphenoyl ester vescalagin that was one member of hydrolyzable tannin, was considered as major active component of antibacterial activity (Becker et al. 2005). Furthermore, the results from various *in vitro* studies presented extracted LS anti-microbial ability on *Bacillus cereus*, *Escherichia coli*, *Mycobacterium smegmatis*, *Micrococcus luteus*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* (Rauha et al. 2000; Dulger & Gonuz, 2004; Borchardt et al. 2009). Hence, the essential oil activities were assumed that were the cause which impacted on the bacterial diversity difference.

CONCLUSION

No any adverse effects from LS supplementation were found on rabbit's performance whereas the difference on bacterial community were reported between control and treatment groups.

ACKNOWLEDGMENT

This research was supported by ''Universita` di Torino (ex 60%)'' grant (Es. fin. 2012-2013). The authors thank gratefully to Biotrade snc for providing *Lythrum salicaria* extract.

REFERENCES

Ayala L, Silvana N, Zoccarrato I, Gómez S. 2011. Use of vulgar oregano (*Origanum vulgare*) as phytobiotic in fatting rabbits. Cuban J Agr Sci. 45:159-161.

Becker H, Scher JM, Speakman J, Zapp J. 2005. Bioactivity guided isolation of antimicrobial compounds from *Lythrum salicaria*. Fitoterapia. 76:580-584.

Borchardt JR, Wyse DL, Sheaffer CC, Kauppi KL, Fulcher RG, Ehlke NJ, Biesboer DD, Bey RF. 2009. Antioxidant and antimicrobial activity of seed from plants of the Mississippi river basin. J Med Plant Res. 3:707-718.

Botsoglou NA, Florou-Paneri P, Christaki E, Giannenas I, Spais AB. 2004. Performance of rabbits and oxidative stability of muscle tissues as affected by dietary supplementation with oregano essential oil. Arch Anim Nutr. 58:209-218.

Casewell M, Friis C, Marco E, McMullin P, Phillips I. 2003. The European ban on growth-promoting antibiotics and emerging consequences for human and animal health. J Antimicrob Chemother. 52:159-161.

Christaki E, Bonos E, Giannenas I, Florou-Paneri P. 2012. Aromatic plants as a source of bioactive compounds. Agriculture. 2:228-243.

Combes S, Michelland RJ, Monteils V, Cauquil L, Soulié V, Tran NU, Gidenne T, Fortun-Lamothe L. 2011. Postnatal development of the rabbit caecal microbiota composition and activity. FEMS Microbiol Ecol. 77:680–689.

Dulger B, Gonuz A. 2004. Antimicrobial activity of certain plants used in Turkish traditional medicine. Asian J Plant Sci. 3:104-107.

Fortun-Lamothe L, Boullier S. 2007. A review on the interactions between gut microflora and digestive mucosal immunity. Possible ways to improve the health of rabbits. Livest Sci. 107:1-18.

Franz C, Baser KHC, Windisch W. 2010. Essential oils and aromatic plants in animal feeding – a European perspective. A review. Flavour Fragr J. 25:327-340.

Humadi SS, Istudor V. 2009. *Lythrum salicaria* (purple loosestrife). medicinal use, extraction and identification of its total phenolic compounds. Farmacia. 57:192-200.

Krieg R, Vahjen W, Awad W, Sysel M, Kroeger S, Zocher E, Hulan HW, Arndt G, Zentek J. 2009. Performance, digestive disorders and the intestinal microbiota in weaning rabbits are affected by a herbal feed additive. World Rabbit Sci. 17:87-95.

Michelland RJ, Combes S, Monteils V, Cauquil L, Gidenne T, Fortun-Lamothe L. 2010. Molecular analysis of the bacterial community in digestive tract of rabbit. Anaerobe. 16:61-65.

Muyzer G, de Waal EC, Uitterlinden AG. 1993. Profiling of complex microbial populations by denaturing gradient gel electrophoresis analysis of polymerase chain reaction-amplified genes coding for 16S rRNA. Appl Environ Microbiol. 59:695-700.

Rauha JP, Remes S, Heinonen M, Hopia A, K□hk□nen M, Kujala T, Pihlaja K, Vuorela H, Vuorela P. 2000. Antimicrobial effects of finnish plant extracts containing flavonoids and other phenolic compounds. Int J Food Microbiol. 56:3-12.

Soultos N, Tzikas Z, Christaki E, Papageorgiou K, Steris V. 2009. The effect of dietary oregano essential oil on microbial growth of rabbit carcasses during refrigerated storage. Meat Sci. 81:474-478.

Sundrum A. 2001. Organic livestock farming a critical review. Livest Prod Sci. 67:207-215.

Szabóová R, Lauková A, Chrastinová I, Strompfová V, Simonová MP, Plachá I, Vasilková Z, Chrenková M, Faix S. 2012. Benefficial effect of plant extracts in rabbit husbandry. Acta Vet Brno. 81:245-250.

Tunalier Z, Kosar M, Kupeli E, Calis I, Baser KHC. 2007. Antioxidant, anti-inflammatory, anti-nociceptive activities and composition of *Lythrum salicaria* L. extracts. J Ethnopharmacol. 110:539-547.

Vauterin L, Vauterin P. 1992. Computer-aided objective comparison of electrophoretic patterns for grouping and identification of microorganisms. Eur Microbiol. 1:37–41.

Effects of Dietary Crude Protein Levels on Growth Performance, Nutrient Digestibility and Nitrogen Retention in Growing Californian Rabbits Fed Available Feedstuffs in Mekong Delta of Vietnam

Truong Thanh Trung, Nguyen Thi Kim Dong

Faculty of Agriculture & Applied Biology, Can Tho University, Vietnam
Corresponding e-mail: tttrung@ctu.edu.vn

ABSTRACT

A study including two experiments was conducted at the Experimental farm of Cantho University in Vietnam. The aim of this study was to evaluate the effects of different dietary crude protein levels in the diets of growing Californian rabbits on growth performance and nutrient digestibility. In experiment 1, feeding trial, sixty Californian rabbits at 42 days of age, was arranged in a completely randomized design with 5 treatments and 3 replications and 4 balanced sex rabbits per experimental unit. The 5 dietary treatments were different protein levels of 15, 17, 19, 21 and 23%, respectively. In the experiment 2, nutrient digestibility trial, had similar design to that of the feeding trial, however, 12-week old rabbits were used. The results of study indicated that crude protein (CP) intakes increased ($P<0.05$) with increasing of crude protein levels in the diets. The average daily gain was the highest and feed conversion ratio was the lowest in the CP21% treatment ($P<0.05$) with 23.3g/rabbit/day and 3.06, respectively. The apparent digestibility coefficients of DM, OM, CP, EE, NDF and nitrogen retention were significantly increased ($P<0.05$) with increasing the levels of CP in the diets. The weight of carcasses, thigh meat and lean meat were significantly higher ($P<0.05$) for animals fed 21% CP (CP21). It could be concluded that growing Californian rabbits fed diet with 21% crude protein had the best growth performance, higher nutrient digestibility and gave better economic returns.

Key Words: Californian Rabbits, Crude Protein, Carcass Yield, Nutrient Digestibility

INTRODUCTION

In recent years, rabbit production based on low cost forages has been increased considerably in Vietnam in order to meet the increasing demand for human food. Local rabbits are popularly raised in the Mekong delta because of a good adaptation to the local climate and feeds but low productivity. In order to upgrade native rabbit production, Californian breeds have been imported. In the Mekong Delta in Vietnam, rabbit production based on locally available feed resources including natural grass, wild vegetables and agro-industrial byproduct. Para grass, *Operculina turpethum* and sweet potato tuber are used as rabbits feed, are widely available in Mekong Delta in Vietnam. Soybean and soya waste can be used as crude protein supplement feeds for growing and reproductive rabbits (Nguyen & Nguyen 2008). The appropriate usages of these feeds for Californian rabbit diets are still limited. Protein is an important component for life processes and effects on growth performance and carcass yield of rabbits. Several authors have studied the optimal dietary levels of protein for growing rabbits (Carabaño et al. 2008) but their studies mainly used commercial diets for rabbits. The studies on nutrient requirements, forage feeding and diet digestibility in Californian rabbits in Mekong Delta in Vietnam are still limited, especially crude protein level requirement in diet. The combination among available feedstuffs in Mekong Delta in diets for growing Californian rabbits to satisfy crude protein needs has not been implemented, yet. This study aimed to determine the optimum level of crude protein level in the diet of growing Californian rabbits fed available feedstuffs in Mekong delta in Vietnam.

MATERIALS AND METHODS

Experiment 1: Feeding trial

The experiment was conducted at the experimental farm of Cantho University. Sixty

Californian rabbits at 42 days of age (average live weight of 470 g) were arranged in a completely randomized design with 5 treatments and 3 replications. Four rabbits (balanced for sex) in one cage was the experimental unit. The treatments were percentage of crude protein in diets at levels of 15, 17, 19, 21 and 23% (DM basic) (CP15, CP17, CP19, CP21 and CP23), respectively. At the end of feeding trial, the experimental rabbits were slaughtered for carcass and meat quality evaluation.

Experiment 2: Digestibility trial

The experimental design was similar to that of the feeding trial; however, 12-week old rabbits were used. The animals had one week for adaptation and 6 days for recording and taking samples of feces and urine.

Feeds, feeding and management

Para grass, *Operculina turpethum*, soybean, soya waste and sweet potato tuber were used in the experiment. Para grass and *Operculina turpethum* were collected daily in the areas surrounding Cantho city. These feeds were given in fresh form and were offered three times a day at 7:00h, 12:00h and 17:00h. Quantities offered and refusals were recorded daily for each forage**.** Fresh water was freely available. The rabbits were vaccinated to prevent hemorrhagic and parasite diseases.

Measurements

Feeds and refusals were analysed for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to AOAC (1990) procedures. Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) were determined following procedures of van Soest et al. (1991). Dry matter, OM, CP, NDF and EE digestibility were calculated according to Mc Donald et al. (2002). Metabolisable energy (ME) of para grass and *Operculina turpethum* was estimated following formulas of Maertens et al. (2002) and NRC (1998) for soybean, soya waste and sweet potato tuber. Rabbits were weighed weekly.

Statistical analysis

The data from both experiments were analyzed using the General Linear Model option in the ANOVA of Minitab (Minitab 2010).

RESULTS AND DISCUSSION

Experiment 1: feeding trial

Chemical composition of feeds used in Experiment 1 was shown in Table 2. In Table 2, the DM of Para grass was 16.7% and higher than *Operculina turpethum* of 15.2%. The CP content of *Operculina turpethum* was 15.5%, while it was 12.6% in Para grass. Neutral detergent fiber (NDF) and ADF content of Para grass were higher than the *Operculina turpethum, i.e.,* (67.1% vs. 38.8% and 43.4% vs. 30.7%), respectively. Soybean and soya waste had higher levels of crude protein and metabolism energy than the forages.

Table 1. Ingredient composition of the experimental diets (%DM)

Feed	Treatment (level of crude protein)				
	CP15	CP17	CP19	CP21	CP23
Operculina turpethum	21.0	21.0	21.0	25.0	25.0
Soybean	11.0	16.0	21.0	25.0	30.0
Soya waste	10.0	10.0	10.0	11.0	12.0
Sweet potato tuber	32.0	27.0	23.0	17.0	13.0
Para grass	26.0	26.0	25.0	21.0	21.0
% CP in diet	15.0	17.0	19.0	21.0	23.0
% NDF in diet	36.0	36.0	36.0	36.0	36.0
ME, MJ/kg dry matter	11.6	11.6	11.6	11.6	11.6

Table 2. Chemical composition of feeds used in Experiment 1 (% in DM, except for DM which is on fresh basis)

Feed	DM	OM	CP	EE	NDF	ADF	CF	ME, MJ/kgDM
Operculina turpethum	15.2	87.9	15.5	6.50	38.8	30.7	18.6	9.69
Soybean	87.9	93.8	45.1	18.1	23.7	13.5	6.56	14.4
Soya waste	12.7	96.0	22.5	9.23	32.4	27.8	15.5	13.4
Sweet potato tuber	26.2	96.9	3.96	1.86	13.5	8.95	3.15	15.5
Para grass	16.7	90.7	12.6	3.70	67.1	43.4	25.7	6.48

DM: dry matter; OM: organic matter; CP: crude protein; EE: ether extracts; NDF: neutral detergent fiber; ADF: acid detergent fibre; CF: crude fiber; ME: metabolisable energy

Table 3. Effect of level of crude protein in diet on feed and nutrient and metabolizable energy (ME) intakes of growing Californian rabbits

Parameter	Treatment					SEM/Prob
	CP15	CP17	CP19	CP21	CP23	
Feed, g/rabbit/day (in fresh form)						
O. turpetlum	100.000[ab]	101.000[a]	99.000[b]	119.000[c]	116.000[d]	0.340/0.001
Soybean	9.100[a]	12.800[b]	17.100[c]	20.300[d]	24.200[e]	0.040/0.001
Soya waste	54.600[a]	56.700[b]	54.600[a]	61.000[c]	65.400[d]	0.190/0.001
Sweet potato tuber	87.300[a]	74.500[b]	63.100[c]	47.400[d]	36.000[e]	0.290/0.001
Para grass	113.000[a]	110.000[b]	106.000[c]	91.400[d]	88.300[e]	0.390/0.001
Feed, g/rabbit/day (DM basis)						
O. turpethum	15.200[a]	15.300[a]	15.000[a]	18.000[b]	17.700[c]	0.060/0.001
Soybean	7.990[a]	11.200[b]	15.000[c]	17.900[d]	21.300[e]	0.030/0.001
Soya waste	6.930[a]	7.200[b]	6.930[a]	7.740[c]	8.310[d]	0.020/0.001
Sweet potato tuber	22.900[a]	19.500[b]	16.500[c]	12.400[d]	9.430[e]	0.090/0.001
Para grass	18.800[a]	18.400[b]	17.700[c]	15.300[d]	14.800[e]	0.080/0.001
Total intake, g/rabbit/day (DM basis)						
Dry matter	71.800	71.600	71.200	71.300	71.400	0.250/0.418
Organic matter	66.700	66.400	66.000	65.900	66.000	0.230/0.091
Crude protein	10.800[a]	12.100[b]	13.500[c]	15.000[d]	16.400[e]	0.030/0.001
Ether extract	4.200[a]	4.730[b]	5.290[c]	5.910[d]	6.490[e]	0.020/0.001
Neutral detergent fiber	25.800	25.900	25.700	25.700	25.800	0.090/0.600
Acid detergent fiber	17.900	17.900	17.700	17.800	17.800	0.060/0.181
Crude fiber	9.990	10.000	9.920	10.000	10.100	0.030/0.098
ME, MJ/day	0.832	0.828	0.825	0.827	0.831	0.003/0.515

Means with different letters within the same rows are significantly different at the 5% level

Feed and nutrient intakes of growing Californian rabbits were presented in Table 3. The intakes of CP and EE (g/rabbit/day) were higher ($P<0.05$) at the higher level of crude protein in diets. The CP intake proportionally increased in the diets with increasing level of CP and they are significantly different ($P<0.05$) among treatments.

The daily weight gain and feed conversion ratio were showed in Table 4. Daily weight gain was significantly different among the treatments ($P<0.05$). The highest daily gain was achieved by rabbits fed CP21 diet, while the lowest value was achieved by rabbits fed CP15 diet. The daily weight gain of rabbits in this experiment was similar to results in the New Zealand White rabbits reported by Wang *et al.* (2012) from 21.5 to 28.1 g/d. Rabbit fed CP21 diet had the best FCR (3.06) ($P<0.05$), while the worst FCR was observed with those fed CP15 diet (3.99). The obtained values for FCR were acceptable levels and consistent with the results being from 3.37 to 3.63 indicated by El-Tahan *et al.* (2012). The economic analysis showed that benefits obtained from the CP21 diets were higher than the other diets due to the better growth rate and feed conversion ratio.

The criteria of carcass weight, lean meat weight and thigh meat weight were significantly affected ($P<0.05$) by the different CP diets (Table 5). In a study of fresh sweet potato vine and water spinach associated with Mom grass and Cuc in the diets, Nguyen & Nguyen (2008) reported that the carcass and lean meat percentage of growing crossbred rabbit increased from 44.0 to 48.7% and from 78.3 to 80.3%, respectively. Crude protein content of rabbit meat in the present experiment varied between 20.8 to 21.0%, while previously reported that the CP content of rabbit meat was in the range of 18.7 to 19.5% reported by Nguyen & Nguyen (2008).

Table 4. Mean values of daily weight gain and feed conversion in growing Californian rabbits fed different CP levels in diets in Experiment 1

Item	Treatment					SEM/Prob
	CP15	CP17	CP19	CP21	CP23	
Initial weight	463.00	469.00	463.00	477.00	475.00	6.960/0.475
Final weight	1975.00^a	2168.00^b	2341.00^c	2435.00^c	2421.00^c	27.000/0.001
Daily weight gain	18.00^a	20.20^b	22.40^c	23.30^c	23.20^c	0.300/0.001
Feed conversion ratio	3.99^a	3.54^b	3.19^c	3.06^c	3.08^c	0.040/0.001
Feed cost (VND/rabbit)	23,209	24,806	26,601	28,221	30,026	-
Total cost (VND/rabbit)	115,946	118,074	120,468	122,628	125,034	-
Income (VND/rabbit)	157,973	173,412	187,291	194,802	193,680	-
Difference (VND/rabbit)	42,028	55,338	66,823	72,174	68,646	-

Means with different letters within the same rows are significantly different at the 5% level. 21,000 VND = 1 USD

Table 5. Carcass and meat quality of Californian rabbits fed different diets

Item	Treatment					SEM/Prob
	CP15	CP17	CP19	CP21	CP23	
Live weight, g (LW)	1990^a	2183^b	2353^c	2466^c	2437^c	24.4/0.001
Carcass weight, g	1047^a	1143^b	1238^c	1289^c	1286^c	16.8/0.001
Carcass percentage, %LW	52.6	52.3	52.6	52.3	52.8	0.25/0.621
Lean meat weight, g	789^a	863^{ab}	940^{bc}	978^c	980^c	21.5/0.001
Lean meat percentage, %	75.4	75.5	75.9	75.9	76.2	0.97/0.970
Thigh meat (TM) weight, g	272^a	310^b	346^c	383^d	372^d	4.98/0.001
Thigh meat percentage, % carcass	26.0^a	27.1^{ab}	27.9^{bd}	29.8^c	28.9^{cd}	0.34/0.001
Caecum length, cm	56.0	54.4	57.9	56.5	56.0	0.84/0.142
Chemical composition of meat, % in fresh						
Dry matter	26.7	26.1	26.3	26.0	26.1	0.32/0.606
Crude protein	21.0	20.9	20.8	21.0	20.8	0.29/0.956
Ether extract	4.15	4.34	4.45	4.38	4.40	0.07/0.092
Ash	2.49	2.51	1.74	2.48	2.71	0.55/0.767

Means with different letters within the same rows are significantly different at the 5% level

Experiment 2: Digestibility and N balance trial

The composition of the feedstuffs offered, feed and nutrient intakes and the effects of different CP levels on nutrient digestibility are shown in Table 6, 7 and 8.

Nutrient intakes of growing Californian rabbits in the experiment 2 were similar pattern of the experiment 1. The apparent digestibility of DM, OM, CP, EE and NDF significantly increased ($P<0.05$) by increasing the levels of CP in experimental diets (Table 8). Apparent crude protein digestibility of rabbits fed CP21 diet was significantly higher ($P<0.05$) than CP15 and CP17 treatments with the lowest value for for the CP15 diet. The results of apparent CP digestibility in the present experiment was consistent (74.9-77.9%) with those reported by El-Tahan *et al.* (2012).

Table 8 also shows that the digestible nutrient values of DM, CP, EE and NDF increased with the increase of CP level in diets and they were significantly different ($P<0.05$) among treatments with the higher values for the CP21 and CP23 treatments. The nitrogen intake and retention were significantly different ($P<0.05$) among treatments with the significant higher values of the CP21 and CP23 treatments.

Table 6. Chemical composition of feeds used in Experiment 2 (% in DM, except for DM which is on fresh basis)

Feed	DM	OM	CP	EE	NDF	ME, MJ/kgDM
Operculina turpethum	15.00	88.00	15.60	6.50	39.50	9.69
Soybean	87.90	95.40	45.00	18.20	30.60	14.40
Soya waste	12.70	95.80	22.60	9.03	30.90	13.40
Sweet potato tuber	26.10	97.00	3.96	1.90	12.50	15.50
Para grass	16.90	89.80	12.40	3.65	66.50	6.48

DM: dry matter, OM: organic matter, CP: crude protein, EE: ether extracts, NDF: neutral detergent fiber, ME: metabolism energy

Table 7. Feed and nutrient intakes (g/day) of rabbits in the diets of the exp. 2

Item	Treatment					SEM/Prob
	CP15	CP17	CP19	CP21	CP23	
Dry matter	53.40	53.30	52.70	52.70	52.60	0.300/0.274
Organic matter	49.60	49.50	48.90	48.80	48.80	0.270/0.193
Crude protein	8.00^{a}	9.02^{b}	10.00^{c}	11.10^{d}	12.10^{e}	0.050/0.001
Ether extract	3.11^{a}	3.52^{b}	3.91^{c}	4.37^{d}	4.78^{e}	0.020/0.001
Neutral detergent fiber	19.20	19.50	19.40	19.50	19.60	0.110/0.294
Metabolisable energy, MJ	0.62	0.62	0.61	0.61	0.61	0.003/0.109

Means with different letters within the same rows are significantly different at the 5% level

Table 8. Nutrient digestibility coefficients (%) and and N balance of rabbits. Experiment 2

Item	Treatment					SEM/Prob
	CP15	CP17	CP19	CP21	CP23	
Apparent digestibility, %						
Dry matter	69.30^{a}	70.90^{ab}	72.30^{bc}	73.90^{c}	73.20^{bc}	0.530/0.001
Organic matter	70.40^{a}	71.40^{ab}	72.90^{abc}	74.50^{c}	73.50^{bc}	0.570/0.003
Crude protein	71.10^{a}	72.80^{ab}	74.50^{bc}	77.30^{c}	77.20^{c}	0.630/0.001
Ether extract	76.80^{a}	79.90^{ab}	81.10^{b}	81.80^{b}	81.50^{b}	0.850/0.011
Neutral detergent fiber	54.40^{a}	58.20^{ab}	61.30^{bc}	65.00^{c}	64.50^{c}	1.030/0.001
Digestible nutrients, g						
Dry matter	37.00^{a}	37.70^{ab}	38.10^{ab}	39.00^{b}	38.50^{ab}	0.350/0.021
Organic matter	34.90	35.30	35.70	36.40	35.80	0.320/0.064
Crude protein	5.69^{a}	6.57^{b}	7.45^{c}	8.56^{d}	9.34^{e}	0.070/0.001
Ether extract	2.39^{a}	2.81^{b}	3.17^{c}	3.58^{d}	3.90^{e}	0.040/0.001
Neutral detergent fiber	10.50^{a}	11.40^{ab}	11.90^{bc}	12.70^{c}	12.70^{c}	0.230/0.001
Nitrogen balance, g/kgW$^{0.75}$						
Intake	1.10^{a}	1.17^{b}	1.24^{c}	1.34^{d}	1.47^{e}	0.010/0.001
Retention	0.66^{a}	0.72^{b}	0.79^{c}	0.89^{d}	0.91^{d}	0.010/0.001

Means with different letters within the same rows are significantly different at the 5% level

CONCLUSION

The conclusion of the study was that local forages and agro-industrial byproducts feedstuffs in Mekong Delta in Vietnam could be used for feeding growing Californian rabbits without negative effects on growth performance, nutrient digestibility and meat composition and the optimum level of dietary crude protein was 21%.

REFERENCES

AOAC. 1990. Official Methods of Analysis (15th edition). Assoc Off Anal Chem. 1:69-90.

Carabaño R, Villamide MJ, García J, Nicodemus JN, Llorente A, Chamorro S, Menoyo D, García-Rebollar P, García-Ruiz AI, de Blas JC. 2008. New concepts and objectives for protein-amino acid nutrition in rabbit. In: Xiccato G, Trocino A, Lukefahr SD, editors. Proceedings 9th World Rabbit Congress. Verona, June 10-13, 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche E Zootecniche. p.477-490.

El-Tahan HM., Amber KH, Morsy WA. 2012. Effect of dietary starch levels on performance and digestibility of growing rabbit. In: Proceedings 10th World Rabbit Congress. Sharm El-Seikh, September 3-6, 2012. Sharm El-Seikh (Egypt): WRSA. p. 501-505.

Maertens L, Perez JM, Villamide M, Cervera C, Gidenne T, Xiccato G. 2002. Nutritive value of raw materials for rabbits: EGRAN tables 2002. World Rabbit Sci. 10:157-166.

McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA. 2002. Digestibility evaluation of foods. In: Animal Nutrition, 6th Edition. New York (USA): Longman Scientific and Technical. p. 245-255.

Minitab. 2000. Minitab reference manual release 16.1.0. Minitab Inc.

NRC. 1998. Nutrient requirements of swine, National Research Council. Washington DC (USA): National Academy of Sciences. p. 3-4.

Nguyen VT, Nguyen TKD. 2008. Effect of water spinach and sweet potato vine assiociated with 2 other natural plants on growth performance, carcass values and economic return of growing crossbred rabbits in the Mekong delta of Vietnam. In: Xiccato G, Trocino A, Lukefahr SD, edotors. Proceedings 9th World Rabbit Congress. Verona, June 10-13, 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche E Zootecniche. p. 763-768.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Symposium: Carbohydrate methodology metabolism and nutritional implications in dairy cattle: methods for dietary fiber, and non-starch polysaccharides in relation to animal nutrition. J Dairy Sci. 74:3583-3597.

Wang XP, Ma MW, Sun LZ, Wang CY, Zhu YL, Li FC. 2012. Effects of different protein, fiber and energy levels on growth performance and the development of digestive organs in growing meat rabbit. In: Proceedings 10th World Rabbit Congress. Sharm El-Seikh, September 3-6, 2012. Sharm El-Seikh (Egypt): World Rabbit Science Association. p. 641-645.

Effects of Coconut Cake Supplement in Diets on Feed Utilization, Nutrient Digestibility, Growth Performance and Economic Return of Crossbred Rabbits

Nguyen Thị Kim Dong, Nguyen Van Thu

Faculty of Agriculture and Applied Biology, Cantho University, Vietnam
Campus II, 3/2 street, Ninh Kieu district, Can Tho city, Viet Nam
Corresponding e-mail: ntkdong@ctu.edu.vn

ABSTRACT

A study was conducted at the experimental farm and laboratory of Cantho University to evaluate feed utilization, nutrient digestibility and growth performance of crossbred rabbits. Sixty crossbred rabbits at 8 weeks of age were allotted in a completely randomized design with 5 treatments that were 5 supplement levels of 10, 20, 30, 40 and 50g coconut cake (COC) per rabbit per day corresponding to the COC10, COC20, COC30, COC40 and COC50 treatments, respectively. Three replications and 4 rabbits (balanced sex) per experimental unit were used. The results show that the DM intake was significantly higher for the rabbits supplemented 30g COC ($P>0.05$). The intakes of CP, EE and ME were higher for the animals fed 30, 40 and 50 g COC ($P<0.05$). The digestibility coefficients of DM, OM, CP, EE and NDF were significantly higher in the 30COC treatment ($P<0.05$). Nitrogen intake and nitrogen retention increased corresponding with increasing COC supplementation in the diets ($P<0.05$). The daily weight gain was significantly higher for rabbits given 30g COC per animal per day ($P<0.05$). The final live weight, the carcasses, thigh meat and lean meat weights were significantly higher for rabbits fed 30g and 40g COC per day ($P<0.05$). In conclusion, the crossbred rabbits supplemented coconut cake in the diets had significantly increased the OM, CP, EE and ME intakes. At the supplementation level of 30g COC per animal per day had higher growth rate, meat production and better profit.

Key Words: Crossbred Rabbit, Coconut Cake, Nutrient Digestibility, Growth Rate, Carcass Weight

INTRODUCTION

Organic rabbit farming based on green forages is an opportunity for the poor farmers for producing to erase starvation and to evaluate poverty in villages of Vietnam. However, the rabbits fed mainly forages in diets to provide protein and fiber, often gave low performance as compared to those fed the concentrate/pellet feed in the industries (Nguyen & Nguyen 2008). Therefore to improve growth performance of rabbits, supplementation of protein and energy feeds is very important to make balanced nutrient diet. Coconut cake contains 21.3% CP and 11 MJ ME/kgDM, is popular and cheap ingredient, used as a source of protein and energy supplement for growing rabbits (Nguyen Le Thu Hang 2012). Besides, water spinach leaves and *Limnophila aromatic*, vegetable residues of human beings, with high protein content (29.5% CP and 18.8% CP, respectively) could be associated with para grass in basal diet to diversity for rabbit feeding. However, the understanding of this scientific area for rabbit performance is still limited. Therefore, a study of growing rabbit performance offered green forages with different supplementation of coconut cake was investigated for improving live weight, rabbit production and increasing producers' income.

MATERIALS AND METHODS

Experiment 1. Feeding trial

Animals and experimental design

The experiment was conducted in experimental farm in Cantho city. Sixty crossbred rabbits (Local × New Zealand breeds) at 9 weeks of age with live weight average of 1040±45 g were arranged in a completely randomized design with 5 treatments, 3 replicates and four rabbits in each experimental unit. The treatments consisted of

5 different supplements of 10, 20, 30, 40 and 50 g coconut to basal diet. The feeding trial lasted for 8 weeks.

Feeds, feeding and management

Para grass, *Limnophila aromatic,* water spinach leaves, soya waste were collected and bought daily in the city, except for coconut cake bought one occasion for throughout the trial. The animals were fed three times a day at 8:00, 15:00 and 19:00h. Fresh water was available for all rabbits almost all day and night. The feed refusals and spillage were collected and weighed daily in the morning to calculate the feed intake. The animals were vaccinated to prevent some diseases, especially rabbit hemorrhagic, parasite and other common diseases.

Measurements

The feeds and refusals were taken for analyses of DM, OM, CP, EE, NDF and Ash following procedure of AOAC (1990) and van Soest et al. (1991). Daily feed intakes, growth rate, feed conversion ratios, and carcass values were measured. The economic analysis was also done among the treatments.

Experiment 2: Digestibility trial

Animals and experimental design

The second experimental design was similar to that of the feeding trial, however, 12-weeks old rabbits were used. The animals had two weeks for adaptation and another week for getting samples by fecal collection for 7 days. Feeds given and refusals were daily measured. Urine was also collected for nitrogen analysis to calculate the nitrogen retention. DM, CP, EE and NDF digestibility were employed according to McDonald et al. (2002).

Statistical analysis

The data from both experiments were analyzed by analysis of variance using the ANOVA of General Linear Model of Minitab Reference Manual Release 16.1.0 (Minitab 2010). Economic analyses were done using current prices in Vietnamese Dong (VND) to compare differences of income and the feed cost among treatments.

RESULTS AND DISCUSSION

Expriment 1: Feeding trial

Feed characteristics

Chemical composition of feed ingredients of rabbit is presented in Table 1.

The coconut cake had high CP and ME contents, is a good energy feed supplement to green forage basal diet to make balanced nutrients for growing rabbits. The coconut cake consisted of 20.3% CP and 11 MJ ME/kg (Thanh 2011) (Table 1). The CP content of *Limnophila aromatic* used in this experiment was higher than the para grass, but lower than the CP content of para grass and water spinach leaves. *Limnophila aromatic* is a new forage source in Vietnam, used to diversify for rabbit feeding.

Table 1: Chemical composition of feed ingredients (% in DM, except for DM which is on fresh basis)

Feed	DM	OM	CP	EE	NDF	Ash	ME, MJ/kg DM
Coconut cake	89.50	95.70	19.20	7.71	64.20	4.35	11.00
Para grass	16.70	89.70	12.40	5.70	67.60	10.30	9.49
Limnophila aromatic	7.65	84.10	18.80	5.57	61.50	15.90	10.50
Water spinach leaves	13.10	89.00	26.30	9.09	27.10	11.00	12.00
Soya waste	11.50	94.50	21.50	7.83	33.90	5.51	11.00

DM: dry matter; OM: organic matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ME: metabolisable energy
Source: Maertens et al. 2002

Feed and nutrient intakes in the Experiment 1

Daily intakes of feed and nutrients are shown in Table 2.

Daily intakes of coconut (COC) linearly increased (P<0.05) corresponding with increasing COC levels in the diets, while para grass (PG) significantly decreased (P<0.05). DM and NDF intakes were significantly higher (P<0.05) in the COC30 treatment as compared to COC10. However, daily intakes of OM, CP, EE and ME were significantly higher for animals supplemented from 30 to 50g COC per rabbit (P<0.05), possibly due to high CP and ME concentrations in COC. The DM intakes in present study are in agreement with the values of 65-75.5g DM of the previous study in which the rabbits fed water spinach basal diets (Samkol et al. 2006). The findings of CP and ME intakes in current study were in a range of 13.6- 15.4g CP and 0.65 to 0.74 MJ ME/day as stated by Nguyen Le Thu Hang (2012), however, the crude protein intakes were higher than those (8.79-11.3 g CP/day) reported by Phimmasan et al. (2004).

Daily intakes of coconut (COC) linearly increased (P<0.05) corresponding with increasing COC levels in the diets, while para grass (PG) significantly decreased (P<0.05). DM and NDF intakes were significantly higher (P<0.05) in the COC30 treatment as compared to COC10. However, daily intakes of OM, CP, EE and ME were significantly higher for animals supplemented from 30 to 50 g COC per rabbit (P<0.05), possibly due to high CP and ME concentrations in COC. The DM intakes in present study are in agreement with the values of 65-75.5 g DM of the previous study in which the rabbits fed water spinach basal diets (Samkol et al. 2006). The findings of CP and ME intakes in current study were in a range of 13.6- 15.4 g CP and 0.65 to 0.74 MJ ME/day as stated by Nguyen Le Thu Hang (2012), however, the crude protein intakes were higher than those (8.79-11.3g CP/day) reported by Phimmasan et al. (2004).

Growth rate, feed conversion ratio and economic analysis in Experiment 1

The significantly higher (P<0.05) daily weight gain and final live weight were found for rabbits supplemented with 30 g COC per day as compared to other treatments (Table 3).

Table 2: Daily intakes of coconut (COC) feed and nutrients of growing rabbits (g/rabbit/day)

Item	COC10	COC20	COC30	COC40	COC50	SE/P
COC (DM)	9.00^{a}	17.90^{b}	23.60^{c}	23.00^{c}	26.70^{c}	0.830/0.001
Para grass	39.20^{a}	31.60^{ab}	32.10^{ab}	25.40^{bc}	18.20^{c}	2.260/0.001
Limnophila aromatic	10.60	10.40	10.30	10.60	10.10	1.630/1.00
DM	62.50^{a}	67.40^{ab}	73.40^{b}	69.80^{ab}	69.50^{ab}	1.680/0.012
OM	56.90^{a}	61.80^{ab}	67.50^{b}	64.20^{b}	64.20^{b}	1.470/0.005
CP	12.00^{a}	13.30^{ab}	14.40^{b}	13.90^{b}	14.10^{b}	0.320/0.003
EE	4.54^{a}	4.99^{ab}	5.45^{b}	5.24^{b}	5.29^{b}	0.110/0.001
NDF	31.00^{a}	34.00^{ab}	37.80^{b}	35.30^{ab}	35.10^{ab}	1.010/0.009
Ash	5.67	5.63	5.91	5.58	5.31	0.210/0.423
ME, MJ/kg DM	0.67^{a}	0.73^{ab}	0.80^{b}	0.76^{b}	0.76^{b}	0.020/0.006

Means with different letters within the same rows are significantly different at the 5% level

Table 3. Live weight, daily gain (g/rabbit) and economic returns (VND/rabbit) of growing rabbits in the Exp. 1

Item	COC10	COC20	COC30	COC40	COC50	SE/P
Initial weight, g	1015.00	1072.00	1056.00	1092.00	1078.00	22.90/0.23
Final live weight, g	2058.00^{a}	2183.00^{a}	2222.00^{b}	2204.00^{b}	2141.00^{a}	32.40/0.03
Daily weight gain, g	18.60^{a}	19.80^{a}	20.80^{b}	19.80^{a}	19.00^{a}	0.35/0.01
FCR	3.35	3.40	3.53	3.51	3.66	0.09/0.17
Total expense	95,627	98,827	101,027	104,227	107,427	
Total income	144,060	152,810	155,540	154,280	149,870	
Profit	48,433	53,983	54,513	50,053	42,443	

Means with different letters within the same rows are significantly different at the 5% level

The daily gains of rabbits in this study were also within the ranges (14.4 to 20.3g/day) as reported by Samkol et al. (2006), but being higher than the results of Nakkitset (2007) (15.9 to 19.4g/day). The final live weights are consistent with those of 2082-2171g (Tung 2012). Feed conversion ratio was resemble among the treatments (P>0.05), and being better than those of 4.5 to 5.5 reported by Phiny & Kaensombath (2006). The effects of intakes of DM (g/day) and ME (MJ/day) on daily weight gain of growing rabbits were presented in regression equations Y1 = 0.011 x^2 + 1.33x + 58.2, with regression coefficient R^2 = 0.74 and Y2 = 81.2x^2 + 105x + 52.4, with regression coefficient R^2 = 0.69, respectively.

The economic analysis was done and showed that the lower total expense was in the COC treatment and higher income was in the COC30 diet, resulting in more profits for animals offered 30 g COC (COC30 diet).

Mean values of slaughter weights, carcass traits and internal organs of growing rabbits

The results of carcass, lean meat and thigh meat weights were significantly higher for the COC30 and COC40 treatments (P<0.05) (Table 4). The results in this study are higher than those in a previous study, *i.e.*, 41.6 to 47.1% (Elamin et al. 2012).

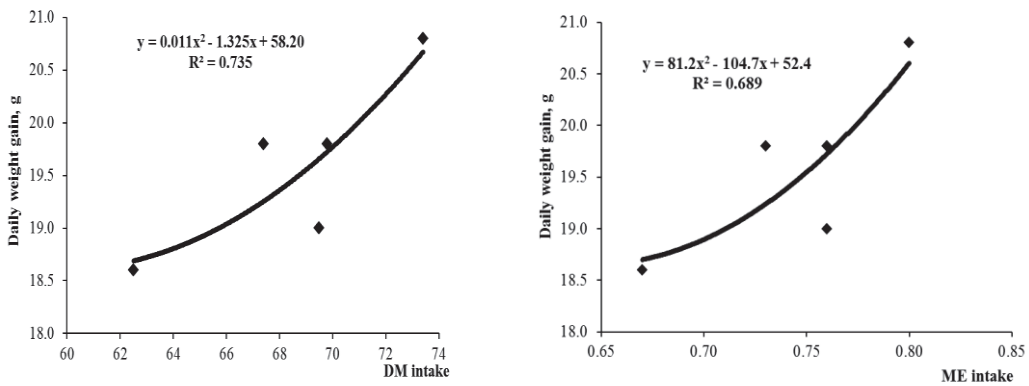


Figure 1. Relationship between DM and ME intakes and DG of growing rabbits

Table 4. Mean values of slaughter weights, carcass traits and internal organs of growing rabbits

Item	Treatment					SE/P
	COC10	COC20	COC30	COC40	COC50	
Live weight, g	2110.0^{a}	2203.0^{ab}	2253.0^{b}	2223.0^{b}	2171.0^{ab}	23.800/0.015
Carcass weight, g	1072.0^{a}	1131.0^{ab}	1183.0^{b}	1151.0^{ab}	1109.0^{ab}	20.600/0.032
% Carcass	50.8	51.3	52.5	51.8	51.1	0.620/0.411
Lean meat weight, g	813.0^{a}	856.0^{ab}	895.0^{b}	872.0^{ab}	837.0^{ab}	15.700/0.034
% Lean meat	75.8	75.5	75.7	75.6	75.5	0.480/0.993
Thigh meat weight, g	319.0^{a}	335.0^{ab}	353.0^{b}	347.0^{b}	338.0^{ab}	5.550/0.013
% Thigh meat	29.7	29.6	29.9	30.1	30.5	0.540/0.791
StomachW./Live W.	5.72	5.69	5.59	5.77	5.90	0.150/0.666
Caecum length, cm	60.8	60.4	58.6	61.4	59.8	0.720/0.154
Caecum weight, g	143	152	149	151	148	5.350/0.480

Means with different letters within the same rows are significantly different at the 5% level

Experiment 2: Digestibility trial

Daily intakes of feed and nutrients of growing rabbits in digestibility

Daily intakes (Table 5) of DM and most of nutrients such as CP, EE, NDF and ME of the rabbits were slightly lower than those obtained in the feeding trial, these may be due to data recorded was only performed in one week of the digestibility experiment.

Apparent digestibility of dietary nutrients, nitrogen retention of growing rabbits

The apparent digestibility coefficients of DM and CP were significantly higher ($P<0.05$) in the COC30 diet as compared to the COC10. Also, EE and NDF digestibility values were higher ($P<0.05$) for the animals offered 30 g and 40 g COC per day, possibly due to higher NDF intake in these diets (Table 7). Our results are in agreement with, but higher than the findings of the DM and CP digestibility (69.6 to 75.7% and 64.4 to 74.8%, respectively) reported by Nguyen & Nguyen (2010).

The results indicated that the nitrogen intake and nitrogen retention increased with increasing levels of COC supplement in the diets from 30 to 50 g per day ($P<0.05$), this probable explanation is higher CP intakes in these dietary treatments. There was linearly regression between N intake and N retention of growing rabbits with $R^2 = 0.97$ (Figure 2).

Table 5. Daily intakes of feed and nutrients of growing rabbits in digestibility exp 2 (g DM/rabbit)

Nutrients	COC10	COC20	COC30	COC40	COC50	SE/P
DM	48.40^{a}	56.90^{ab}	66.70^{b}	64.00^{ab}	61.10^{ab}	3.68/0.040
OM	44.20^{a}	52.40^{ab}	61.50^{b}	59.80^{b}	57.40^{ab}	3.26/0.023
CP	9.97^{a}	11.20^{ab}	14.30^{c}	13.70^{bc}	14.00^{c}	0.59/0.001
EE	3.73^{a}	4.40^{ab}	5.13^{bc}	5.33^{bc}	5.50^{c}	0.21/0.001
NDF	21.40^{a}	26.00^{ab}	31.70^{b}	30.30^{b}	28.90^{ab}	1.82/0.018
Ash	4.20^{ab}	4.57^{ab}	5.20^{a}	4.27^{ab}	3.67^{b}	0.42/0.202
ME* (MJ/kg DM)	0.53^{a}	0.63^{ab}	0.73^{b}	0.73^{b}	0.71^{b}	0.04/0.016

Means with different letters within the same rows are significantly different at the 5% level

Table 6. Apparent digestibility (%) of dietary nutrients and nitrogen retention of growing rabbits

Item	COC10	COC20	COC30	COC40	COC50	SE/P
Apparent digestibility (%)						
DM	65.4^{a}	72.5^{ab}	76.8^{b}	74.6^{ab}	69.8^{ab}	2.11/0.03
OM	65.8^{a}	73.3^{ab}	77.3^{b}	75.8^{b}	71.3^{ab}	2.00/0.02
CP	80.5^{a}	82.9^{ab}	85.4^{b}	85.0^{ab}	82.9^{ab}	1.06/0.05
EE	74.2^{a}	79.8^{ab}	82.9^{b}	82.6^{b}	81.0^{ab}	1.72/0.03
NDF	45.1^{a}	57.2^{ab}	63.8^{b}	61.3^{b}	52.4^{ab}	3.26/0.02
N balance (g/kg $W^{0,75}$)						
N intake	1.13^{a}	1.29^{ab}	1.57^{c}	1.42^{bc}	1.52^{bc}	0.060/0.002
N retention	0.78^{a}	0.92^{ab}	1.26^{c}	1.13^{bc}	1.16^{bc}	0.060/0.001

Means with different letters within the same rows are significantly different at the 5% level

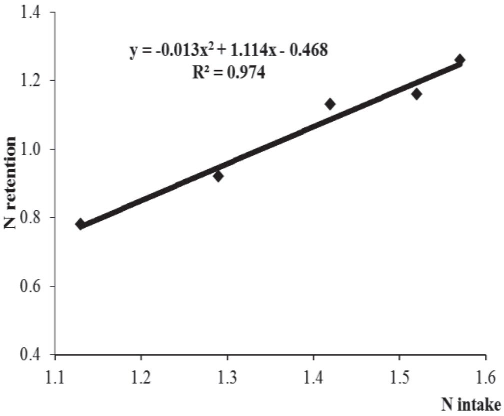


Figure 2. Relationship between N intake and N retention of growing rabbits

CONCLUSION

Supplementation of coconut cake 30 to 40 g/rabbit/day to the diets enhanced dry matter and nutrient intakes, and nutrient digestibility of the diet. At level of 30 g coconut supplementation gave higher growth rate and carcass traits and gave better benefits for rabbit production.

REFERENCES

AOAC. 1990. Official methods of analysis (15th edition). Washington DC (USA): Association of Official Agricultural Chemists. 1:69-90.

Elamin KLE, Elkhairey MA, Bakhiet AO, Ahmed HB, Musu AM. 2012. Carcass and non-corcass traits of local rabbits Fed different sources of fodder in Sudan. Asian J Anim Vet Adv. 7:341-345.

Maertens L, Peter JM, Villamide M, Cervera C, Gidenne T, Xiccato G. 2002. Nutritive value of raw materials for rabbit. World rabbit Sci. 10:157-166.

McDonald P, Edwards RA, Greehalgh JFD, Morgan CA 2002. Digestibility evaluation of foods. In: Animal Nutrition. 6th Edition. New York (USA): Longman Scientific and Technical. p. 245-255.

Minitab. 2010. Minitab Reference Manual release 16.1.0. Minitab Inc.

Nakkitset S. 2007. Evaluation of head lettuce (*Lactuca sativa*) residues and Mimosa pigra as feed resources for growing rabbits. [MSc Thesis]. [Uppsala (Sweden)]: Swedish University of Agricultural Science.

Nguyen Le Thu Hang. 2012. Effects of different protein levels in diets on growth rate, nutrient digestibility and cecotropes characteristics of rabbit breeds. [BSc. Thesis]. [Cantho (Vietnam)]: Faculty of Agriculture and Applied Biology Cantho University.

Tung NT. 2012. Effects of different neutral detergent fiber in diets on growth performance, nutrient digestibility and cecotropes characteristics of rabbit breeds. [BSc. Thesis]. [Cantho (Vietnam)]: Faculty of Agriculture and Applied Biology Cantho University.

Nguyen VT, Nguyen TKD. 2008. A study of associated fresh forages for feeding growing crossbred rabbits in the Mekong Delta of Vietnam. In: Proceedings of International MEKARN workshop 2008 of Organic Rabbit farming Based on Forages. 25-27 November 2008, Cantho University, Cantho City, Vietnam. http://www.mekarn.org/prorab/Nvthu.htm

Nguyen VT, Nguyen TKD. 2010. Study of water hyacinth (*Eichhornia crassipes*) as a feed resource for feeding growing rabbits. Mekarn Workshop "Livestock, Climate Change and the Environment". Long Xuyen City, 16-18 November 2009. Long Xuyen City (Vietnam): An Giang University.

Phimmasan H, Kongvongxay S, Chahay T, Preston TR. 2004. Water spinach (*Ipomoea aquatica*) and Stylo 184 (*Stylosanthes guianensis* CIAT 184) as basal diets for growing rabbits. Livest Res Rural Dev. 16(5). Art.#34http://www.lrrd.org/lrrd16/5/hong16034.htm.

Phiny C, Kaensombath L. 2006. Effect on feed intake and growth of depriving rabbits access to caecotropes. In: Preston TR, Ogle RB, editors. MEKARN Proceedings of Workshop on Forages for Pigs and Rabbits. Phnom Penh, Cambodia, 22-24 August 2006. Hanoi (Vietnam): Agricultural Publishing House. p. 183-190.

Samkol P, Preston TR, Ly J. 2006. Digestibility indices and N balance in growing rabbits fed basal diet of water spinach supplemented with broken rice. Livest Res Rural Dev. 18(2) Article#22.http://www.lrrd.org/lrrd18/2/samk18025.htm.

Samkol P, Preston TR, Ly J. 2006. Effect of increasing offer level of water spinach (Ipomoea aquatica) on intake, growth and digestibility coefficients of rabbits. Livest Res Rural Dev. 18(2) Article #25. http://www.lrrd.org/lrrd18/2/samk18025.htm.

Thanh TM. 2011. Effect of different coconut meal supplements on growth performance and nutrient digestibility of Californian rabbits. [BSc Thesis]. [Cantho (Vietnam)]: Faculty of Agriculture and Applied Biology Cantho University.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle: methods for dietary fiber, and non-starch polysaccharides in relation to animal nutrition. J Dairy Sci. 74:3585-3597.

A Response of Energy Intakes, Growth Rate and Carcass Values of Crossbred Rabbits to the Supplementation of Sweet Potato Tuber (*Ipomoea batatas)* in the Mekong Delta of Vietnam

Nguyen Van Thu, Nguyen Thi Kim Dong

Faculty of Agriculture and Applied Biology, Can Tho University
Campus II, 3/2 street, Ninh Kieu district, Can Tho city, Viet Nam
Corresponding e-mail: nvthu@ctu.edu.vn

ABSTRACT

To evaluate effects of the supplementation of sweet potato tubers in diets on nutrient utilization, growth and meat production of growing rabbits, sixty crossbred rabbits (Californian × local) at 45 days of age (703±51 g/rabbit) were arranged in one experiment of complete randomized design with 5 treatments and 3 replications. Four rabbits balancing in sex were used for one experimental unit. The treatments were the supplementation levels of sweet potato tubers of 0, 10, 20, 30 and 40 gDM/rabbit/day corresponding to SPT0, SPT10, SPT20, SPT30 and SPT40 treatments, respectively. The fresh sweet potato tubers were prepared by washing and cut into small slides for feeding. The feeds used for the experiment were Para grass (*Brachiaria mutica*), water spinach leaves, soya waste and oil-extracted soybean meal, in which the Para grass was fed *ad libitum*. The experimental results indicated that supplementing SPT at levels of 30 and 40 gDM in diets significantly (P<0.05) increased for the daily dry matter (DM), organic matter (OM) and metabolizable energy (ME) intakes. However no significant (P>0.05) intakes of CP, EE, NDF and ADF were found in different treatments. The daily weight gains (WG) were significantly different (P<0.05) among the treatments and were 17.8, 19.5, 21.6, 21.9 and 21.9 g/rabbit for the SPT0, SPT10, SPT20, SPT30 and SPT40 treatments, respectively. Similarly, the carcass weight values were significantly different (P<0.05) among the treatments with highest value for the SPT30 treatment. The economic analysis showed that the profits were higher for the SPT20, SPT30 treatments and they were 22,054 and 21,404 VND/kgWG, respectively. It was concluded that the SPT supplementation to crossbred rabbit diets should be recommended being from 20 to 40 gDM/rabbit/day to improve the growth performance, profit and sustainable production.

Key Words: Rabbit, Soluble Carbohydrate, Supplements, Meat Production, Economic Return

INTRODUCTION

In recent year due to the serious animal diseases have been occurred in Vietnam such as porcine reproductive and respiratory syndrome (pig), avian influenza (chicken and ducks) and foot and mouth disease (cattle and buffaloes), rabbits are considered to develop for producing meat for human consumption (Otte et al. 2007). In the Mekong delta rabbits are fed green forages and local supplements available of protein or energy to improve the production and income for the producers. There are abundant feed resources for raising rabbits which farmers could collect or buy with the low prices such as Para grass (*Brachiaria mutica*), paspalum grasses, water spinach, sweet potato vines, *Operculina turpethum*, tofu waste, brewery waste, *etc*. (Nguyen Van Thu & Nguyen Thi Kim Dong 2008). Many studies have attempted to find out the supplementation sources for developing the rabbit herds in better performance. Sweet potato has been widely planted in different regions in Vietnam with 1.65 million ton per year (Rau Hoa Qua Viet Nam 2007). Particularly, in the Mekong delta in 2012 the sweet potato area was 21,500 ha in Vinh Long, Dong Thap, Tra Vinh, Soc Trang, *etc.* with the yield of 22.8 tons/ha/crop and production of 513,000 ton/year. As a results there has been a large amount of its byproducts such as the small and waste tubers which could be used for human. This is a good carbohydrate source of energy feed for animals (Scott 1995; Sangkhom & Preston 2009). Therefore the objectives of this study are to evaluate the supplementation levels of fresh sweet potato tubers as energy source in crossbred rabbit diets on intake, growth and carcass value. The results will be applied for the rabbit producers to improve their income.

MATERIALS AND METHODS

Animals and experimental design

The experiment was conducted at the Experimental Farm of Long Hoa, Binh Thuy of Can Tho City and the laboratory of Department of Animal Sciences of Can Tho University, Vietnam and from October 2009 to May 2010. Sixty crossbred female rabbits from 45 to 50 days of age (589±66.8 g/rabbit) were arranged in a complete randomized design with 5 treatments and 3 replications. Two males and two females were housed in a wire mesh and wood cage, as an experimental unit. The dietary treatments were sweet potato tuber supplementation to the diets at levels of 0 (SPT0), 10 (SPT10), 20 (SPT20), 30 (SPT30) and 40 g (SPT40) (DM basis). The diets were adjusted every week by increasing the allowance by 5% (DM basis). The water spinach leaves (WSL), tofu waste and soybean offered in the treatments aimed to supply protein and energy in which the crude protein (CP) level was in different treatments was around 13.0%. The experiment period was 10 weeks.

Feeds, feeding and management

Para grass was collected daily in the areas surrounding Cantho University. WSL were bought from farmers who planted and sold only WS stems for human consumption. The tofu waste was bought from the small plant making tofu for human, while the soybean cake was bought from the animal feed company. The sweet potato tubers were bought from the market with the same variety. They were cleaned by water and cloths, then eliminated the inedible parts and cut into slides for feeding. The animals were fed three times a day at 8:00, 15:00 and 19:00 h. Para grass was offered *ad libitum* for all dietary treatments. Fresh water was available at all times. The refusals and spillage were collected and weighed daily in the morning to calculate the feed intake. The animals were vaccinated to prevent some diseases, especially rabbit hemorrhagic diarrhea and parasite diseases.

Measurements taken

The feeds and refusals were taken for analyses of DM, OM, CP, EE, NDF, ADF, and Ash following the procedures of AOAC (1990) and van Soest et al. (1991). Metabolizable energy (ME) was calculated by suggestion of Maertens et al. (2002). At the beginning of the experiment two rabbits per experimental unit were weighed individually and thereafter weekly. Daily feed intakes, growth rate, and feed conversion ratios were measured and calculated. After finishing the experiment all rabbits were slaughtered for evaluating the carcass values. An economic analysis was also done for each treatment.

Statistical analysis

The data from the experiment were analyzed by analysis of variance using the ANOVA of General Linear Model of Minitab Reference Manual Release 13.20 (Minitab 2000). Economic analyses were done using current prices in Vietnamese Dong (VND) to compare net incomes and feeds cost in the different treatments.

Table 1. Feeds sweet potato tuber (SPT) (g DM/rabbit/day) in diets used in different treatments of the experiment

Feed	Treatment				
	SPT0	SPT10	SPT20	SPT30	SPT40
Sweet potato tuber	0.00	10.00	20.00	30.00	40.00
Para grass	*Ad libitum*	*Ad libitum*	*Ad libitum*	*Ad libitum*	*Ad libitum*
Water spinach leaves	15.00	17.50	12.50	10.00	10.00
Tofu waste	10.50	10.50	8.40	8.40	6.30
Soy bean cake	5.43	5.43	9.05	11.80	12.70

SPT0, SPT10, SPT20, SPT30 and SPT40: sweet potato tuber supplemented at 0, 10, 20, 30 and 40 g per day per head

RESULTS AND DISCUSSION

Chemical composition of feeds used in the Exp

The ME of SPT in the experiment was the highest compared to the other feeds and consistent with that reported by NIAH (2002) because they were similar in DM content (26.2%). While the DM and CP contents of SPT was some what lower than those reported by Dominguez (1990) being 26.2 and 3.96%. The EE, NDF and ADF of SPT in the present study were similar to these presented by Olorunnisomo et al. (2006). There were the higher values of CF and NFE of the experiment compared to these stated by Peters et al. (2001) being 4,67 and 85,9%, respectively. The Para grass with the higher NDF content was used for main feed of rabbits and consistent with that presented by (Nguyen Thi Kim Dong & Nguyen Thanh Van 2008). The CP contents of WSL, tofu waste and soybean cake were high and used for protein supplement source. The values were similar to these stated by Phan Thuan Hoang (2009) and Phung Thi Thuy Lieu (2008).

In Table 3 indicated that the daily SPT intake increased gradually from the SPT0 to SPT40 treatment ($P<0.05$), while the Para grass, WSL and tofu waste intake generally reduced when increasing the SPT. The soybean cake intake was significantly different ($P<0.05$) among the treatments and increasing from the SPT0 to the SPT40 treatment. The DM and OM intakes were significantly different ($P<0.05$) among the treatments and gradually increased from the SPT0 to the SPT40 treatment. The DM and OM intakes of the treatment of SPT30 and SPT40 were significantly higher ($P<0.05$) than those of SPT0 treatment. Similarly the daily ME intake in different treatments also followed the pattern of DM and OM intakes ($P<0.05$) with the lowest value for SPT0 (0.60 MJ ME/rabbit and the highest one for the SPT40 (1.10 MJ ME/rabbit). However, the other nutrients of CP, EE, NDF and ADF were not significantly different ($P<0.05$) among the treatments.

The daily DM intakes of the present study were similar to those of crossbred rabbit from 8 to 18 weeks of age being from 60.7 to 65.0 g DM/rabbit (Nguyen Van Thu & Nguyen Thi Kim Dong 2008), while these figures of New Zealand rabbit from 7 to 13 weeks of age were from 62.3 to 81.8 gDM/rabbit (Yamani et al. 1994). The daily CP intakes in the experiment were higher than the report of Fatufe et al. (2010) in crossbred rabbit in Nigeria being from 9.46 to 10.2 g/rabbit, however they were lower than the CP intakes reported by Doan Thi Gang et al. (2006) for the growing New Zealand rabbits being from 20.1 to 25.4 g/rabbit. The daily EE intakes in the present experiment was higher than those reported by Akinmutimi & Osuagwu (2008) being from 2.39 to 3.09, but lower than results in crossbred rabbit presented by Phung Thi Thuy Lieu (2008) being from 5.07 to 6.33 g/rabbit. The NDF and ADF intakes were tendentiously reduced when increasing SPT in the diet and they were 15.7 and 27.0 g/rabbit, respectively. In the experiment on different levels of NDF in diets of crossbred rabbits Nguyen Thi Kim Dong & Nguyen Truong Giang (2008) indicated that the daily NDF and ADF intakes were from 24.0 to 50.0 g/rabbit and from 14.7 to 23.0 g/rabbit, respectively.

Table 2. Chemical composition (%DM) of feed used in Exp

Thực liệu	DM	OM	CP	EE	CF	NDF	ADF	NFE	Ash	ME* MJ/kg
SPT	26,20	96,90	3,96	1,86	3,24	8,59	5,48	87,90	3,06	15,60
Para grass	17,30	88,50	12,10	3,33	26,60	66,40	33,80	46,50	11,50	8,32
WSL	12,20	90,00	25,60	6,74	12,90	33,30	20,20	44,90	9,99	12,00
Tofu waste	11,10	96,00	22,50	9,23	17,50	32,40	27,80	46,80	3,99	11,00
Soybean cake	87,60	90,00	42,50	2,22	5,80	27,20	18,50	39,50	10,00	11,70

SPT: sweet potato tuber; WSL: water spinach leaves; DM: Dry matter; OM: organic matter; CP: crude protein; EE: Ether extract; CF: crude fibber; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; NFE: nitrogen free extract; ME*: metabolizable energy (Maertens et al. (2002)

Table 3. Daily feed, nutrient (g DM/rabbit) and ME intakes of rabbit in the experiment

Items	Treatment					±SE/P
	SPT0	SPT10	SPT20	SPT30	SPT40	
Sweet potato tuber	-	10.30[a]	22.00[b]	29.50[c]	39.40[d]	1.470/0.001
Para grass	25.00[a]	23.60[ab]	21.40[ab]	18.30[b]	17.10[b]	1.070/0.003
Water spinach leaves	14.60[a]	14.90[a]	12.70[ab]	9.95[b]	9.82[b]	0.810/0.002
Tofu waste	10.60[a]	10.60[a]	9.59[a]	8.84[ab]	6.95[b]	0.460/0.001
Soybean cake	7.62[a]	7.71[a]	9.10[ab]	11.30[ab]	11.90[b]	0.820/0.011
DM	57.40[a]	66.80[ab]	74.70[ab]	77.90[b]	85.10[b]	3.970/0.005
OM	52.20[a]	61.40[ab]	69.30[bc]	72.60[bc]	79.70[c]	3.680/0.003
CP	12.90	13.20	13.30	13.30	13.30	0.740/0.995
EE	3.27	3.42	3.37	3.20	3.16	0.160/0.761
NDF	26.90	27.00	26.10	24.10	23.60	1.280/0.260
ADF	15.40	15.70	15.20	14.20	13.90	0.760/0.411
Ash	5.22	5.44	5.45	5.23	5.38	0.300/0.962
ME (MJ/rabbit/day)	0.60[a]	0.75[ab]	0.90[bc]	0.97[bc]	1.10[c]	0.050/0.001

SPT0, SPT10, SPT20, SPT30 and SPT40: sweet potato tuber supplemented at 0, 10, 20, 30 and 40 g per day per rabbit. The data with different superscript letters in the same row differ significantly (P<0.05)

Table 4. Growth rate, feed conversion ratio and economic return of rabbits supplemented sweet potato tubers

Item	Treatment					±SE/P
	SPT0	SPT10	SPT20	SPT30	SPT40	
Final live weight (g/rabbit)	1951.000[a]	2093.000[ab]	2255.000[bc]	2282.000[c]	2271.000[c]	37.300/0.001
Daily weight gain (g)	17.800[a]	19.500[ab]	21.600[bc]	21.900[c]	21.900[c]	0.460/0.001
Feed conversion ratio	3.230	3.420	3.460	3.550	3.890	0.190/0.248
Cost of feed (VND/kg WG)	7,971	8,524	9,082	9,975	10,845	
Total cost (VND/kg WG)	29,786	28,843	27,946	28,596	29,563	
Profit (VND/kg WG)	20.214	21.157	22.054	21.404	20.437	

SPT0, SPT10, SPT20, SPT30 and SPT40: sweet potato tuber supplemented at 0, 10, 20, 30 and 40 g per day per rabbit .The data with different superscript letters in the same row differ significantly (p<0.05). Profit was calculated based on the price of SPT (700 VND/kg), Para grass and water spinach leaves (300 VND/kg), tofu waste (300 VND/kg), soybean cake (10,000 VND/kg) and rabbit live weight (50,000 VND/kg)

The daily ME intakes of crossbred rabbits of the present study were from 0.60 to 1.10 MJ ME/rabbit and similar to those showed by Lam Thanh Binh (2009) when feeding crossbred rabbits from 8 to 18 weeks of age with water spinach, tofu waste and cassava chip (0.72-0.89 MJ ME/rabbit).

The final live weights of rabbit of the SPT30 and SPT40 treatments were significantly higher (P<0.05) than those of the SPT0 and SPT10 treatments, and similarly the daily weight gains followed the pattern of the final live weight. The profit was higher for the SPT20 and SPT30 treatments. The final live weights of rabbit were consistent with those reported by Nguyen Thi Xuan Linh (2008), and the relationship between daily weight gain and ME intake was presented in the figure 1 with $y= -17.48 x^2 + 38.04 x + 1.367$ and $R^2=0.836$.

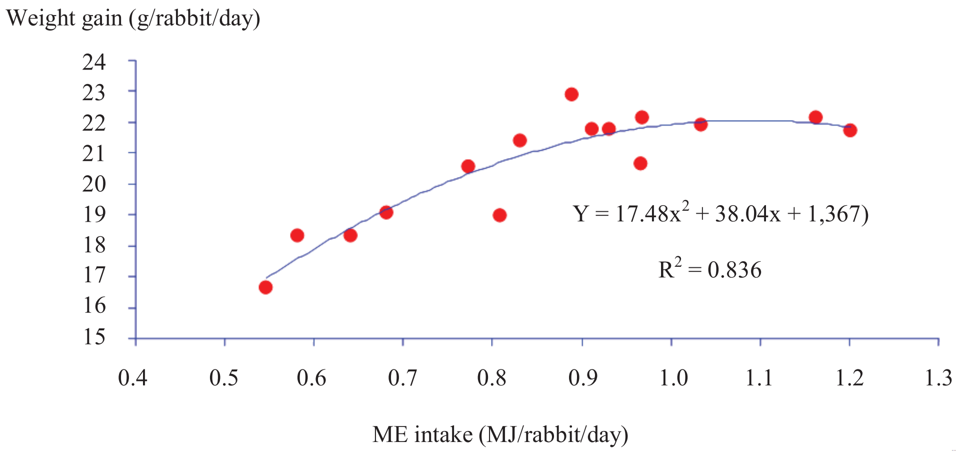


Figure 1. The relationship between daily weight gain and ME intake of growing rabbits

The carcass quality and viscera of rabbits in the experiment were presented in Table 5.

In general the carcass value and meat production were improved by the SPT supplementation. The carcass and meat weights were significantly different ($P<0.05$) among the treatments with the highest value for the SPT30 treatment, however their percentages were not significantly ($P>0.05$). They were from 49.0 to 51.0% and from 55.7 to 71.4%. The hind thigh weight of rabbit was numerically improved by the supplementation, but not statistically different ($P>0.05$). The digestive tract, stomach and caecum length were not significantly different ($P>0.05$) among the treatments. Ouyed & Brun (2008) reported that the carcass percentage of crossbred rabbits fed pellets (16% CP and 2735 kcal ME/kg) was from 52.4 to 54.8%. However, the carcass percentage of the present study was consistent with that stated by Farinu (1994) being from 49.0 to 49.9%. The meat percentage calculated on the carcass of crossbred rabbits in this experiment was from 55.7 to 71.4% and it was lower than that presented by Phung Thi Thuy Lieu (2008) being from 71.3 to 75.3%.

Table 5. The carcass quality and viscera of rabbits supplemented different levels of sweet potato tuber

Criteria	Treatment					±SE/P
	SPT0	SPT10	SPT20	SPT30	SPT40	
Live weight (g)	1880.00^{a}	2000.00^{ab}	2106.00^{ab}	2240.00^{b}	2180.00^{b}	55.500/0.007
Carcass weight (g)	938.00^{a}	979.00^{ab}	1036.00^{ab}	1143.00^{b}	1093.00^{ab}	38.800/0.023
Carcass percentage (%)	49.90	49.00	49.20	51.00	50.20	1.660/0.910
Meat weight (g)	525.00^{a}	668.00^{ab}	722.00^{ab}	815.00^{b}	767.00^{b}	49.000/0.016
Meat percentage (%)	55.70	68.20	69.60	71.40	70.20	3.800/0.080
Hind thigh weight (g)	286.00	301.00	302.00	334.00	3070.00	17.200/0.442
Hind thigh percentage (%)	30.50	30.80	29.10	29.20	28.10	0.980/0.335
Digestive tract (%)	23.80	23.30	23.40	24.90	23.20	1.000/0.755
Stomach (%)	6.37	7.09	7.57	7.32	7.14	0.450/0.454
Caecum length (cm)	47.30	50.70	49.30	50.30	50.70	1.930/0.711

SPT0, SPT10, SPT20, SPT30 and SPT40: sweet potato tuber supplemented at 0, 10, 20, 30 and 40 g per day per rabbit .The data with different superscript letters in the same row differ significantly ($P<0.05$)

CONCLUSION

It was concluded that under feeding condition of the present study supplementing from 20 to 40 g sweet potato tuber gave better rabbit growth performance and profit, and fresh sweet potato tuber should be used to supplement rabbits for improving the ME intake, growth and economic return.

REFERENCES

AOAC. 1990. Official methods of analysis (15th edition), Washington DC (USA): Association of Official Agricultural Chemists. 1:69-90.

Akinmutimi AH, Osuagwu CC. 2008. Response of weaner rabbits fed graded levels of sweet potato meal in place of maize-based diet. Pak J Nutr. 7:705-709.

Doan Thi Gang, Khuc Thi Hue, Dinh Van Binh, Nguyen Thi Mui. 2006. Effect of Guinea grass on feed intake, digestibility and growth performance of rabbits fed a molasses block and either Water Spinach (*Ipomoea aquatica*) or Sweet Potato (*Ipomoea batatas* L.) vines. In: Workshop-seminar "Forages for Pigs and Rabbits". Phnom Penh, 22-24 August, 2006. Phnom Penh (Cambodia): MEKARN-CelAgrid. p. 191-203. Available from: http://www.mekarn.org/proprf/gang.htm.

Dominguez PL. 1990. Sistema de alimentaciòn porcina con desperdicios procesados y otros subproductos agroindustriales. En: Figueroa V, Preston TR, editores. Taller Regional sobre Utilizacion de los recursos alimentarios en la produccion porcina en America Latina y el Caribe. Roma (Italia): FAO-Instituto de Investigaciones Porcinas, Habana, Cuba.

Farinu GO. 1994. Effect of feeding a compound diet based on non-conventional feedstuffs on growth and carcass characteristics of rabbits. World Rabbit Sci. 2:123-126. Available from: http://www.wrs.upv.es/files/journals/vol%202_4_farinu.pdf.

Fatufe AA, Matanmi IO, Alalade AO. 2010. "Performance and carcass characteristics of growing rabbits fed bacterial protein meal". Afr J Food Agric Nutr Dev. 10(4). Available from: http://www.bioline.org.br/pdf?nd10038.

Lam Thanh Binh. 2009. Effects of tofu waste supplementation and energy feed sources in diets on growth, nutrient digestibility and economic analysis. [MSc Thesis]. [Can Tho (Vietnam)]: Department of Animal Sciences, Faculty of Agriculture & Applied Biology, Can Tho University.

Maertens L, Perez JM, Villamide M, Cervera C, Gidenne T, Xiccato G. 2002. Nutritive value of raw materials for rabbits: EGRAN tables 2002 World Rabbit Sci. 10:157-166.

Minitab. 2000. Minitab reference manual release 13.21. Minitab Inc.

Nguyen Thi Kim Dong, Nguyen Thanh Van. 2008. Effect of different levels of cabbage waste (*Brassica olerea*) replacement in para grass (*Brachiaria mutica*) basal diet on growth performance and nutrient digestibility of crossbred rabbits in Mekong delta of Viet Nam. In: Preston R, Thu NV, editors. Proceedings of MEKARN Rabbit Conference: Organic rabbit production from forages. MEKARN Workshop 2008: Organic rabbit production from forages. Cantho City , 25-27 November 2008. Cantho (Vietnam): Cantho University. Available from: http://www.mekarn.org/prorab/dongt.htm.

Nguyen Thi Kim Dong, Nguyen Truong Giang. 2008. Effect of different levels of neutral detergent fiber in the diets on feed utilization, growth rate and nutrient digestibility of growing crossbred rabbits, MEKARN Workshop 2008: Organic rabbit production from forages, Cantho University, Cantho City, Vietnam, from: http://www.mekarn.org/prorab/dong.htm.

Nguyen Thi Xuan Linh. 2008. Effect of water spinach (*Ipomoea aquatica*) in basal diet of Para grass (*Brachiaria mutica*) on meat production and reproduction of crossbred rabbits in the Mekong delta of Vietnam. [MSc Thesis]. (Can Tho [Vietnam]): Dept of Animal Sciences, Fac. of Agric & Appl. Biology, Can Tho University.

Nguyen Van Thu, Nguyen Thi Kim Dong. 2008. Effect of water spinach and sweet potato vine associated with 2 other natural plants, on growth performance, carcass values and economic return of growing crossbred rabbits in the Mekong Delta of Vietnam. WRSA Proceedings. Available form: http://world-rabbit-science.com/WRSA-Proceedings/Congress-2008-Verona/Papers/N-NguyenVan2.pdf.

NIAH. 2002. Chemical composition and nutritive values of feeds. Hanoi (Vietnam): Agriculture Publishing House.

Olorunnisomo OA, Salami AE, Adeleye IOA. 2006. "Improvement in yield and chemical composition of sweet potato for livestock feeding through tillage and fertilizer application", Agric J. 1: 206-210. Available from: http://docsdrive.com/pdfs/medwelljournals/aj/2006/206-210.pdf.

Otte J, Pfeiffer D, Tiensin T, Price L, Silbergeld E. 2007. HPAI risk, bio-security and small-holder adversity, In: Proceedings of World's Poultry Science Association-Asian Pacific Working Federation Group on Small-Scale Family Poultry Farming Symposium, Bangkok, Thailand. p. 1-8.

Ouyed A, Brun JM. 2008. Comparison of growth performances and carcass qualities of crossbred rabbits from four sire lines in quebec, 9th World Rabbit Congress, Verona, Italy. Available from: http://www.agrireseau.qc.ca/grandsgibiers/documents/G-Ouyed1.pdf.

Peters D, Nguyen Thi Tinh, Thai Thi Minh, Phan Huu Ton, Nguyen The Yen, Mai Thach Hoanh. (2001). Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam. International Potato Center (CIP). Available from: http://fastonline.org/CD3WD_40/LSTOCK/001/Pigs/feed-improve/pigfeed.htm.

Phan Thuan Hoang. 2009. A study of nutrient digestibility, growth and economic analysis of crossbred rabbit (New Zealand × local) and exotic breeds in the Mekong delta of Vietnam. [MSc Thesis]. (Can Tho [Vietnam]): Department of Animal Sciences, Faculty of Agriculture and Applied Biology. Can Tho (Viet Nam): Can Tho University.

Phung Thi Thuy Lieu. 2008. Effects of crude protein levels on growth, nutrient digestibility and reproduction of crossbred rabbits. [MSc Thesis]. (Can Tho [Vietnam]): Department of Animal Sciences, Faculty of Agriculture and Applied Biology. Can Tho (Viet Nam): Can Tho University.

Rau Hoa Qua Viet Nam. 2007. "Sweet potato tuber", Center for information of Industry and Trading, Minitry of Industry and Trading. http://www.rauhoaquavietnam.vn/default.aspx.NewsID=947.

Sangkhom I, Preston TR. 2009. Effect of supplementation with sweet potato root and paddy rice on growth performance of local rabbits fed water spinach (*Ipomoea aquatica*) and paper mulberry (*Broussonetia papyrifera*) as basal diets. Livest Res Rural Dev. Available from: http://www.lrrd.org/lrrd21/10/sang21176.htm.

Scott GJ. 1995. Sweet potatoes as animal feed in developing countries: present patterns and future prospects. Agric Consum Prot. Available from: http://www.fao.org/DOCREP/003/T0554E/T0554E13.htm.

Van Soest PJ, Robertson JB, Lewis BA. 1991. "Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle: methods for dietary fiber, and nonstarch polysaccharides in relation to animal nutrition". J Dairy Sci. 74:3585-3597.

Yamani KA, Ayyat MS, Abdalla MA. 1994. Evaluation of the traditional rabbit diet versus thepelleted diet for growing rabbits for small scale units. Int Conf Rabbit Prod Hot Clim. from: http://ressources.ciheam.org/om/pdf/c08/95605295.pdf.

Effects of Different Supplement of Cassava Chip in Para Grass and Water Spinach Basal Diets on Reproductive Performance of Californian Rabbits

Nguyen Thị Kim Dong, Nguyen Van Thu

Faculty of Agriculture & Applied Biology, Cantho University, Vietnam
Corresponding email: ntkdong@ctu.edu.vn

ABSTRACT

An experiment was done at the Experimental farm Long Hoa in Binhthuy district of Cantho city to evaluate the effects of different supplement levels of cassava chip (CAC) in para grass and water spinach basal diet on the reproductive performance of Californian rabbits in two litters. The experiment was a completely randomized design, with 5 treatments as 5 diets and 6 replicates. One male rabbit at 5-6 months of age per experimental unit and 8 California female rabbits were used for mating service for the study. Five treatments were the supplement levels of cassava chip of 10 g (CAC10), 20 g (CAC20), 30 g (CAC30), 40 g (CAC40), and 50 g (CAC50) per doe per day, respectively. In two litters the results indicated that DM and ME intakes significantly increased (P<0.05) when CAC supplement levels was increased in the diets. Significantly higher litter weight at birth and litter weight at weaning (P<0.05) were found for rabbits offered 40 g CAC/day for litter one. Litter sizes at birth, milk yield and daily weight gain of does were significantly higher (P<0.05) in the CAC40 and CAC50 dietary treatments for both litters. A comparison of results between the two litters showed that litter weight at weaning, milk yield and daily gain of kitten were significantly higher for the litter two, however being higher daily gain of does for litter one (P<0.05). It was concluded that at supplement level of 40g cassava chip had better reproductive performance and gave higher economic returns for Californian does.

Key Words: Doe, Cassava Tuber, Milk Production, Litter Size at Birth and Weaning

INTRODUCTION

Rabbit meat production has increased considerably in Vietnam in recent years in order to meet the increasing demand for human food from animal products. It is also increasingly popular due to the fact that it is very nutritious, lean and low in fat and cholesterol. However, pure breeding rabbit stocks are still limited, so it is impossible for producer to buy Californian weaned rabbits for their production. Almost recent studies have focused on feeds and feeding of growing rabbits rather than on reproductive does. Improving the nutrition of breeding rabbits is important for increasing their productivity. In particular determining the optimal level of energy-supplied for pure breeding rabbits makes the better rabbit production and gives the high income for the rabbit keepers (Ren et al. 2003). In the Mekong delta, besides abundant green forages, there is a lot of carbohydrate feeds such as cassava tuber, sweet potato tuber, molasses *etc*., that are valuable energy feed sources for livestock. Especially, para grass and water spinach leaf were used as basal feed diet with local energy and protein feed supplementation from dried cassava chips and soya waste to make balanced nutrient diets that can increase feed utilization and reproductive performance of Californian rabbits. Therefore this study aimed to evaluate the efficiency of dried cassava chip supplement in diets on reproductive performance of Californian does.

MATERIALS AND METHODS

Animals and experimental design

The trial was carried out at the Experimental farm Long Hoa in Binhthuy district, Cantho city. Thirty 6 months old Californian rabbits with live weight average of 2860 g were arranged in a complete randomized design with 5 treatments and 6 replications. The dietary treatments were different supplementation levels of 10, 20, 30, 40 and 50 g dried cassava chips to para grass and water spinach leaf basal diet, corresponding to the CAC10, CAC20, CAC30, CAC40 and CAC50 treatments. Soya waste with amount of 200 g and 30 g concentrate and 20 g oil-extracted soybean were offered per rabbit per day. Does were housed individually in separate per wire mesh and woody cage, and each doe was considered as an experimental unit. The eight female Californian rabbits were used for mating services and the trial was monitored for 2 litters.

Feeds, feeding and management

Para grass (PG), water spinach leaves (WSL) and soya waste (SW) were collected and bought daily, except for dried cassava chips bought from farmers in one occasion to be used during experiment. The animals were fed three times a day at 8:00, 14:00 and 18:00 h. The WSL and SW were adjusted weekly by increasing allowances by 5, 10 and 15% in the second, third and fourth week of pregnancy, respectively. During lactation period allowances were increased by 10% in the first week, 30% for the second and third week, and 40% in the fourth week. All animals had access to fresh water at all times. The breeding service was done at two weeks after birth. The new-born animals were weaned at the 30th day. Before the experiment started, all does were vaccinated to prevent rabbit hemorrhagic and parasite diseases.

Measurements

Reproduction criteria were recorded in 2 litters. Feeds given and refusals were taken for analyses of DM, OM, CP, EE, Ash and NDF following procedure of AOAC (1990) and van Soest et al. (1991) and ME (Maertens et al. 2002). The measurement taken included: daily feed and nutrient intakes for each litter, litter size at birth and weaning, daily milk yield recorded by weighing the kids before and after suckling.

Statistical analysis

The data were analyzed by analysis of variance using the ANOVA of General linear model of Minitab Reference Manual Release 16.1.0 (Minitab 2010). For the comparison of the reproduction criteria between the litters the paired T test of Minitab Reference Manual was used.

RESULTS AND DISCUSSION

Feed characteristics

The para grass (PG) contained higher DM, but lower CP concentrations as compared to water spinach leaves (WSL). Supplementation of SW and ESB to para grass and WSL diets provided protein, while CAC supplemented energy for does in the diets. The CP content of WSL and SW used in our experiment are similar to values (27.0 and 21.2%, respectively) reported by Thoai (2012). The CP and ME concentrations of CAC in a current study are consistent with the results of 2.70% CP and 13.4 MJ ME stated by Nguyen & Nguyen (2012).

Characteristics of feeds used in the trial are presented in Table 1.

Table 1. Chemical composition of feeds (% DM) used in the trial

Feed (%)	DM	OM	CP	EE	Ash	NDF	ME, MJ/kg DM
Cassava chip (CAC)	90.00	97.30	2.85	1.38	2.67	15.00	13.30
Para grass (PG)	15.50	89.20	12.60	4.50	10.80	65.50	8.23
Water spinach leaves (WSL)	11.50	90.60	29.60	8.00	9.40	41.00	12.00
Soya waste (SW)	12.40	96.20	21.00	15.50	3.80	36.50	11.20
Oil-extracted soybean (ESB)	87.60	89.80	41.80	3.40	10.20	27.50	11.40
Concentrate (CON)	89.50	92.20	19.90	7.35	7.80	25.20	11.90

DM: dry matter; OM: organic matter; CP: crude protein; EE: ether extraction; NDF: neutral detergent fiber and ME: metabolisable energy (Maertens et al. 2002)

Feed and nutrient utilization

The daily intakes of feed, nutrient and ME of the does were shown in Table 2

The results of pregnant and lactation periods of the Californian does indicate that daily DM and OM intakes were significantly higher ($P<0.05$) for the CAC40 and CAC50 treatments. Especially, The ME intake considerably increased with increasing CAC levels in the diets ($P<0.05$), reaching the highest results for the CAC40 and CAC50 treatments (Table 2). The DM intakes are in a range of 111 to 145 g, but being higher ME intakes than those (1.06-1.53 MJ/rabbit) of a study on Californian does reported by Trang (2012).

Effect of cassava chip supplement on reproductive performance of does, litter 1

For litter 1, litter size at birth and at weaning had tendency to increase for the does supplemented CAC ($P>0.05$), while the weight of litter at birth and at weaning were the highest ($P<0.05$) for the does supplemented CAC in the CAC40 and CAC50 treatments (Table 3). The litter size at birth is consistent with the findings stated by Mai (2005) (3-8 kids/litter) and Thoai (2012) (5.67-7.33 kids/litter), but being lower than report of Lebas et al. (1986) (7-9 kids/litter). The relationship between ME intake and litter size at birth was presented in Figure 1 with $R^2 = 0.99$.

Table 2. Daily intakes of feed, nutrients and ME of Californian rabbits in litter 1

Item	Treatment					SE/P
	CAC10	CAC20	CAC30	CAC40	CAC50	
Daily intake of nutrients and ME in pregnant period (g/doe)						
DM	113.00	112.00	114.00	120.00	120.00	2.520/0.130
OM	104.00	105.00	106.00	113.00	111.00	2.410/0.080
CP	23.00	22.80	22.50	23.00	23.10	0.320/0.830
EE	6.47	6.54	6.09	6.33	6.28	0.280/0.820
NDF	38.30	37.00	39.00	39.00	39.00	1.440/0.830
ME (MJ/doe)	1.24^{a}	1.27^{a}	1.31^{ab}	1.41^{b}	1.39^{b}	0.030/0.002
Daily intake of nutrients and ME in lactation period (g/doe)						
DM	123.00^{a}	127.00^{a}	139.00^{b}	152.00^{c}	151.00^{c}	2.430/0.001
OM	113.00^{a}	117.00^{a}	128.00^{b}	141.00^{c}	140.00^{c}	2.200/0.001
CP	26.00	26.80	26.60	27.10	26.40	0.370/0.410
EE	7.15	7.06	7.14	7.42	7.27	0.120/0.310
NDF	46.60	44.40	48.90	46.40	47.10	1.240/0.210
ME (MJ/doe)	1.27^{a}	1.31^{a}	1.46^{b}	1.62	1.63^{c}	0.020/0.001
Daily intake of nutrients and ME in pregnant and lactation period (g/doe)						
DM	118.00^{a}	119.00^{a}	126.00^{ab}	136.00^{b}	135.00^{b}	2.170/0.001
OM	109.00^{a}	111.00^{a}	117.00^{ab}	127.00^{bc}	126.00^{c}	2.020/0.001
CP	24.40	24.80	24.60	25.00	24.70	0.260/0.660
EE	6.80	6.80	6.60	6.90	6.78	0.170/0.860
NDF	42.50	40.70	43.90	42.70	43.00	0.180/0.260
ME (MJ/doe)	1.26^{a}	1.29^{a}	1.39^{b}	1.51^{c}	1.52^{c}	0.020/0.001

$^{a, b, c}$ Mean values with different superscripts within the same row are different at $P<0.05$

Table 3. Effect of cassava chip supplement on reproductive performance of does, litter 1

Item	Treatment					SE/P
	CAC10	CAC20	CAC30	CAC40	CAC50	
Pregnancy duration (day)	30.00	29.50	30.30	30.30	30.00	0.380/0.630
Litter size at birth (rabbit)	6.50	7.00	7.50	8.00	7.75	0.420/0.140
No of alive rabbit at birth	6.50	6.75	7.25	7.50	7.50	0.380/0.270
Weight at birth (g/kitten)	61.60	56.10	57.20	54.70	56.10	2.700/0.470
Weight of litter at birth	381.00[a]	390.00[ab]	427.00[ab]	435.00[c]	430.00[c]	14.500/0.050
Litter size at weaning (rabbit)	6.25	6.75	7.00	7.50	7.25	0.390/0.250
Weight at weaning (g/rabbit)	415.00	413.00	420.00	446.00	437.00	15.200/0.460
Weight of litter at weaning (g)	2593.00[a]	2778.00[ab]	2919.00[abc]	3333.00[c]	3161.00[bc]	128.000/0.007
Milk yield (g/day)	96.80[a]	108.00[ab]	118.00[abc]	133.00[c]	127.00[bc]	4.760/0.001
Milk amount (g/kitten/day)	15.70	16.13	16.90	17.90	17.60	0.990/0.490
Daily gain of litter (g/litter)	2212.00[a]	2401.00[ab]	2521.00[abc]	2923.00[c]	2755.00[bc]	116.000/0.005
Daily gain (g/kitten)	11.80	11.90	12.10	13.10	12.70	0.470/0.260
Daily gain of doe in pregnant time	16.00	16.40	17.60	17.80	17.70	0.480/0.050

[a, b, c] Mean values with different superscripts within the same row are different at P<0 05

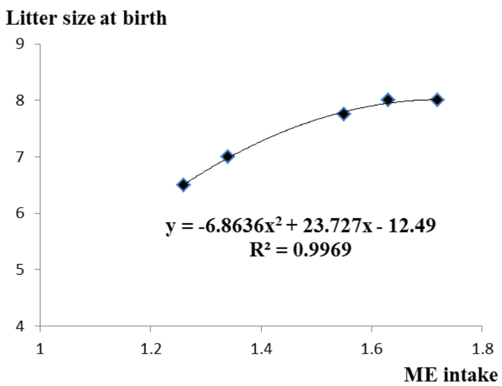


Figure 1. Effect of ME intake on litter size at birth

Milk yield was affected by CAC supplement in the diets corresponding with increase of ME intakes. The results were significantly higher (P<0.05) for the animals fed from 40 g to 50 g CAC in the CAC40 and CAC50 treatments. The data recorded in our study is considerably higher than those (67.3-83 g/day) of a study on Californian does cited by Khoi (2012).

Daily intakes of feed, nutrients and ME of Californian does supplemented different levels of cassava chips, litter 2

Table 4 shows that the DM and ME intakes obtained in litter 2 were higher than those in litter 1. The daily intake average of DM, OM and ME increased following with increasing the CAC supplement levels in diets (P<0.05) getting the highest in the CAC40 and CAC50 treatments. The ME intakes are consisted with those (1,42-1,50 MJ/rabbit), while DM intakes were lower than the values of 148 g to 150 g of a trial on does supplemented oil- extracted soybean in diets (Trinh 2012).

Effect of cassava chip supplement on reproductive performance of does, litter2

For litter 2, litter size at birth was significantly higher (P<0.05) in the CAC40 and CAC50 treatments. Also, the litter size at birth and at weaning are in agreement with data cited by Linh (2008) (5.76-7.33 kids/litter) and Thao (2012) (5.33-7.0 kids/litter), respectively. The CAC supplementation clearly improved milk yield of does, and getting the highest value (P<0.05) for the animals given 40 g CAC in the CAC40 diet. The results obtained in a present study are better than the values (72.2-92.8 g/day) of crossbred does supplied dried sweet potato tuber (Loan 2010). Effect of ME intake on milk production and litter size at weaning of Californian does is shown in Figure 2 with R^2= 0.95 and R^2= 0.85

Table 4. Daily intakes of nutrients and ME of Californian does supplemented different levels of cassava chips, litter 2

Item	Treatment					SE/P
	CAC10	CAC20	CAC30	CAC40	CAC50	
Daily intake of nutrients and ME in pregnant period (g/doe)						
DM	110.000[a]	115.000[a]	134.000[b]	141.000[bc]	145.000[c]	1.910/0.001
OM	102.000[a]	107.000[a]	124.000[b]	131.000[bc]	136.000[c]	1.850/0.001
CP	21.600	21.700	21.300	22.100	22.200	0.370/0.460
EE	8.600	9.050	9.480	8.750	8.450	0.260/0.100
NDF	47.200	47.400	47.600	48.800	48.600	0.750/0.470
ME (MJ/doe)	1.170[a]	1.250[a]	1.480[b]	1.550[bc]	1.630[c]	0.020/0.001
Daily intake of nutrients and ME in lactation period (g/doe)						
DM	125.000[a]	129.000[a]	143.000[b]	153.000[c]	160.000[d]	1.480/0.001
OM	115.000[a]	120.000[a]	133.000[b]	142.000[c]	150.000[d]	1.320/0.001
CP	25.600	25.800	25.900	25.700	25.800	0.170/0.720
EE	9.600	9.700	9.700	10.100	10.300	0.210/0.130
NDF	51.200	50.900	51.600	49.800	51.600	0.600/0.250
ME (MJ/doe)	1.350[a]	1.420[b]	1.610[c]	1.700[d]	1.820[e]	0.010/0.001
Daily intake average of nutrients and ME in pregnant and lactation period (g/doe)						
DM	118.000[a]	122.000[a]	138.000[b]	147.000[c]	153.000[c]	1.510/0.001
OM	109.000[a]	113.000[a]	129.000[b]	137.000[c]	143.000[c]	1.410/0.001
CP	23.600	23.700	23.600	23.900	24.000	0.170/0.430
EE	9.100	9.350	9.600	9.450	9.380	0.120/0.100
NDF	28.300	28.400	28.800	29.800	29.600	0.430/0.090
ME (MJ/doe)	1.260[a]	1.340[b]	1.550[c]	1.630[d]	1.720[e]	0.010/0.001

[a, b, c, d, e] Mean values with different superscripts within the same row are different at P<0 05

Table 5. Effect of cassava chip supplement on reproductive performance of does, litter 2

Item	Treatment					SE/P
	CAC10	CAC20	CAC30	CAC40	CAC50	
Pregnancy duration (day)	30.000	30.000	29.800	30.000	30.300	0.440/0.950
Litter size at birth (rabbit)	6.500[a]	7.000[a]	7.750[b]	8.000[b]	8.000[b]	0.360/0.030
No of alive rabbit at birth	6.500	7.000	7.500	7.800	7.500	0.310/0.080
Weight at birth (g/kitten)	62.800	59.700	56.400	57.100	55.600	2.570/0.310
Weight of litter at birth	406.000	419.000	435.000	453.000	442.000	14.100/0.190
Litter size at weaning (rabbit)	6.500	7.000	7.300	7.500	7.500	0.310/0.180
Weight at weaning (g/rabbit)	440.000	437.000	443.000	471.000	460.000	16.000/0.530
Weight of litter at weaning (g)	2860.000	3065.000	3206.000	3530.000	3448.000	178.000/0.100
Milk yield (g/day)	106.000[a]	119.000[ab]	128.000[ab]	141.000[c]	134.000[bc]	5.100/0.002
Milk amount (g/kitten/day)	16.400	17.200	17.100	18.300	18.100	1.040/0.700
Daily gain of litter (g/litter)	2454.000	2646.000	2771.000	3077.000	3006.000	173.000/0.120
Daily gain (g/kitten)	12.600	12.600	12.800	13.700	13.370	0.530/0.500
Daily gain of doe in pregnancy	10.700 [a]	10.900[a]	11.800[b]	12.000[b]	11.900[b]	0.330/0.050

[a, b, c] Mean values with different superscripts within the same row are different at P<0 05

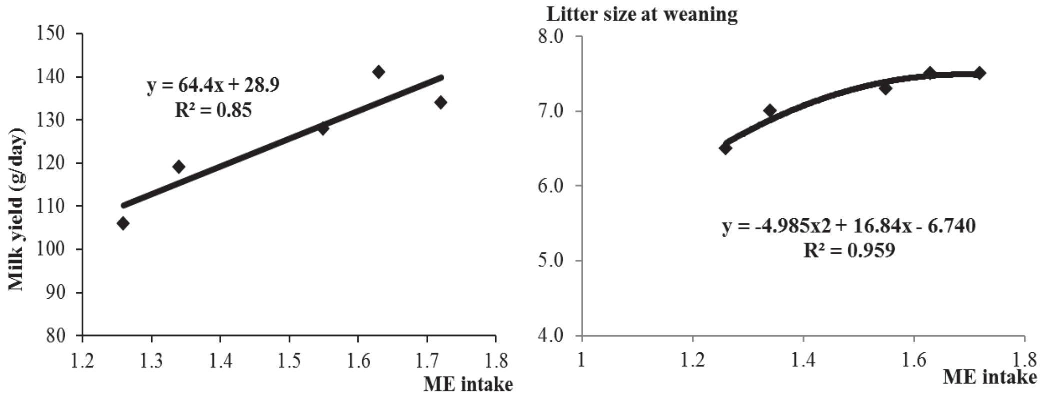


Figure 2. Effect of ME intake on milk production and litter size at weaning of does in litter 2

Comparison the reproductive performance between two litters

A comparison of reproductive criteria of the does between two litters is presented in Table 6. There was no significant difference in litter size at birth and at weaning, weight at birth ($P>0.05$) between two litters, while litter weight at weaning, milk yield and daily weight gain of kitten were significantly higher ($P<0.05$) for litter 2. Also, daily weight gain of does in pregnant period was higher for litter 1 ($P>0.05$).

Analysis of economic returns of Californian does supplemented cassava chips of two litters

In Table 7 analysis of economic returns of Californian does were supplemented cassava chips in the diets of two litters indicate that the lower total expense, but higher income were found in the CAC40 treatment, resulting in giving more benefits for Californian does fed 40 g cassava chips per day.

Table 6. Comparison the reproductive performance among two litters

Item	Litter 1	Litter 2	SE/P
Pregnancy duration (day)	30.00	30.00	0.260/1.000
Litter size at birth (rabbit)	7.40	7.50	0.230/0.670
No of alive rabbit at birth	7.10	7.30	2.200/0.450
Litter size at weaning	7.00	7.20	0.190/0.300
Weight at birth (g/rabbit)	57.10	58.30	1.500/0.430
Litter weight at weaning (g)	2,957.00[a]	3,222.00[b]	82.400/0.005
Milk yield (g/day)	116.00[a]	126.00[b]	0.330/0.001
Milk amount (g/kitten/day)	16.80	17.40	0.480/0.250
Daily gain of litter (g/litter)	2,562.00	2,791.00	77.400/0.008
Daily gain (g/kitten)	12.30[a]	13.00[b]	0.050/0.001
Daily gain of doe in pregnant time	17.10[a]	11.50[b]	0.090/0.001

Table 7. Analysis of economic returns of does supplemented cassava chips of two litters (VND)

Item	Treatment				
	CAC10	CAC20	CAC30	CAC40	CAC50
Litter size at weaning rabbit	6.4	6.9	7.3	7.5	7.4
Income from selling rabbits	448,000.0	483,000.0	511,000.0	525,000.0	518,000.0
Feed cost	39,140.0	40,017.0	38,206.0	39,607.0	39,885.0
Housing	10.0	10.0	10.0	10.0	10.0
Medicine cost	20.0	20.0	20.0	20.0	20.0
Total expense	39,170.0	40,047.0	38,236.0	39,637.0	39,915.0
Profit	408,830.0	442,953.0	472,764.0	485,363.0	478,085.0

Cost were 70,000 VND/weaned rabbit, 8000 VND/kg dry cassava chips

CONCLUSION

Dried cassava chip is a valuable energy source, could be used for feeding rabbit does. The Californian does supplemented cassava chips at level of 40g per day improved DM and ME intakes and gave better reproductive performance and profits.

REFERENCES

AOAC. 1990. Official methods of analysis (15th edition). Association of Offical Analytical Chemists. 1:69-90.

Khoi DHN. 2012. Effect of supplement levels of coconut meal in diets on reproductive performance of Californian rabbits. [Graduate Thesis]. (Cantho [Vietnam]): Cantho University.

Lebas F, Coudert P, Rouvier R, de Rochambeau H. 1986. Rabbit Husbandry, Health and Production. Rome (Italy): Food and Agriculture Organization.

Linh NTX. 2008. Effect of water spinach in para grass basal diets on reproductive performance of crossbred rabbits in the Mekong delta. [MSc Thesis]. (Cantho [Vietnam]): Cantho University.

Loan DTB. 2010. Effect of supplement levels of dried sweet potato tuber in diets on reproductive performance of crossbred rabbits. [MSc Thesis]. (Cantho [Vietnam]): Cantho University.

Maertens L, Peter JM, Villamide M, Cervera C, Gidenne T, Xiccato G. 2002. Nutritive value of raw materials for rabbit. World Rabbit Sci. 10:157-166.

Mai HTX. 2005. Rabbit feeding and management. Ho Chi Minh City (Vietnam): Agricultural Publishing House.

MINITAB. 2010. Minitab reference manual release 16.1.0 Minitab Inc.

Nguyen TKD, Nguyen VT. 2012. Effects of dried chip casava supplementation in diets of crossbred rabbits intake and digestibility, meat production and economic return. J Anim Sci Technol. 36: 77.

Ren KL, Li YP, Ren JL, He DC, Liang QZ. 2003. Study of dietary energy and protein levels for reproducing Rex rabbits. In: Proceedings of the 8th World Rabbit Congress. http://www.dcam.upv.es/8wrc/docs/Feeding% 20and% 20Nutrition/Short%20Papers/959-963 Renlp_mod.pdf.

Thao LNT. 2012. Effect of soybean meal supplement in diets on reproductive performance of Californian rabbits does. [Graduate Thesis]. (Cantho [Vietnam]): Cantho University.

Thoai PTH. 2012. Effect of catfish oil supplement in diets on reproductive performance of Californian rabbits does. [Graduate Thesis]. (Cantho [Vietnam]): Cantho University.

Trang TTH. 2012. Effect of soybean meal supplement in diets on reproductive performance of Californian rabbits does. [Graduate Thesis]. (Cantho [Vietnam]): Cantho University.

Trinh TTK. 2012. Effect of soybean meal supplement in diets on reproductive performance of Crossbred rabbits does. [Graduate Thesis]. (Cantho [Vietnam]): Cantho University.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Symposium: Carbohydrate methodology. metabolism and nutritional implications in dairy cattle: methods for dietary fiber and nonstarch polysaccharides in relation to animal nutrition. J Dairy Sci. 74:3585-3597.

Effect of Supplementation Levels of Coconut Cake on Reproductive Performance of Californian Rabbit Fed Basal Diets of Para Grass (*Brachiaria mutica*) in the Mekong Delta of Vietnam

Nguyen Van Thu, Nguyen Thi Kim Dong

Faculty of Agriculture & Applied Biology, Can Tho University, Vietnam
Campus II, 3/2 street, Ninh Kieu district, Can Tho city, Viet Nam
Corresponding email: nvthu@ctu.edu.vn

ABSTRACT

A study was implemented on 30 Californian does by using a complete randomized design with 5 treatments and 6 replications to evaluate their reproductive performance over two litters. The supplementation levels were 10, 15, 20, 25 and 30 g coconut cake were corresponding to the CO10, CO15, CO20, CO25 and CO30 treatments. The does were fed Para grass *ad libitum*, while other supplements of soybean and tofu waste were fed at the same levels in different treatments. The results showed that the average dry matter intakes (DMI) of the does in different treatments in the first litter was similar (P>0.05) and were from 130 to 144 g/doe/day, however in the second litter these were significantly different (P<0.05) with highest value (156 g) for the CO25 treatment and the lowest one (137 g) was for the CO10 treatment. The average crude protein intakes (CPI) of the first litter were significantly different (P<0.05) with the highest value (30.4 g/doe/day) of CO25 treatment, while in the second litter these were not significantly different (P>0.05) and were from 29.6 to 32.5 g/doe/day. The average metabolizable energy intakes (MEI) were significantly different (P<0.05) in both two litters and had a tendency of the increase MEI for the treatments when supplementing coconut cake. The litter sizes at birth and at weaning were higher for the CO20 and CO25 treatments and the daily milk yield was increased (P<0.05) when supplementing the coconut cake in both two litters. These criteria in litter 2 was tendentiously higher than in the litter 1. It was concluded that under feeding conditions of present study supplementing 20 g coconut cake per doe per day gave better reproductive performance of the Californian rabbit.

Key Words: Rabbit, Supplements, Agro-Industrial Byproducts, Reproductivity, Green Forages

INTRODUCTION

In recent years rabbit production has been developed well in Vietnam to satisfy the demand of meat. This has also gave better income for the producers, particularly for the peasants who is living in the rural areas with the low financial benefits from their production. They have utilized the natural grasses and agro-industrial byproducts available in the villages for feeding the rabbits. In the Mekong delta of Vietnam where the rabbit production has rapidly developed due to the advantages of suitable climate, rich soil and fresh water. Californian rabbits were imported this region over ten years, then they have been adapted to the living environment with local feed resources (Phan Thuan Hoang & Nguyen Van Thu 2010). In Vietnam the coconut areas are about 200.000 ha and they were mainly in the Mekong delta provinces (Agriviet 2009), then as a result there is a huge amount of coconut byproducts produced such as coconut cake and oil. The coconut cake is widely used as feed resources supplying protein and energy for pigs, chicken and other ruminants, however, studies of effects of coconut cake supplementation on reproduction of the rabbit have been limited in Vietnam. Therefore, this study aimed to evaluate the response of reproductivity of the Californian rabbits supplemented different levels of coconut cake for a practice recommendation.

MATERIALS AND METHODS

Animals and experimental design

The study was implemented at the Experimental farm Long Hoa and the

Laboratory E205 of Department of animal sciences of Cantho University in 2010. Thirty Californian does were allocated in a complete randomized design with 5 treatments and 6 replications to evaluate their reproductive performance over two litters. The treatment were supplementation levels of 10, 15, 20, 25 and 30 g coconut cake corresponding to the CO10, CO15, CO20, CO25 and CO30. The treatments were described as in Table 1.

Feeds, feeding and management

The does were fed Para grass *ad libitum*, while other supplements of *Operculia turpethum* leaves, soybean and tofu waste were fed at the same levels in different treatments. Para grass was collected daily in the areas surrounding Cantho University. Coconut cakes were bought from the company. The animals were fed three times a day, at 8:00, 15:00 and 19:00h. The diets were adjusted weekly by increasing allowances by 5, 10 and 15% in the second, third and fourth week of pregnancy, respectively. During the lactation period allowances were increased by 10% in the first week, 30% in the second and third week, and 40% in the fourth week. All animals had access to fresh water at all times. The does were kept individually in separate cages, and only one buck was used for mating. The breeding service was done at two weeks after birth. The new-born animals were weaned at the 30th day. Refusals and spillage were collected and weighed daily in the morning to calculate feed intake. Weights of rabbits at birth and weaning, and daily milk yields were measured. The does were weighed weekly from mating to parturition and their weight gains calculated during pregnancy. Before entering experiment all does were vaccinated to prevent some diseases, especially rabbit Hemorrhagic diarrhea and also parasite diseases.

Measurements taken

Reproduction criteria were recorded in 2 litters. Feeds and refusals were taken for analyses of DM, OM, CP, NDF and ADF following the procedure of AOAC (1990) and van Soest et al. (1991). The measurement taken including: daily feed and nutrient intakes for each litter, litter size at birth and weaning and daily milk yield recorded by weighing the kids before and after suckling of kids.

Statistical analysis

The data of experiments were analyzed by analysis of variance using the ANOVA of General linear model of Minitab Reference Manual Release 13.20 (Minitab 2000) to compare the differences among the treatments. For the comparison of the reproduction criteria between the litters the paired T test of Minitab Reference Manual was also used.

RESULTS AND DISCUSSION

Chemical composition (% DM) and energy of feeds

In Table 2 showed that Para grass (PG) contained higher DM, but lower CP concentration as compared to *Operculia turpethum* leaves. Tofu waste, soybean and coconut cake had higher CP content and energy. Coconut cake had higher DM and NDF as compared to tofu waste and soybean.

Table 1. Feeds (in fresh) of treatments (g/doe/day) used in the experiment at the start of experiment

	Treatments				
	CO10	CO15	CO20	CO25	CO30
Coconut cake	10	15	20	25	30
O. turpethum	200	200	200	200	200
Tofu waste	200	200	200	200	200
Soybean	25	25	25	25	25

CO10, CO15, CO20, CO25 and CO30: the coconut cake supplemented at levels of 10, 15, 20, 25 and 30 g/doe/day

Table 2. Chemical composition and energy of feed used in the experiments

	DM	OM	CP	EE	NDF	Ash	ME, MJ/kg
Para grass	17.70	89.10	12.90	3.70	65.60	10.90	8.23
O. turpethum leaves	11.90	87.90	15.50	6.52	38.80	12.10	10.70
Tofu waste	12.20	96.00	23.50	9.23	22.90	4.00	11.20
Soybean	92.80	94.80	42.30	11.40	22.90	5.20	12.10
Coconut cake	95.70	96.00	21.30	7.18	56.70	3.97	11.00

DM: dry matter; OM: organic matter; CP: crude protein; EE: Ether extraction; NDF: neutral detergent fiber; ME: metabolizable energy

The CP and ME of tofu waste and soybean were similar to those presented by Nguyen Tan Nam (2011) and Phan Thi Huyen Thoai (2012). While the DM and CP of Para grass in the present study were somewhat higher those reported by Nguyen Tan Nam (2011).

Feed and nutrient utilization and reproduction

Litter 1

The average feed and nutrient intakes of rabbits of pregnancy and lactation periods in litter 1 was presented in Table 3.

The DM and OM intakes for both pregnancy and lactation periods were similar (P>0.05) among the treatments, while the ME intake was significantly different (P<0.05) among the treatments with the higher values for the CO20 and CO25 treatments (Table 3). The CP and EE intakes for the CO25 treatment were significantly (P<0.05) higher than those of the CO10 treatment. The NDF intakes were similar among the treatments and higher than those reported by Nguyen Tan Nam (2011) when studying on the crossbred rabbits (New Zealand × local) being from 44.0 to 46.7 g/doe/day. But they were lower than results of Californian rabbits stated by Phan Thi Huyen Thoai (2012) being from 57.6 to 69.1 g/doe/day.

In Table 4 showed that the litter size at birth, weight of litter at birth, number of alive rabbit at weaning and milk production of litter 1 were significantly different (P<0.05) among the treatments with the highest values for the CO20 treatment. Although the values of the C20 treatment were higher, they were not significantly different (P>0.05) among the treatments for the number of alive rabbit at birth, weight of litter and rabbit at weaning and milk consumed of kitten per day. The number of rabbit at birth of present study (5.67-7.0) was higher than that reported by Phan Thi Huyen Thoai (2012) being from 5.33 to 6.67 for the Californian rabbits. However, it was lower than that of crossbred rabbits stated by Truong Thanh Trung (2006). The weight of litter at birth was higher that presented by Nguyen Thi Xuan Linh (2008) and Truong Thanh Trung (2006). The milk production of litter was from 67.3 to 82.0 g/d and similar to that reported by Phan Thi Huyen Thoai (2012).

Litter 2

The DM and OM intakes in litter 2 was not significantly different (P>0.05), while the CP and EE intakes were significantly (P<0.05) higher for the CO25 and CO30 treatments as compared to the CO10 treatment. The ME and NDF intakes were not significantly different (P>0.05) among the treatments, even though the values of the CO20 and CO25 treatments were numerically higher than those of the others.

In Table 6 showed that the litter size at birth and number of live rabbit at birth, milk production of litter were significantly different (P<0.05) among the treatments with the highest values for the CO20 treatment. While the weight of litter at birth and weaning, number of alive rabbit at weaning were numerically higher for the CO20 treatment compared to the other treatments, but they were not statistically significant (P>0.05) among the treatments. The number of Californian rabbit at birth and milk production of litter in litter 2 in this experiment were consistent with those reported by Phan Thi Huyen Thoai (2012).

Table 3. Average feed, nutrient (gDM) and ME intakes of rabbits for both pregnancy and lactation periods in litter 1

Items	Treatments						
	CO10	CO15	CO20	CO25	CO30	±SE	P
DM	140.00	143.00	146.00	147.00	141.00	2.26	0.225
OM	129.00	131.00	135.00	136.00	131.00	2.00	0.163
CP	30.10^{a}	30.70^{ab}	31.80^{ab}	32.20^{b}	31.80^{ab}	0.32	0.004
EE	9.82^{a}	10.00^{ab}	10.40^{bc}	10.60^{b}	10.50^{ab}	0.09	0.001
NDF	61.30	62.60	64.10	64.40	60.70	1.53	0.376
Ash	11.00^{a}	10.90^{a}	10.70^{a}	10.20^{ab}	9.19^{b}	0.27	0.005
ME, MJ/doe/day	1.43^{a}	1.46^{ab}	1.51^{ab}	1.53^{b}	1.49^{ab}	0.02	0.030

The data with different superscript letters in the same row differ significantly (P<0.05)

Table 4. The reproductive criteria of does in different treatments in litter 1

Items	Treatments					
	CO10	CO15	CO20	CO25	CO30	±SE/P
Litter size at birth	5.67^{a}	6.67^{ab}	7.00^{b}	7.00^{b}	6.33^{ab}	0.300/0.020
Number of live rabbit at birth	5.67	6.67	6.67	6.33	6.33	0.330/0.270
Weight of litter at birth (g)	313.00^{a}	315.00^{a}	367.00^{b}	364.00^{b}	322.00^{ab}	16.900/0.050
Weight of rabbit at birth (g)	55.20	47.80	52.40	52.00	51.20	3.180/0.610
No. of live rabbit at weaning	5.00^{a}	5.67^{a}	6.67^{b}	6.00^{ab}	6.00^{ab}	0.210/0.002
Weight of litter at weaning	1327.00	1245.00	1283.00	1277.00	1043.00	198.000/0.800
Weight of rabbit at weaning (g)	265.00	296.00	323.00	274.00	276.00	28.000/0.620
Milk production of litter (g/d)	67.30^{a}	74.70^{ab}	82.00^{b}	77.70^{b}	77.90^{b}	2.020/0.005
Milk consumed of rabbit (g/d)	13.40	13.20	12.40	12.90	13.00	0.640/0.800
Weight gain of rabbit (g/d)	7.01	8.26	9.03	7.39	7.50	0.910/0.560
Alive rabbit at weaning (%)	88.90	85.70	100.00	95.20	95.20	5.380/0.400

CO10, CO15, CO20, CO25 and CO30: the coconut cake supplemented at levels of 10, 15, 20, 25 and 30 g/doe/day. The data with different superscript letters in the same row differ significantly (P<0.05)

Table 5. The average feed, nutrient intakes (gDM) and ME intakes of rabbits for both pregnancy and lactation periods in litter 2

Items	Treatments						
	CO10	CO15	CO20	CO25	CO30	±SE	P
DM	144.000	146.000	149.000	149.000	146.000	2,360	0,456
OM	132.000	134.000	137.000	137.000	135.000	2,120	0,344
CP	30.600^{a}	31.200^{ab}	32.100^{ab}	32.400^{b}	32.600^{b}	0.380	0.017
EE	10.000^{a}	10.200^{ab}	10.500^{bc}	10.700^{bc}	10.700^{c}	0.110	0.030
NDF	63.300	64.800	66.400	65.400	62.800	1.480	0.429
Ash	11.500^{a}	11.300^{a}	11.000^{a}	10.300^{ab}	9.620^{b}	0.270	0.002
ME (MJ/rabbit/day)	1.460	1.490	1.540	1.550	1.530	0.020	0.072

CO10, CO15, CO20, CO25 and CO30: the coconut cake supplemented at levels of 10, 15, 20, 25 and 30 g/doe/day. The data with different superscript letters in the same row differ significantly (P<0.05)

Table 6. The reproductive criteria of does in different treatments in litter 2

Items	Treatments						
	CO10	CO15	CO20	CO25	CO30	±SE	P
Litter size at birth	6.00^{a}	6.67^{ab}	7.00^{b}	7.00^{b}	6.67^{ab}	0.21	0.04
Number of alive rabbit at birth	6.00^{a}	6.00^{a}	7.00^{b}	6.67^{ab}	6.67^{ab}	0.21	0.02
Weight of litter at birth (g)	283.00	322.00	377.00	348.00	316.00	21.40	0.09
Weight of rabbit at birth (g)	47.20	53.70	53.90	52.20	48.00	3.97	0.65
Number of alive rabbit at weaning	5.67	6.00	6.67	6.33	6.33	0.30	0.24
Weight of litter at weaning	1568.00	1730.00	2306.00	1728.00	1774.00	186.00	0.13
Weight of rabbit at weaning (g)	273.00	288.00	346.00	276.00	278.00	24.30	0.26
Milk production of litter (g/d)	70.90^{a}	76.50^{ab}	84.40^{b}	81.10^{ab}	80.80^{ab}	2.76	0.04
Weight gain of rabbit (g/d)	12.60	12.80	12.70	12.90	12.80	0.74	1.00
% alive rabbit at weaning	94.40	100.00	95.20	95.20	95.20	4.45	0.90

CO10, CO15, CO20, CO25 and CO30: the coconut cake supplemented at levels of 10, 15, 20, 25, and 30 g/doe/day. The data with different superscript letters in the same row differ significantly (P<0.05)

Table 7. The reproductivity of Californian rabbits supplemented coconut cake in different treatments of the litter 1 as compared to the litter 2

Item	Litter 1	Litter 2	± SE	P
Litter size at birth	6.530	6.670	0.130	0.330
Number of alive rabbit at birth	6.330	6.470	0.190	0.050
Weight of litter at birth (g)	336.000	349.000	12.60	0.060
No. of alive rabbit at weaning	5.870	6.200	0.130	0.019
Weight of litter at weaning (g)	1235.000	1821.000	126.000	0.005
Weight of kitten at weaning (g)	287.000	292.000	14.000	0.710
Milk production of litter (g/d)	75.900	78.800	2.120	0.036
Daily weight gain (g)	7.840	8.030	0.460	0.690
Alive kitten at weaning (%)	93.000	96.000	2.910	0.320

In comparison the reproductive criteria between litter 1 and litter 2 indicated that the number of alive rabbit at birth and at weaning, weight of litter at weaning and milk production of litter of the litter 2 was significantly higher (P,0.05) than these of the litter 1, while the other criteria were not statistically different (P>0.05). The above results were consistent with these reported by Vo Thanh Dung (2008) and Nguyen Thi Kim Dong et al. (2008).

The economic analysis was also done for both two litters and indicated that the CO20 treatment gave the better profits as compared to the others and they were 354023, 352256, 441776, 338478 and 352446 VND/doe for the CO10, CO15, CO20, CO25 and CO30 treatments, respectively.

CONCLUSION AND RECOMMENDATION

It was concluded that supplementing 20 g coconut cake per doe per day gave the better reproductivity and economic return under the feeding condition of the present study. Coconut cake should be supplemented in rabbit diets to improve rabbit reproductive performance and more studies on coconut cake could be done to utilize this local supplement for rabbits and to reduce the production cost.

REFERENCES

Agriviet. 2009. The coconut. http://agriviet.com/home/archive/index.php/t-8968.html.

AOAC. 1990. Official methods of analysis (15th edition), Washington DC (USA): Association of Official Analytical Chemists. 1:69-90.

Maertens L, de Groote G. 2002. Proceedings of the III World Rabbit Science Association Congress. Budapest, 3, p. 45-52.

Minitab. 2000. Minitab reference manual release 13.20. Minitab Inc.

Nguyen Tan Nam. 2011. Effect of intact corn supplementation in the basal diet of Para grass (*Brachiaria mutica*) on reproduction of crossbred rabbits (New Zealand × local). [B.Sc. Thesis]. (Can Tho [Vietnam]): Can Tho University.

Nguyen Thi Kim Dong, Nguyen Van Thu, Brian Ogle, TR Preston. 2008. Effect of supplement level of water spinach leaves in diets based on Para grass on intake, nutrient utilization, growth rate and economic returns of crossbred rabbits in Mekong delta, Vietnam. Int J Livest Res Rural Dev. 20(9). Available from: http://www.lrrd.org/lrrd23/lrrd23.htm.

Nguyen Thi Xuan Linh. 2008. Effect of *Ipomoea aquatica* on meat production and reproductivity of crossbred rabbits (New Zealand × local) in the Mekong delta of Vietnam. [M.Sc. Thesis]. (Can Tho [Vietnam]): Can Tho University.

Phan Thi Huyen Thoai. 2012. Effects of catfish oil supplementation in diets on reproductive criteria of Californian does rabbit. [B.Sc. Thesis]. (Can Tho [Vietnam]): Can Tho University.

Phan Thuan Hoang, Nguyen Van Thu. 2010. A study of caecal fermentation, nutrient digestibility and nitrogen retention of rabbit (Vietnamese). J Sci. 6:1-7.

Truong Thanh Trung. 2006. Preliminary results of study of crude protein in diets on reproductive performance of crossbred rabbits in Mekong delta. [B.Sc. Thesis]. (Can Tho [Vietnam]): Can Tho University.

Vo Thanh Dung. 2008. Effect of the supplementation levels of *Psophocarpus scandens* in diets on reproductivity of crossbred rabbit (New Zealand × local). [B.Sc. Thesis]. (Can Tho [Vietnam]): Can Tho University.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle: methods for dietary fiber, and nonstarch polysaccharides in relation to animal nutrition, J. Dairy Sci. 74: 3585-3597.

Alfalfa as Forage Crop for Rabbits

Dwi Retno Lukiwati

Animal Science and Agriculture Faculty, Diponegoro University, Semarang Indonesia
Corresponding e-mail: drlukiwati_07@yahoo.com

ABSTRACT

Alfalfa (lucerne) is important forage legume as protein and mineral source for ruminant and pseudo-ruminant (rabbit) productivity in Indonesia. Rabbits have the ability to utilize forage materials, and exploiting this attribute will be of advantage to local producers who may not be able to afford the cost of commercial diets. Earlier studies indicates that expensive and imported feedstuff can be substituted with local forages containing high protein and minerals in example alfalfa. Alfalfa, rich in protein, minerals and vitamins can be harvested for hay, haylage, green-chop, or by grazing. However, alfalfa contains water-soluble substance that are toxic. A strategy to reduce the risk of toxic will be presented in the review article.

Key Words: *Medicago sativa*, Rabbit, Toxic

INTRODUCTION

Alfalfa (*Medicago sativa* L.) originated from the Mediterranean basin and southwest Asia (Iran, Afganistan) and was one of the first forage crops to be dometicated (Cook et al. 2005). Alfalfa is cultivated in more than 80 countries in area exceeding 36 million ha (Radovic et al. 2009). China was one of earliest countries to grow alfalfa (lucerne). In 126 BC, China began raising lucerne along the Yellow River. Alfalfa is one of more than 100 species of cultivated forage in China and sown on 1804.7 thousand ha in 1998 (Hu Zizhi & Zhang Degang 2001). Alfalfa is perennial herbaceous legume, and one of the most important legume forages of the world due to its high nutritional quality, yields and high adaptability in temperate, subtropical and tropical regions. It is also known as blaue luzerne (German), lucerne (English), luzerna (Portuguese), luzerne (French), mielga (Spanish), murasaki-umagoyashi (Japanese) (Barnes et al. 2007). Alfalfa grown best on soils that are well drained, neutral in pH, and have high fertility (Lukiwati 2009). It is climatically adapted to 96% of the area used for dryland agriculture. Harvesting later at early flowering provides acceptable forage and nutrient yields and reasonable stand persistence (Sheaffer & Evers 2007). Dry matter production of alfalfa on 132 kg P/ha of rock phosphate or superphosphate fertilizer was 1.19 ton and 1,12 ton/ha, respectively at the first cutting (Sunarni et al. 2012).

Rabbit production in Indonesia and another tropical countries is based on the use of different green forage sources with high percentage of soluble and insoluble fiber. The ability of rabbits to thrive on forages, makes rabbits production cheap. Exploiting this attribute will be of advantage to local producers who may not be able to afford the cost of commercial diets. One strategy to improve raising rabbit is utilizing legume alfalfa as protein and mineral sources (Lukiwati 2009). Capra et al. (2010) showed a significant increase in linolenic acid content in the intramuscular and dissectible fat when including fresh alfalfa ad libitum in the diet of growing rabbits in Uruguay. The use of fresh alfalfa in the diet of rabbit is, in Indonesia condition, a particularly suitable strategy for small farmers. This, however is, limited since fibre digestion in this monogastric herbivore is post gastric in the caecum (Davidson & Spread 1975). Alfalfa also contains water-soluble substance that are toxic (Tava et al. 1993), and hay is a simple technology can be used to eliminate this problem.

FEEDING STRATEGY WITH ALFALFA

Alfalfa hay is the most widely used fibre source in rabbit diets, and high palatable in the range 30-40 %. It provides long and digestible fibre, thus promoting adequate transit time for the digesta and a balance growth of of the caecal flora (de Blas & Mateos 2010). Alfalfa hay is also a valuable source of protein (25% of dietary protein) and rich in calcium though its nutritive value varies greatly, depending on several factors such as the harvesting and drying process or plant maturity at harvest. High levels of alfalfa hay (88 and 96%) decreased rabbit mortality by 13.6 and 10.3%, respectively (Fernandez-Carmona et al. 1998). Better growth rates were achieved by feeding chopped alfalfa hay of higher nutritional quality rather than alfalfa hay cubes (Linga & Lukefahr 2000).

REFERENCE

Barnes RF, Nelson CJ, Fick GW. 2007. Terminology and Classification of Forage Plants. In: Barnes RF, Nelson CJ, Moore KJ, Collins M, editors. Forages 6th edition vol. II. Carlton (Australia): Blackwell Publishing. p. 3-14.

Capra G, Grompone MA, Nurruzola, Pardo MJ, Martinez R, Fradiletti, Gozzano S, Repiso L, Marquez R. 2010. Effect of fresh alfalfa in the diet of growing rabbits on growth performance, carcass characteristics and fat composition. In: Proceedings IV Congreso Cunicultura de las Americas. Cordoba, 22-24 September 2010. Cordoba (Argentina): Congreso Cunicultura de las Americas.

Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M, Schultze-Kraft R. 2005. Tropical Forages: an interactive selection tool. Brisbane (Australia): CSIRO, DPI & F (Qld.), CIAT and ILRI.

Davidson NJ, Spread B. 1975. Nutrition of New Zealand White. Pro Soc. 24:75-83.

De Blas C, Mateos GG. 2010. Feed Formulation. In: De Blas C, Wiseman J, editors. Nutrition of the Rabbit. 2nd edition. London (UK): CAB International.

Fernandez-Carmona J, Bernat F, Cervera C, Pascual JJ. 1998. High lucerne diets for growing rabbits. World Rabbit Sci. 6:237-242.

Hu-Zizhi, Zhang-Degang. 2001. The Pasture/ Forage Resource Profile for China. Lanzhou (China): Gansu Agricultural University.

Linga SS, Lukefahr SD. 2000. Feeding of alfalfa hay with molasses blocks or crumbles to growing rabbit fryers. Livest Res Rural Develop. 12:1-11.

Lukiwati DR. 2009. Forages for Rabbit in Indonesia. In: Proceedings of the First Conference On Asian Rabbit Production Development. Changchun. 10 September, 2009. China. p. 140-146.

Radovic J, Sokolovic D, Markovic J. 2009. Alfalfa most-important perennial forage legume in animal husbandry. Biotechnol Anim Husb. 2:465-475.

Sheaffer CC, Evers GW. 2007. Cool-season Legumes for Humid Areas. In: Barnes RF, Nelson CJ, Moore KJ, Collins M, editors. Forages. 6th Edition. Volume II. Carlton (Australia): Blacwell Publishing. p. 179-190.

Sunarni, Karno, Lukiwati DR. 2012. Direct application of phosphorus fertilizer to improve dry matter production and digestibility of alfalfa. J Trop Forage Sci. 2:8-11.

Tava A, Forti D, Odoardi M. 1993. Alfalfa Saponins: Isolation, chemical characterisation and biological activity against insects. In: Rotili P, Zannone L, editors. The future of lucerne – biotechnology, breeding and variety constitution. Proceedings of the X International Conference of the Eucarpia, *Medicago* spp. Group. Lodi (Italy): Lodi Istituto Sperimentale per le Colture Foraggere. p. 283-288.

Effects of Fiber Levels and Curcuma Levels on The Growth Performance and Incident of Enteritis of Weanling Rabbits

Tuti Haryati, Raharjo YC, Susanna IWR

Indonesan Research Institute for Animal Production, PO Box 221, Bogor 16002
Corresponding e-mail: purringcats2001@yahoo.com.au

ABSTRACT

High incidence of diarrhoea in weanling rabbits caused high rate of mortality. Diarrhoea or enteritic problem in rabbits is usally triggrede by the increase population of pathogenic bacteria in the caecum. This population may, however be controlled by high dietary level of indigestible fiber, and low protein and carbohydrate, and also by some feed additives that have bacteriostatic and peristaltic ragulation properties, including herbals. Among them, Curcuma (Curcuma longa) has been reported to have curing effect on the diarrhoea in human. In this experiment, levels of dietary fiber and curcuma is studied. Three levels of dietary fiber (12, 14 and 16%) and four levels of curcuma (0.0; 0.1; 0.2 and 0.3% air basis). All treatments contained 13% crude fiber, 17% cude protein and 2500 to 2550 kcal/kg DE. Each treatment consisted of 5 replicates, each of 5 weanling rabbits (about 650 + 50 g initial body weight). Feed and water were provided ad libitum throughout the experimental period. Measurements were made on body weight, bodyweight gain, feed consumption, feed conversion, mortality, carcass percentage and digestibility of dry matter. Results showed that higher crude fiber reduced the feed consumption, bodyweight, bodyweight gain, feed efficiency and also digestibility of dry matter and slightly decrease the carcass percentage. Some of them did cause significant differences. No interaction were detected among levels of fiber and curcuma. Curcuma has a slight beneficial effects on the body weight gain and also survivability of the animals, but not on the other parameteres measured. Crude fiber levels of 14 and 16% at 0.2% curcuma in the diet gave the highest bodyweight gain and lowest rate of mortality.

Key Words: Fiber, Curcuma, Rabbit Growth

INTRODUCTION

Rabbits are herbivorous monogastric livestock, which requires the availability of fiber in high enough quantities, not only to support the normal peristalsis, but also helps balance between nutrient digestion with intestinal microbiota (Gidenne & Garcia 2006). In the rabbit, the fiber may be a component of a highly controversial chemical feed. Low-fiber rations produce high feed efficiency (Lang 1981; Potte et al. 1981) but the physiological (Laplace 1978; Cheeke & Patton 1980) and nutritional (Patton et al. 1983; Cheeke et al. 1987) which causes diarhea often resulting in mortality, a rabbit disease that causes the most deaths, especially in young rabbits 2-8 weeks (Furtun-Lamothe & Gidenne 2006). Diarhea caused by an imbalance of bacteria/other microbiota in the digestive system of the rabbit. This balance must be maintained to ensure the process of movement, digestion, nutrient absorption and elimination of residual feed digestion (Fortune-Lamothe & Gidenne 2006). Diarrhea may occur by bacterial *i.e.* cocci, coli, salmonella, and clostridia (Carabano et al. 2006) due to the high density, poor sanitation, environmental changes and stressful. Reported more than 13 causes diarrhea which causes high mortality (Soeripto 2007). Fiber plays an important role in keeping the digestive processes running normally and nutritional balance with the microbiota populations (de Blaas et al. 1999; Gidenne 2003). However, the mechanism is unclear and inconsistent. At high levels, lower fiber digestibility (Fekete & Gippert 1985; Raharjo et al. 1990) but stimulates motility of the caecum and colon (Ehrlein et al. 1983) and reduce the occurrence of enteritis (Cheeke 1983). However Morisse et al. (1985) reported that a high-fiber diet and low starchy even cause diarrhea.

In the rabbit rations, crude fiber content should be more than 12%, and is largely a fraction of 'indigestible'. But never mentioned how much needs 'indigestible fiber fraction' and how tolerances for fractions are 'digestible'. There is a recommendation that the use of the fiber is no longer as crude fiber, but more specifically the level of ADF and ADF-lignin. Research in 2007 related to the digestibility and growth of rabbits from 4 different types of fibers. The results of the digestibility trial are presented in Table 1. The results are 4 types (source of fiber) gives the data of fiber that provide the most optimal growth or the lowest mortality.The digestibility of the fiber fraction, with the potential as a great source of 'indigestible' fiber is rice straw. But rice straw is not consisten in composition. Raharjo et al. (1990) showed a decrease in weaning mortallitas through the use of rice husk to 20%. However, the analysis of fiber composition and digestibility of rice husk as a source does not support the 'indigestible fiber'. These results require a re-analysis. Moreover, it will be considered the result of the *in vivo* test is the fourth source of fiber.

Fibers, especially the 'indigestible' important role in maintaining the balance in the digestive process of rabbits. Fiber deficiency causes diarrhea that resulted in high mortality at weaning rabbits. Fiber types 'indigestible' also allegedly very decisive in maintaining the balance of the digestive process, so it is recommended to use in the formulation of ADF and ADF-lignin (Xiccato et al. 2006). Among a variety of herbs commonly used to treat diarhea is turmeric/curcuma (*Curcuma longa*). In addition to improving the performance of livestock, curcuma may also prevent or reduce the incidence of diarhea. On the other hand, reported that the herbal ingredients such as turmeric (*C. longa* or *C. domestica*), ginger (*C. xantorrhiza* Roxb) and garlic (*Allium sativum* Linn) is known to be antibacterial and immune-boosting (Setiawan 1998; Thakare 2004; Murdiati 2006) has long been used to treat diarhea in humans. Result of exploratory experiment in Balitnak showed that 2% fresh curcuma give the body weight gain a better and lower mortality compared with the xanthoriza and garlic (Table 2). Sinurat et al. (2009) also showed growth and a better FCR and lower mortality in broiler chickens with add curcuma in the rations.

The combination of fiber and curcuma level appropriate to provide optimal growth performance in weaning rabbits.

METHODOLOGY

Three levels of fiber (12; 14 and 16%) and 3 levels of curcuma (1; 2 and 3% wet or equal to 0.1; 0.2 and 0.3% dry air weight). Fiber source used was a mixture of mostly rice hulls and sugarcane shoots. Entire ration treatment had higher levels of fiber (13%), protein (17%) and energy (2550 kcal/kg) of the same. Other nutrients to meet the needs of the rabbit in accordance to NRC (1977). Five replicates, each consisting of 5 weaning rabbits with a body weight 650 + 50 g, were used for each treatment. Feed and water provided ad lib. The study was conducted from weaning ages 6 weeks to 7 weeks of the study. Measurements were made on the growth performance (feed intake, body weight, body weight gain, feed conversion) and weekly mortality, as well as the dry matter digestibility (DMD).

Table 1. Composition and digestibility of fiber from various sources of fiber (%)

Nutrient	Sawdust		Cane shoots		Rice hull		Rice straw	
	Composition	Digestibility	Composition	Digestibility	Composition	Digestibility	Composition	Digestibility
CF	59.80	-9.61	27.00	-9.39	10.43	48.71	20.00	-14.41
ADF	66.10	-6.22	37.90	4.58	19.20	29.11	50.30	-5.57
NDF	79.20	3.08	60.60	2.59	27.60	11.37	61.30	-3.26
Lignin	7.38	-9.23	3.20	-1.11	2.80	46.66	4.70	-18.09

Table 2. Effects of garlic, Curcuma, and *C. xanthorriza* for 5 weeks in rabbits after weaning

Treatment	BWG (g)	Consumption (g/d)	FCR	Mortality (%)
Control	19	82	4.51	33
Garlic	17	75	4.97	33
Curcuma	22	84	3.86	0
C. xanthorriza	20	81	4.23	17

RESULTS AND DISCUSSION

The chemical composition of the ration and the results of this experiment are shown in Table 1. Result of composition analysis is different from calculated. Protein content, which is calculated rations had higher levels of 17% (dry air), while the results of the analysis were 21.5 to 22.4% (dry), or 19.14 to 19.94 (dry air) which mean 2% higher than expected. In contrast to crude fiber, calculated levels were 12, 14 and 16%, while the results of the analysis showed 9.9, 10.8 and 12.9%, much lower than that prepared rations. This may because of few fish meal have a higher protein content, while the fiber content of cane shoots were lower than usual composition. It can also occur when the cane shoots were taken from young leaves of sugarcane, with a low fiber content and high protein.

Animal response to the treatment are shown in Table and Figure below. There is no significant interaction between the level of fiber with the level of curcuma on any parameter. Table 2 shows the feed intake of rabbits for 7 weeks, while the Figure 1 and Figure 2 shows the effect of fiber content and levels of turmeric on feed consumption. Increased fiber causes a decrease in feed intake from 88 grams to 72 g/h/d, while at 0.2 curcuma and 0.3% levels in the diet led to a significant decrease in consumption (92 vs 77 g/h/d). The increase in fiber content, which is voluminous and resulting in consumption decreased, this may be related to the development of the capacity of the stomach, which is increasingly limited to accommodate the volume of high-fiber feed. However poorly understood, why the increase in curcuma caused a decrease in consumption, whereas in humans it stimulates appetite.

Table 3. Composition of ration

Fiber	Curcuma	Counted			Analysis		
		DE	CP	CF	CP	GE	CF
12	0.0	2518	17.0	12.2	22.4	4022	9.6
	0.1				22.1	3999	9.7
	0.2				22.1	4189	9.4
	0.3				21.5	4330	10.9
14	0.0	2517	17.1	14.0	22.0	5323	10.7
	0.1				21.9	4597	10.0
	0.2				22.5	4255	11.2
	0.3				22.4	4349	11.2
16	0.0	2505	17.1	16.0	23.4	4414	12.8
	0.1				22.0	4384	13.2
	0.2				22.7	4129	12.9
	0.3				22.3	2282	12.7

Effect of fiber level and turmeric to the weekly feed consumption shown in Figure 1 and Figure 2. In the early weeks, (weeks 1 to 4), although not significantly, higher fiber content (16%) showed higher consumption, while at the end of the week, the high fiber content of feed consumption will be lower. This may related to the development of the capacity of the stomach, which is increasingly limited to accommodate the volume of high fiber feed.

In Figure 2 it appears that the weekly feed intake of various diet containing curcuma does not vary in the first 5 weeks, but slightly higher in rations with low levels of Curcuma. Cumulatively increased levels of Curcuma lowered feed intake.

The response of growth performance in weight of crude fiber and curcuma level in the diet are shown in Table 5. The results showed that 14% of crude fiber in the ration gave the highest body weight, although not significantly different with 12% fiber, but significantly higher than the 16% crude fiber. It is associated with low feed intake (Table 2) and a lower digestibility (Table 6) on high crude fiber ration.

Tabel 4. The effect of various levels of fiber and curcuma on feed consumption (g/h/d)

Curcuma (%)	Fiber (%)			
	12	14	16	Rataan
0	100	100	75	92
0.1		107	55	81
0.2	83	43	78	68
0.3	81	71	79	77
Average	88	80	72	79

Rabbits in the treatment of 12% fiber and 0.1% curcuma death occurs entirely, so there is no data

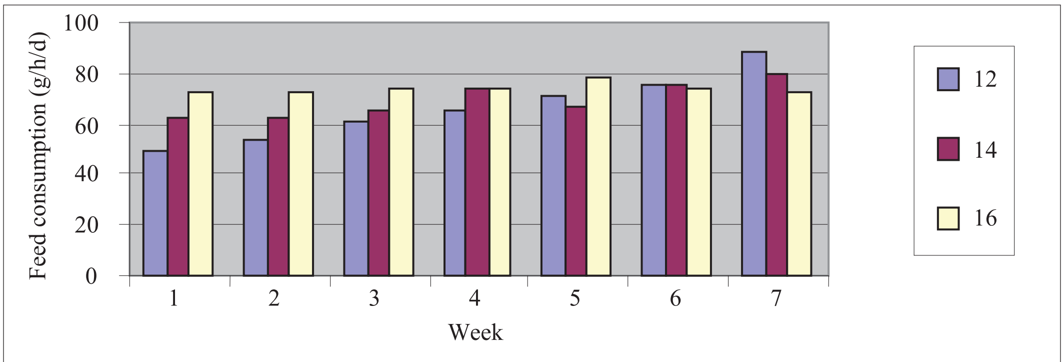


Figure 1. Feed consumption of various crude fibre content (g/h/d)

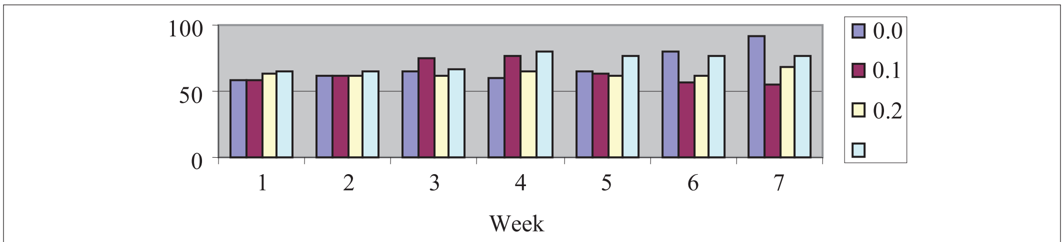


Figure 2. The effect of curcuma levels to feed consumption (g/h/d)

Figure 3 and 4, respectively show the rabbit body weight growth curve is influenced by the fiber and curcuma level from week 6 to week 12. In Figure 3 it appears that the curves of the body weight of rabbits fed diet with 14% crude fiber content was consistently higher than the other two feed treatments. On the other hand, although at week 4 to week 6 trial occurred considerable variation in body weight to the level of curcuma, but at week -7, the difference is very small (Figure 4).

The results indicate that 14% of fiber and 0.1% of curcumin the diet gave the best results of body weight than other treatments. However at 0.1% of curcuma and 12% fiber occurs very high incidence of mortality, so that all animal experiments on the treatment are died. The whole dead animals showed of diarrhea and/or bloating symptoms. The response of body weight gain (BWG) rabbit on the level of fiber and curcuma are presented in Table 4. The highest body weight gain produced by a rabbit ration with fiber content 14 and 16% (24 g//h /d). This value is comparable to or even better than some of the results of previous studies (27 g/h/d). The highest body weight gain generated from rabbits 0.0 and 0.1% curcuma. These results are consistent with the response to body weight (Table 3).

Table 5. The Effect of fiber and curcuma level on body weight in week 7th (g/h)

Curcuma (%)	Fiber(%)			
	12	14	16	Average
0.0	1978	2030	1366	1791
0.1	death	2224	1533	1879
0.2	1748	1657	1520	1642
0.3	1881	1679	1590	1717
Average	1869	1898	1502	1757

Tabel 6. Body weight gain (g/h/d) of rabbit that fed with different level of fiber and curcuma

Curcuma (%)	Fiber(%)			
	12	14	16	Average
0.0	28	29	16	24
0.1		28	20	24
0.2	21	20	18	20
0.3	22	19	18	20
Average	24	24	18	

Weekly body weight gain response to the level of the fiber (Figure 5) and the level of turmeric (Figure 6), although it seems slightly vary each week, but did not significantly different (18 to 24 g/h/d). In the last 2 weeks, the addition of 0.1% curcuma produce the lowest body weight gain.

For crude fiber, in the last 3 weeks, rabbits were given with high crude fiber (16%) consistently produced the lowest body weight gain. It is associated with a lower feed quality, which is indicated by the lower digestibility of dry matter in the high-fiber feed (Table 6)

Effect of fiber level and curcuma in the diet on feed conversion are shown in Table 5.Tabel shows that lever of fiber effected to feed conversion (fibers 12; 14 and 16% yield conversion of 3.17; 3.71 and 4.16), which means the less efficient use of feed. The higher the fiber the higher amount of feed needed to produce the same amount of body weight. It is common in all animals, both monogastric and ruminant, because fiber is generally not digestible and less contribution to the formation of cell-cell growth.

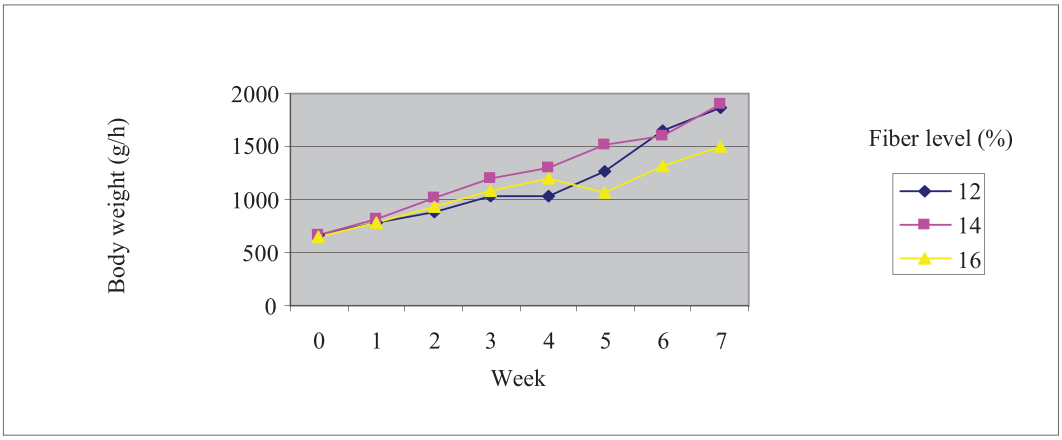


Figure 3. Effect of fiber level on body weight (g)

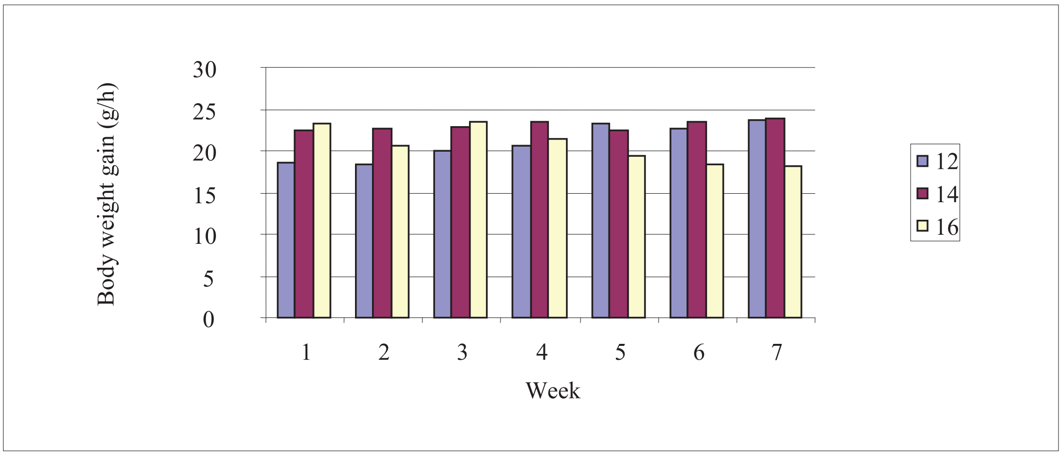


Figure 4. Effect of fiber level on weekly body gain (g)

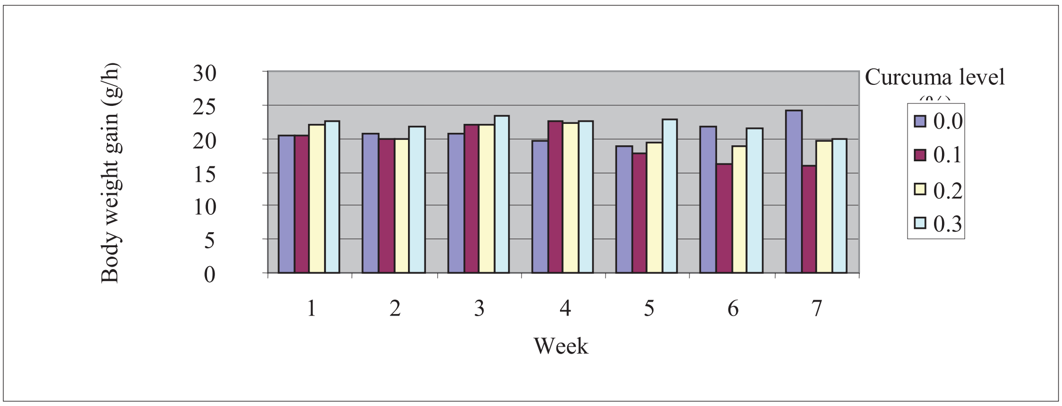


Figure 5. Effect of curcuma level on weekly body gain (g)

On the other hand, increasing of curcuma level in the diet led to an improves of FCR, eventhough not significantly (3.74 to 3.92). This is in contrast to that produced in chickens (Sinurat et al. 2009), which reported that the addition of curcuma gives better FCR.

Figure 7 shows the weekly FCR response of the crude fiber level in rations. The Figure shows a consistent pattern that almost every week, increased levels of crude fiber of the will improves FCR in rabbits. In Figure 10, first week to the fourth week of the study showed that the difference in the level of fiber does not affect the FCR, but in the last three weeks, 0.1% curcuma gives the lowest FCR, which means it provides the most efficient use of the high ration. In situations of low mortality, the addition of 0.1% curcuma in the diet may be the best choice (see also Table 2, 3 and 4).

Table 6 shows the response of dry matter digestibility of fiber and turmeric level in the ration. Fiber levels significantly affect the dry matter digestibility of the ration.The higher the fiber content, the lower the dry matter digestibility ration (72 vs 64 vs 58%). At the level of 16% crude fiber in the ration with 58% dry matter digestibility shows that the ration is very inefficient for use as feed. With the exception of very low prices sources of fiber, the use of 16% with 58% fiber digestibility potentially economically loss. Curcuma levels, by contrast, did not significantly affect dry matter digestibility. The whole ration with different levels of curcuma have dry matter digestibility not differ significantly (63-68%).

Table 7. Effect of fiber and curcuma level on feed conversion

Curcuma(%)	Fiber (%)			
	12	14	16	Average
0.0	3.60	3.45	4.15	3.74
0.1	n.a.	3.76	3.70	3.73
0.2	3.41	3.86	4.17	3.81
0.3	3.39	3.76	4.60	3.92
Average	3.47	3.71	4.16	

n.a.: not available data

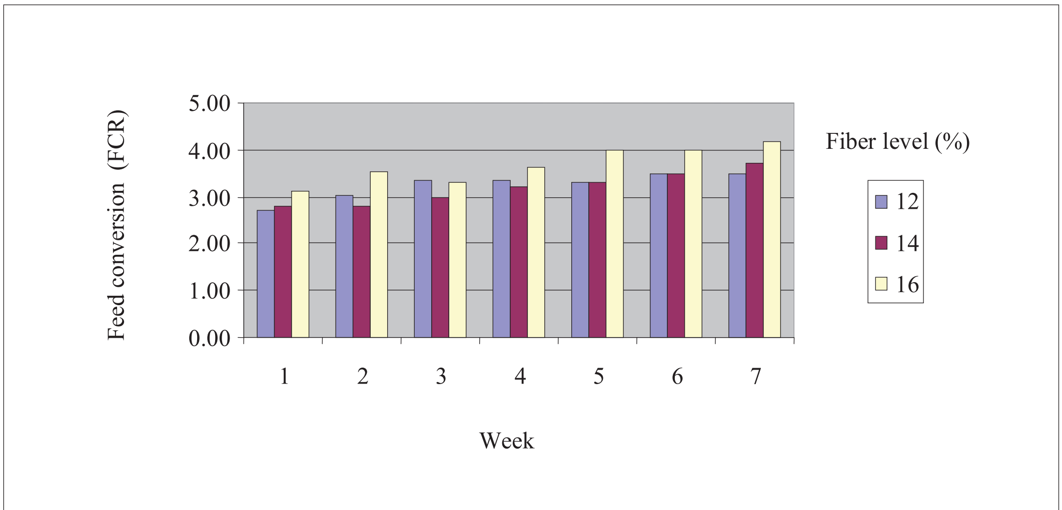


Figure 6. Effect of fiber level on feed conversion

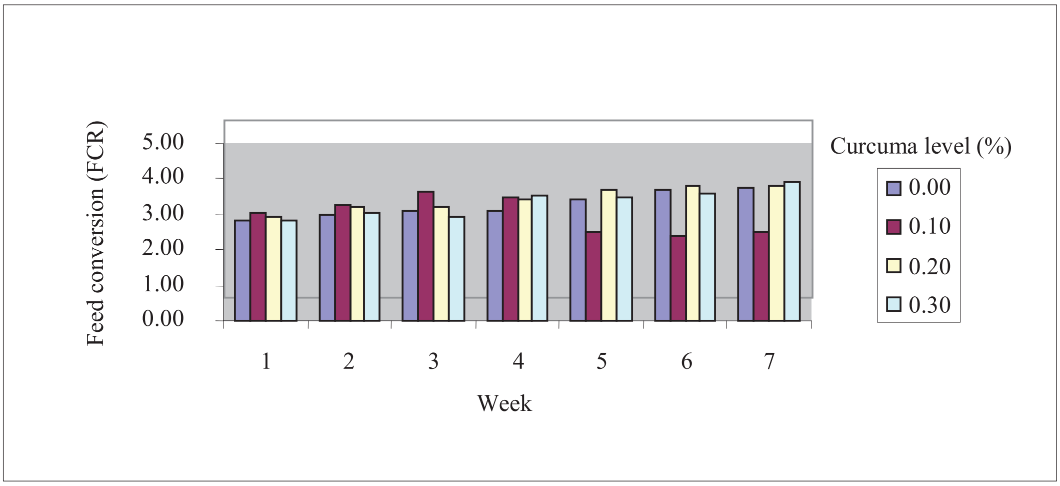


Figure 7. Effect of curcuma level on feed conversion

Tabel 8. Effect of fiber and turmeric levels on feed dry matter digestibility

Curcuma(%)	Fiber (%)			
	12	14	16	Average
0.0	71.64	64.85	58.02	64.84
0.1	76.27	64.53	58.53	66.44
0.2	71.19	64.84	57.81	64.61
0.3	69.17	63.73	57.01	63.30
Average	72.07	64.49	57.84	64.80

Effect of fiber level and curcuma on mortality rabbits are shown in Table 7. The mortality rate of rabbits (Figure 8) in this study were very high in any combination of treatments, ranging from 25 (14 and 16% fiber at 0.2% curcuma) - 100% (12% fiber at 0.1% curcuma). There is a significant interaction between levels of curcuma with the level of fiber in the diet on rabbit mortality.

Except at level 0%, increasing levels of curcuma and fiber significantly lower of mortality in rabbits. However, the effect is not always consistent. at level 0.1 and 0.2% curcuma, mortality decreased with increasing crude fiber content, but at the level of 0.3% curcuma, increasing crude fiber is not consistent decline, which at 16% fiber mortality increased again. While at every level of crude fiber, mortality is very fluctuating with increased levels of curcuma. Lowest mortality occurs in the ration with 14 and 16% fiber at 0.2% of curcuma. Sinurat et al. (2009) reported that 0.2% Curcuma resulted best production performance of broiler chickens.

Figure 8. Mortality of rabbits during experiment

Tabel 9. Effect of fiber and curcuma level on mortality rabbits for 7 weeks (%)

Curcuma (%)	Fiber (%)			
	12	14	16	Average
0	58.33	50.00	50.00	52.78
0.1	100.00	58.33	41.67	66.67
0.2	58.33	25.00	25.00	36.11
0.3	50.00	33.33	41.67	41.67
Average	66.66	41.67	39.58	49.31

The high mortality rate is very unusual case, although mortality at the level of farmers in Lembang, Magelang and Karo were also higher at the same time, so it takes a very serious effort to mitigate them. More than 90% mortality was recorded showing symptoms of enteritis, either bloating (Figure 9) and diarhea (Figure 10).

Figure 9. Bloating in rabbits (enlargement of caecum due to gas formation)

Figure 8 shows the percentage mortality of rabbits from the first week until the seventh week due to the influence of crude fiber content in the ration. It seems clear that the low crude fiber content (12%) led to higher mortality. This is consistent with some results that showing the 'indigestible fiber' (undigested fiber) can reduce the incidence of diarrhea (Cheeke 1983; Cheeke & Patton 1980, Gidenne & Garcia 2006).

Figure 10. Diarrhea and bloating (note the black part of the wet/liquid faeces and enlarged caecum without content), as well as complications with the green-black liver on the side lobus)

Effect of fiber level and turmeric to the percentage of carcasses are presented in Table 8. There was no significant difference between treatments, though there is a tendency that increased fiber content causes a decrease in the percentage of carcasses. However this is more due to the low growth achieved (Table 2. Pattern carcass percentage appears to correlate linearly with body weight. High body weight gives a higher percentage of carcass , and vice versa. This happens at small rabbits, the percentage of the head, feet, skin become greater than the total body weight of carcass percentage consequently be lower.

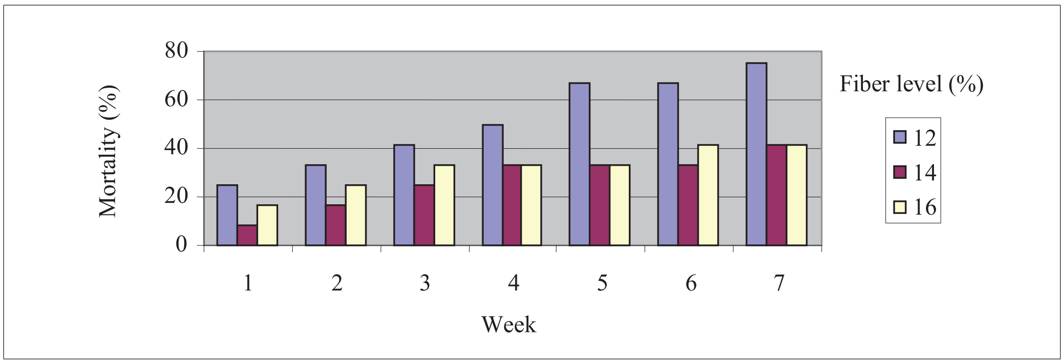


Figure 11. Rabbit mortality (%) from various fiber levels for 7 weeks

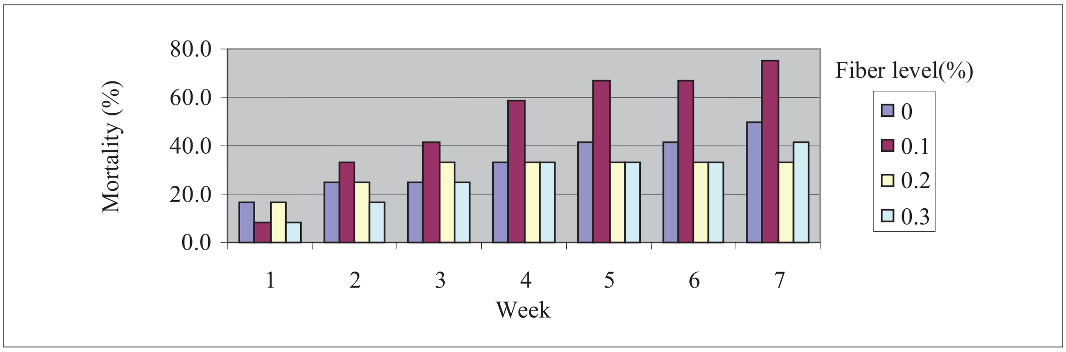


Figure 12. Rabbit mortality (%) from various curcuma levels for 7 weeks

Tabel 10. Effect of fiber and turmeric level in the diet on rabbit carcass percentage at week 7

Curcuma (%)	Fiber (%)			
	12	14	16	average
0.0	49.78	50.30	45.66	48.58
0.1	death	51.24	46.13	48.68
0.2	47.48	47.57	46.20	47.08
0.3	48.81	47.79	47.90	48.16
Average	48.69	49.22	46.47	

On the other hand, the level of 0.1% curcuma in the diet apparently caused the highest mortality (Figure 9). But other than that, an increase in curcuma lowers mortality, yet unknown mechanism of 'stimulation' or 'inhibition' curcuma on mortality rabbits

Percentage rabbit carcass that only 46-50% is considered low, due to the commercial rabbit, carcass percentage can reach 56%. Carcass percentage less than 50% carry a potential reduction in profits or even losses.

CONCLUSION

The results of this study indicate that the level of crude fiber significantly affect feed consumption, body weight, body weight gain, and digestibility of the ration. Also the reduction in mortality rabbits. Effect of crude fiber more real and more consistent than the effect of curcuma level. Crude fiber level of 14% and 0.2% curcuma is the best combination of performance in delivering growth and lowest mortality. However, the mortality that occurred in this study was very high. The rate of mortality such as this, can not be obtained an economic benefits to be gained. Therefore, it is suggested that attention to mortality reduction is a higher priority compared to other efforts.

REFERENCE

Carabano R, Badiola I, Licois D, Gidenne T. 2006. The digestive ecosystem and its control through nutritional or feeding strategies. In: Maertaens L, Coudert P, editors. Recent Advances in Rabbit Science. Merelbeke (Belgium): ILVO. p. 211-228.

Cheeke PR. 1983. The significance of fiber in rabbit nutrition. J Appl Rabbit Res. 6:103-106.

Cheeke PR, Patton NM, Lukefahr SD, McNitt JI. 1987. Rabbit Production. Danville (USA): The Interstate Printers and Publishers Inc.

Cheeke PR, Patton NM. 1980. Carbohydrate overload of the hindgut – a probable cause of enteritis. J Appl Rabbit Res. 3:20-23.

Ehrlein HJ, Reich H, Schwiger M. 1983. Colonic motility and transit of digesta during hard and soft faeceas formation in rabbits. J Physiol. 33:75-86.

Fekete S, Gippert T. 1985. Effect of crude fiber on protein utilization by rabbit. J Appl Rabbit Res. 8:31-38.

Fortun-Lamothe L, Gidenne T. 2006. Recent Advances in digestive physiology of the growing rabbit. In: Maertaens L, Coudert P, editors. Recent Advances in Rabbit Science. Merelbeke (Belgium): ILVO. p. 201-210.

Gidenne T. 2003. Fibres in rabbit feeding for digestive troubles prevention: respective role of low-digested and digestible fibre. Livest Prod Sci. 81:105-117.

Gidenne T, Garcia J. 2006. Nutritional and feeding strategies improving the digestive health of the young rabbit. In: Maertaens L, Coudert P, editors. Recent Advances in Rabbit Science. Merelbeke (Belgium): ILVO. p. 229-238.

Laplace JP. 1978. Gastrointestinal transit in monogastric animals. III. Feeding behaviour (feed intake-caecotrophy), gastrointestinal motility and transit and pathogeny of diarrhea in the rabbit. Ann Zootech. 27:225-265.

Pond KR, Ellis WC, Akin DE. 1984. Ingestive mastication and fragmentation of forages. J Anim Sci. 58:1567-1574.

Morisse JP, Boiletot E, Maurice R. 1985. Changes induced by feeding in intestinal environment of rabbits (VFA, NH3, pH). Rec Med Vet. 161:443-44.

Murdiati T. 2006. Tanaman obat untuk ternak. Seminar Indolivestock Indonesia. Jakarta.

Patton NM, Holmes HT, Cheeke PR. 1983. Hairballs and pregnancy toxemia. J Appl Rabbit Res. 6:99.

Raharjo YC, Cheeke PR, Patton NM. 1990. Evaluation of rice hulls as a fiber source for weanling rabbits. J Appl Rabbit Res. 13:10-13.

Setiawan C, Muis X, Ishwara. 1998. Tanaman Obat Keluarga. Jakarta (Indonesia): PT Intisari Mediatama.

Thakare M. 2004. Pharmacological screening of some medical plants as antimicrobial and feed additive. Laksburg (Virginia): Virginia Polytechnic Institue and State University.

Xiccato G, Trocino A, Nicodemus N. 2006. Nutrition of the young and growing rabbit: a comparative approach with the doe. In: Maertaens L, Coudert P, editors. Recent Advances in Rabbit Science. Merelbeke (Belgium): ILVO. p. 239-247.

Sinurat AP, Purwadaria T, Bintang IAK, Ketaren PP, Bermawie N, Raharjo M, Rizal M. 2009. The Utilization of turmeric and *Curcuma xanthorrhiza* as feed additive for broilers. JITV. 14:90-96.

IMPACT OF FEED RESTRICTION AND OF THE HYGIENE OF HOUSING ON RABBIT PERFORMANCES AND HEALTH

Gidenne T[1], Le Floc'h N[2], Oceane M[1, 3], Isabelle O[3], Sylvie C[1]

[1]INRA, UMR1289 TANDEM, F-31326 Castanet-Tolosan, France
[2]INRA, UMR1348 PEGASE, 35590 Saint-Gilles, France
[3]INRA, UMR 1331 TOXALIM, 31027 Toulouse, France
Corresponding e-mail : thierry.gidenne@toulouse.inra.fr

ABSTRACT

Limiting the post-weaning intake of the young rabbit is known to improve its resistance to digestive troubles, while poor hygiene of housing is supposed to have a negative impact on performances and health. These two factors have been studied in a 2 × 2 factorial design: free intake "AL" or restricted at 70% of AL, and high *vs* low hygiene of housing. The poor hygiene of housing was obtained by avoiding cleaning the room before and during the experiment. This experimental design was applied to four groups of 105 rabbits, fed a pelleted experimental diet. They were housed in two rooms (control and poor hygiene) and in collective cages, from weaning (28 days) to slaughter (63 days). No significant interactions were found between the two main factors, restriction and hygiene, for performances and health parameters. With a 30% reduced intake the weight gain was meanly reduced by 16% (49.9 *vs* 41.7 g/day from 28 to 63 days old, P<0.001). Accordingly, the feed conversion was sharply improved for restricted rabbit groups by 16% (2.47 *vs* 2.11 from 28 to 63 days old, P<0.001). The level of housing hygiene did not modify significantly the growth, although the post weaning tended to be lower during the two weeks after weaning (42.6 *vs* 41.3 g/days, P = 0.09). The feed conversion was surprisingly better for rabbit housed with a poor level of hygiene (2.30 *vs* 2.25 from 28 to 63 days old, P = 0.03) sourcing from a slightly lower intake (107.0 *vs* 103.2 g/days, P = 0.02). Over the whole experiment (28 to 63 days old), the mortality rate was relatively low (11%) suggesting a relatively good health status. Although the number of rabbits was insufficient to reach substantial conclusions about the health impact, we detected a positive impact of the feed restriction on the mortality rate during the post-weaning period (28-40 days old): 1.9 *vs* 6.2% (P = 0.046). For the whole growth period, restriction of low hygiene did not affect significantly the mortality rate, although we recorded the highest mortality for the rabbits fed freely in poor hygiene housing (15/105).

Key Words: Feed Restriction, Hygine, Rabbit, Health

INTRODUCTION

Limiting the post-weaning intake of the young rabbit is now known to improve its resistance to digestive troubles (Gidenne et al. 2012), while the feed conversion is improved. In contrast a poor hygiene of housing is supposed to have a negative impact on performances and health, as demonstrated in the piglet (Le Floc'h et al. 2010). However, these two factors may interact in determining performances and health as recently showed in pig (Pastorelli et al. 2012). We thus aimed to determine the effect of a moderate post-weaning feed restriction in the rabbit to cope with a poor housing hygiene, in terms of growth and health.

MATERIALS AND METHODS

Restriction and housing hygiene were studied according to a 2 × 2 factorial design: free intake "F" or restricted "R" at 70% of F, and high vs low hygiene of housing (H and L), and thus corresponded to four groups of 105 rabbits: HF, HR, LF, LR. Rabbits (INRA hybrid line) were fed the same pelleted experimental diet (crude protein 17.4%, ADF = 18.4% as fed) and housed in collective cages (5 rabbit/cage), in two independent breeding rooms (high or low hygiene), from weaning (28 days) to slaughter (63 days). The intake of the R groups was adjusted three times per week to reach 70% of the intake of F groups within each room. The poor hygiene of housing was obtained by avoiding cleaning one breeding room before and during the experiment. Mortality was checked daily, while morbidity (rabbits having clinical signs of diarrhea or a very low growth) was checked weekly as for the intake and live weight control.

RESULTS AND DISCUSSION

No significant interactions were found between the restriction and hygiene, for performances or health status. From 28 to 63d old the mortality rate was relatively low (meanly 11%) suggesting a good health status. Although the number of rabbits was insufficient to reach substantial conclusions about the health impact, we observed that mortality from digestive troubles started one week after weaning (Figure 1) and levelled after 7 weeks of age.

We detected a significant positive impact of the feed restriction on the mortality rate during the post-weaning period (28-40 days old): 1.9 *vs* 6.2% (P = 0.046). For the whole growth period, restriction or low hygiene did not affect significantly the mortality rate, although we recorded the highest mortality for the rabbits fed freely in poor hygiene housing (15/105).

In parallel, the morbidity rate was not affected by the restriction strategy, but was surprisingly lower in low hygiene of housing (Table 1) during the post weaning period.

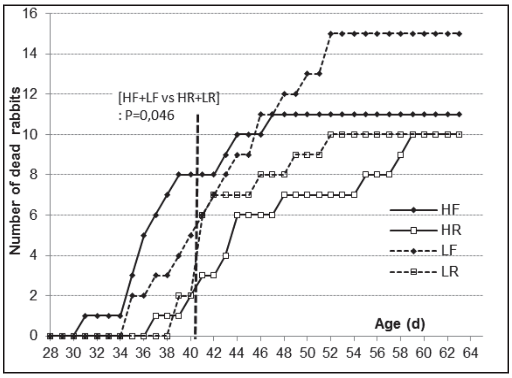


Figure 1. Effect of housing hygiene and of restriction on the post-weaning mortality kinetic

With a 30% reduced intake the weight gain was meanly reduced by 16% (49.9 *vs* 41.7 g/days from 28 to 63 days old, P<0.001, Table 2). Accordingly, the feed conversion was sharply improved for restricted rabbit groups by 16% (2.47 *vs* 2.11 from 28 to 63 days old, P<0.001), as found previously (Gidenne et al. 2012). The level of housing hygiene did not greatly affect the growth, although the post weaning daily gain tended to be lower during the two weeks after weaning (42.6 *vs* 41.3 g/days, P = 0.09). The feed conversion was surprisingly better for rabbit housed in poor hygiene conditions (2.30 *vs* 2.25 from 28 to 63 days old, P = 0.03), sourcing from a slightly lower intake (107.0 *vs* 103.2 g/days, P = 0.02).

Table 1. Effect of housing hygiene and of 30% intake restriction on rabbit morbidity*

Period (days old)	Groups				P levels		
	HF	HR	LF	LR	Hygiene	Restriction	H × R
28-42	10/105	7/105	3/105	4/105	0.045	0.92	0.46
43-64	11/97	13/102	4/98	10/98	0.072	0.13	0.26
28-64	16/105	18/105	5/105	11/105	0.006	0.14	0.29

* number of morbidity cases on initial number of alive rabbits within a period
H: high hygiene of housing; L: low hygiene of housing; F: free feed intake; R: restricted feed intake

Table 2. Effect of housing hygiene and of 30% intake restriction on rabbit performances

	Groups				P levels			
	HF	HR	LF	LR	RMSE	Hygiene	Restriction	H × R
Feed intake (g/d)								
28-42 days old	88.10	58.80 µ	87.10	58.60µ	4.50*	0.310*	nc	
43-64 days old	149.60	108.50 µ	143.40	103.30µ	6.60*	0.016*	nc	
28-64 days old	125.30	88.60 µ	120.90	85.40µ	4.80*	0.017*	nc	
Live weight (g)								
28 days old	650.00	649.00	651.00	647.00	84.00	0.960	0.760	0.86
42 days old	1363.00	1127.00	1337.00	1118.00	152.00	0.260	<0.001	0.61
63 days old	2410.00	2115.00	2377.00	2105.00	211.00	0.330	<0.001	0.62
Weight gain (g/d)								
28-42 days old	51.00	34.20	49.20	33.40	7.40	0.086	<0.001	0.47
43-64 days old	49.60	47.00	49.00	46.70	6.40	0.460	<0.001	0.83
28-64 days old	50.30	41.90	49.40	41.50	4.90	0.210	<0.001	0.62
Feed conversion								
28-42 days old	1.75	1.73	1.78	1.76	0.09	0.130	0.300	0.88
43-64 days old	3.00	2.31	2.93	2.21	0.12	<0.010	<0.001	0.77
28-64 days old	2.48	2.11	2.45	2.05	0.08	0.030	<0.001	0.62

* Root mean square error and P levels for the comparison of LF and HF groups only;
µ For LR and HR groups the intake level is fixed, and thus means have a null variance and were not compared. nc: not calculable

CONCLUSION

Our strategy of feed restriction improved sharply the feed conversion, from 2 weeks after weaning, and was beneficial for the health of the rabbit during the post-weaning period. Our model of hygiene degradation seemed insufficiently stressful to affect the health of the rabbit, and should be further investigated.

REFERENCES

Gidenne T, Combes S, Fortun-Lamothe L. 2012. Feed intake limitation strategies for the growing rabbit: effect on feeding behaviour, welfare, performance, digestive physiology and health: a review. Animal. 6:1407-1419.

Le Floc'h N, Matte JJ, Melchior D, van Milgen J, Seve B. 2010. A moderate inflammation caused by the deterioration of housing conditions modifies Trp metabolism but not Trp requirement for growth of post-weaned piglets. Animal. 4:1891-1898.

Pastorelli H, Le Floc'h N, Merlot E, Meunier-Salaun MC, van Milgen J, Montagne L. 2012. Feed restriction applied after weaning has different effects on pig performance and health depending on the sanitary conditions. J Anim Sci. 90:4866-4875.

GENETICS, BREEDING, AND REPRODUCTION

Productivity of Flemish Giant Cross (Fz-3) as Broiler Rabbit

Bram Brahmantiyo, Raharjo YC, Prasetyo LH

Indonesian Research Institute for Animal Production
Jl. Veteran III, Ciawi PO Box 221 Bogor 16002, Indonesia
Corresponding e-mail: brahmantiyo@gmail.com

ABSTRACT

Flemish Giant cross (FZ-3) rabbit has been developed to contain blood ratio of 37.5% of Flemish Giant and 62.5% of Reza (crossbred of Rex and Satin rabbit) and is expected to become a superior broiler rabbit. A total of 280 heads of FZ-3 rabbits were produced and evaluated for their does and kits productivity. FZ-3 Doe has good productivity in litter size at birth (6.85+1.27 kits). The weaning weight of kit was 752.93+171.42 g /head, and body weight at age of 10 weeks was 1325.21+317.31 g/head, while its adult weight was 3333.82+427.19 g/head. Carcass percentage of FZ-3 rabbit slaughtered at 10 weeks was 43.85%, while the proportion of commercial cuts of loin and hindquarter was 60.69%.

Key Words: Rabbit, Carcass, Commercial Cut

INTRODUCTION

Indonesian population grows rapidly. As the consequences of this century, the increasing need of food including meat, provision of employment and income levels should be fulfilled for the population especially in rural areas. Fulfillment of meat by ruminants may be difficult to be achieved due to the time of reproduction is quite long. Therefore, we need to look for other alternatives such as poultry and rabbits which can multiply rapidly in a short time.

Four things that are very attractive for raising rabbits are (Cheeke 1986; Cheeke at al. 1987):

1. Rabbit has biological ability to grow and multiply rapidly in the marginal conditions and intensive care (per year of a rabbit doe can produce >120 kg live weight intensive conditions or 40 kg in marginal conditions),
2. Rabbit is a profitable agribusiness for pet, meat and qualified breeding stock (ratio B/C = 1 : 46 to 3 : 15), with the conditions of higher demand than supply,
3. Efforts to develop rabbit agribusiness in most of the Indonesian Province are conducted in micro, small and medium enterprises, both as individually and as a group (from Aceh through Papua province, the scale of ownership of 8-800 does),
4. A source of new income for farmers in rural and urban growth nodes and support businesses (food, cages, pet accessories).

Increasing rabbit meat consumption has been a challenge in the last few years. High prices associated with lack of interest in whole carcasses have contributed to this situation. The development of processed products such as retail cuts is an attempt to meet the changing demand. Knowledge about carcass traits such as weight and percentage of prime retail cuts are essential for this new market. According to Blasco & Ouhayoun (1996), the first retail cuts are hind legs, loin and fore legs.

In 2008, Indonesian Research Institute for Animal Production imported giant rabbit named Flemish Giant from Belgium. The Flemish Giant (FG) has potential advantages as a terminal-sire breed for improving live market and carcass weights (Carregal 1980; Ouhayoun 1980; Lukefahr et al. 1982, 1983a,b, 1984). Rex and Satin rabbits are well known for their beautiful and attractive furs, apart from their tender, low cholesterol and low fat meat. Furs from the Rex is soft and uniform in height, while from the Satin is dense and shiny. For these particular traits a piece of prime quality raw Rex pelt is expectedly worth of USD 8-14.00 in the global market; while dense and shine of Satin fur is similar to mink fur, one of the most valuable commodity in the fur industry.

The efforts to produce dense, soft and shiny fur with uniform length, hence increases its fur quality and economic value (expectedly more than USD 10-18.00 per piece), have been carried out since 1996. Results showed that such expected breed, we name the breed as Reza appeared in the F2 offspring (Prasetyo 1999) at about 23 out of 925 offsprings and low survivability (<30%). Hybrid vigour of the F1, in term of growth rate/bodyweight, however increased >10%, hence producing more meat and wider pelt/skin. Breeding within Rezas, apparently caused very high mortality of the offspring (Raharjo & Gultom 2002).

Other shortage faced in the rabbit production is the breed quality, which is small in size, low productivity and high mortality. Attempt to improve the breed and its productivity will be carried out by crossing of Flemish Giant, which is big (may reach 12 kg at mature age, but having poor quality fur) with Reza (medium weight). To produce medium (in weight) Reza, a crossing will be carried out through FG × Reza and its F1 (FZ-1 with proportion ½ FG and ½ Reza) is crossed rotational with Reza and FZ-1 to produce FZ-2 (proportion ¼ FG and ¾ FG) and rotational crossed between FZ-1 × FZ-2 to produce FZ-3 (proportion 3/8 FG and 5/8 Reza). This FZ-3 is expectedly having Reza-type fur. Having this done, we produce the medium (bigger) size Reza. Hybridization (crossbreeding) is very encouraged to produce a broiler rabbit (fryer) and Flemish Giant rabbits are very suitable for use as a superior male will be mated with the females of other breeds as a terminal sire breed (Sartika 2005).

The aim of this study was to evaluate Flemish Giant cross (FZ-3) rabbit performance consisted of the growth rate, doe productivity and carcass traits on 10 weeks of slaughter age.

MATERIAL AND METHODS

The study was conducted at the Research Institute for Animal Production (RIAP), Ciawi, West Java in January to June 2011. RIAP is located at 300 m above sea level with ambient temperature ranged between 22-28°C with an average annual rainfall reaches 3500-4000 mm.

The study used 50 females and 10 males of Flemish Giant cross (FZ-3 Rabbits with blood proportion were 37.5% of Flemish Giant and 62.5% of Reza). The interse mating of FZ-3 rabbits for four parities (parity 2 to 5) produced 281 heads of progeny. Galvanised wire cages 0.75×0.60×0.40 m (length×width×height) were used for the growing-fattening period. The cages had a hopper feeder and an automatic cup drinker and were located in an open-air shelter with asphalted cardboard roofing. Rabbits were fed *ad libitum* (the diet contained 2700 kkal ME/kg; crude protein: 16.0%; crude fibre: 14.0%), drinking water was also available *ad libitum*.

Productivity of FZ-3 rabbit was observed by measurements on reproductive performance (litter size at birth, litter size at weaning, total litter weight at birth and total litter weight at weaning) and body weight of doe (pregnant and lactating does) on a weekly basis, as well as mortality of kitten during lactation and performance of growth (weekly body weight from weaning to 20 weeks of age), Carcasses were prepared as recommended by the World Rabbit Science Association (Blasco & Ouhayoun 1996) by removing the skin, the distal parts of the tail, fore and hindleg, urogenital organs, and the digestive tract and carcass yield (Fennel et al. 1990) of 10 weeks of age were randomly selected in the initial population. Data were analyzed by descriptive analysis.

RESULTS AND DISCUSSION

Evaluation of doe productivity is shown in Table 1. FZ-3 rabbit shows the litter size at birth (6.85+1.27 kits) is equal with the Flemish Giant rabbit (6.86+1.18 kits) and higher than Reza rabbit (6.16±1.14 kits) (Brahmantiyo et al. 2010).

FZ-3 rabbit seems to have mothering ability is good with the number of LS at birth and LS at weaning reached 6.85+1.27 kits and 4.97+1.46 kits, respectively. The results agrees with Afifi & Khalil (1992) which stated that crosses were done to improve productivity of doe through increased litter size at birth and also litter weight at birth and litter weight at weaning.

Table 1. Performance of FZ-3 doe rabbits

Traits	FZ-3
Litter size (LS) at birth (head)	6.85±1.27
LS at weaning (head)	4.97±1.46
Mortality (%)	0.26±0.20
Total litter weight at birth (g)	354.90±86.99
Total litter weight at weaning (g)	3611.15±1080.96
Doe body weight at give birth (g)	3333.82±427.19
Doe body weight at weaning (g)	3369.40±414.17

Growth performance of FZ-3 rabbits is shown in Table 2. Birth, weaning and the weight of 10 weeks of age reached 52.99+10.66 g/kit, 752.93+171.47 g/kit and 1325.21+317.31 g/head, respectively. Birth weight of FZ-3 rabbit is the same as Rex (52.11 g/kit), Satin (55.22 g/kit) and Reza (52.97 g/kit) rabbits, but weaning weight of FZ-3 is higher than Rex (635.18 g/kit), Satin (625.50 g/kit) and Reza (575.43 g/kit) (Brahmantiyo et al. 2010). Body weight of FZ-3 rabbits on 10 weeks of age reached 1325.21 g/head higher than the body weight at 12 weeks of age of Rex (1318.86 g/head), Satin (1313.87 g/head) and Reza (1261.57 g/head). Reza crosses with Flemish Giant rabbits increased the weaning and mature weight, so the rabbit FZ-3 is expected to produce sufficient meat production.

Evaluation of productivity of FZ-3 rabbits was done on slaughter age of 10 weeks. Carcass production is shown in Table 3. Lukefahr et al. (1983a) reported that the effect of genetic group × gender interaction on several carcass characters was not significant, so in this result it was not separated between sex. The percentage of carcass, meat and bone of FZ - rabbits were 43.85, 69.10 and 30.90%, respectively. Carcass percentage was still lower compared with the results of Ozimba & Lukefahr (1991) on New Zealand White (NZW), Californian and their crossbreds with an average 55%. This difference was influenced by the slaughtered age (10 weeks vs 4 months) and breed. Diwyanto et al. (1985) reported that the carcass productions of NZW, local, NZW × local and Chinchilla × local rabbits were 45.8, 42.6, 48.9 and 46.7%, respectively.

Table 2. Performance of growth of FZ-3 rabbits with CV: coefficient of variance

Traits	Average (g/head)	CV (%)
Body weight at birth	52.99±10.66	20.12
Body weight at 3 weeks	292.01±75.59	25.89
Body weight at 6 weeks	752.93±171.47	22.77
Body weight at 10 weeks	1,325.21±317.31	23.94
Body weight at 16 weeks	2,082.26±427.62	20.54
Body weight at 20 weeks	2,562.27±369.35	14.41

Table 3. Carcass characteristics of FZ-3 rabbit

Traits	Average
Slaughter weight (g)	1436.83±24.25
Carcass weight (g)	630.17±46.94
Offal weight (g)	367.83±11.17
Pelt weight (g)	147.50±7.34
Lean meat weight (g)	436.50±28.45
Bone weight (g)	194.83±15.46
Carcass percentage (%)	43.85
Percentage of offal (%)	25.60
Percentage of pelt (%)	10.26
Percentage of lean meat (%)	69.10
Percentage of bone (%)	30.90

Table 4. Commercial cuts of FZ-3 rabbit

Commercial cuts	weight (g)	Std	Proportion from carcass weight (%)
Foreleg	207.33	23.59	32.90
Rack	45.83	10.19	7.27
Loin	131.17	15.38	20.81
Hindquarter	251.33	20.09	39.88

Carcass traits are influenced by the adult weight and the maturity of rabbits at the age of slaughter (Pla et al. 1996; Piles et al. 2000; Dalle Zotte 2002). In this study, carcass was produced from 10 weeks of age. Carcasses were cut into commercial cut and then the proportion of these pieces was shown in Table 4. Commercial cut is important for evaluating of economic value of rabbit meat. Commercial cut such as loin and hindleg have higher economic value than the foreleg and rack pieces. Therefore, the carcass evaluation was based on the proportion of commercial cuts to give a final result economically. FZ-3 rabbit produced commercial pieces for foreleg, rack, loin and hindquarter 32.90, 27.07, 20.81 and 39.88%, respectively. Total piece of high economic value (loin and hindquarter) was as much as 60.69% of the total carcass produced.

Commercial rabbit meat is usually produced by a three-way cross involving crossbred females mated to males from a sire line. The crossbred females are obtained by mating males and females from two female lines selected for litter size, while the sire lines are generally selected for growth rate, carcass yield, and meat quality (Baselga 2004; Pascual & Pla 2007). FZ-3 as broiler rabbit were developed by crossing Flemish Giant and Reza rabbits, that designed to have bigger on bodyweight and wider fur than Reza, also have good on reproduction. A crossbreeding scheme involving crossbred does would be justifed by the performance of the lines that produce the crossbred does and their heterosis effect on litter size (Ouyed et al. 2007; Ouyed 2009).

FZ-3 rabbits were reared in the same premises after weaning and reaching bodyweight at slaughter were due to their potential in the growth rate. Bodyweight at slaughter on 10 weeks of age was 1436.83 + 24.25 g/head. Metzer et al. (2006) reported bodyweight at slaughter on 9 weeks of Pannon White and Zika (crossbred of Pannon White and Hycole) were 2644 ± 15.9 g/head and 2758 ± 22.2 g/head, respectively. FZ-3 showed lower bodyweight at slaughter than Pannon White and Zika rabbits because of difference on breed and environment, also interaction between breed and environment. Pannon White and Zika were selected rabbit for high growth rate, which improves the body weight at a fixed age (Piles et al. 2000).

Carcass traits are basically influenced by the adult body weight and maturity at slaughter (Dalle Zotte 2002). Slaughtering the rabbits at the same bodyweight, later matured larger sized breeds or lines have poorer dressing out percentage than that of the smaller sized ones (Lukefahr et al. 1982; Maertens 1992; Pla 1996; Pla et al. 1996; Gómez et al. 1998; Dalle & Ouhayoun 1998). This is partly due to the different growth rate of tissues and organs (Cantier et al. 1969; Deltoro & López 1985). The skeleton and digestive tract mature earlier, the intensive growth of muscle starts later and fat is the latest.

CONCLUSION

Flemish Giant cross (FZ-3) has potency as meat producer with litter size at birth, weaning weight and the weight of 10 weeks of age and adult weights reached 6.85 + 1.27 kits, 752.93 g/head, 1325.21 + 317.31 g/head and 3333.82 + 427.19 g/head. Carcass of FZ-3 rabbit that were slaughtered on 10 weeks of age was 43.85 and 60.69% proportion of commercial pieces of loin and Hindquarter.

REFERENCES

Afifi EA, Khalil MH. 1992. Crossbreeding experiments of rabbits in Egypt: Synthesis of results and overview. CIHEAM. Option Mediteranean. Rome (Italy): FAO.

Baselga M. 2004. Genetic improvement of meat rabbits. Programmes and diffusion. In: Proceedings 8th World Rabbit Congress, Puebla 7-10 September, 2004. Puebla (Mexico): World Rabbit Congress. p. 1-13.

Blasco A, Ouhayoun J. 1996. Harmonization of criteria and terminology in rabbit meat research. World Rabbit Sci. 4:93-99.

Brahmantiyo B, Raharjo YC, Martojo H, Mansjoer SS. 2010. Performa produksi kelinci Rex, Satin dan persilangannya. JITV. 15:131-137.

Cantier J, Vezinet A, Rouvier R, Dauzier L. 1969: Allométrie de croissance chez le lapin (*Oryctolagus cuniculus*). 1-Principaux organes et tissus. Ann Biol Bioch Biphys. 9:539.

Carregal RD. 1980. Evaluation de la heterosis, de la capacidad de combination y de 10s effectos maternos y reciprocos en conejos. In: Proceedings 2nd World Rabbit Congress, Barcelona. Barcelona (Spain): World Rabbit Congress.

Cheeke PR 1986. Potentials of rabbit production in tropical and subtropical agricultural systems. J Anim Sci. 63:1581-1586.

Cheeke PR, Patton NM, Lukefahr SD, McNitt JL. 1987. Rabbit production. 6th Ed. Danvile (USA): The Interstate Printers and Publisher, Inc.

Dalle Zotte A. 2002. Perception of rabbit meat quality and major factors influencing rabbit carcass and meat quality. Lives Prod Sci. 75:11-32.

Dalle Zotte A, Ouhayoun J. 1998. Effect of genetic origin, diet and weaning weight on carcass composition, muscle physicochemical and histochemical traits in the rabbit. Meat Sci. 50:471-478.

Deltoro J, López AM. 1985. Allometric changes during growth in rabbits. J Agric Sci Camb. 105:339-346.

Diwyanto K, Sunarlim R, Sitorus P. 1985. Pengaruh persilangan terhadap nilai karkas dan preferensi daging kelinci panggang. Ilmu dan Peternakan. 1:427-430.

Fennel FL, Ekhator NN, Coppings RJ. 1990. A note on the calculation of carcass yield. J Appl Rabbit Res. 13:91-92.

Gómez EA, Baselga M, Rafel O, Ramon J. 1998. Comparison of characteristics in five strains of meat rabbit selected on different traits. Livest Prod Sci. 55:53-64.

Lukefahr S, Hohenboken WD, Cheeke PR, Patton NM, Kennick WH. 1982. Carcass and meat characteristics of Hemish Giaut and New Zealand White purebred and terminal-cross rabbits. J Anim Sci. 54:1169-1174.

Lukefahr S, Hohenboken WD, Cheeke PR, Patton NM. 1983a. Appraisal of nine genetic groups of rabbits for carcass and lean yield traits. J Anim Sci. 57:899-907.

Lukefahr S, Hohenboken WD, Cheeke PR, Patton NM. 1983b. Breed, heterotic and diet effects on postweaning litter growth and mortality in rabbits. J Anim Sci. 57:1108-1116.

Lukefahr S, Hohenboken WD, Cheeke PR, Patton NM. 1984. Genetic effects on maternal performance and litter performance pre-weaning and post weaning traits in rabbits. J Anim Sci. 38:293-300.

Maertens l. 1992. Selection scheme, performance level and comparative test of two lines of meat rabbits. J. Appl. Rabbit Res. 15: 206-212.

Ouhayoun J. 1980. Comparative development of the body components of three genetic types of rabbits during postnatal growth. (In French) Reprod Nutr Develop. 20:949.

Ouyed A, Lebas F, Lefrançois M, Rivest J. 2007. Performances de reproduction des lapines de races pures (Néo-Zélandais Blanc, Californien et Géant Blanc du Bouscat) et des croisés, en élevage assaini au Québec. In: Proceedings 12èmes Journ Rech Cunicole, 27-28 November, 2007. Le Mans (France): Les Journées de la Recherche Cunicole.

Ouyed A. 2009. Évaluation du rendement en carcasse, en muscle et du poids des différentes parties des lapins de lignées pures et hybrides. Rapport final déposé au Conseil pour le Développement de l'Agriculture du Québec et au Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec.

Ozimba CE, Lukefahr SD. 1991. Evaluation of purebreed and crossbreed rabbits for carcass merit. J Anim Sci. 69:2371-2378.

Pascual M, Pla M. 2007. Changes in carcass composition and meat quality when selecting rabbits for growth rate. Meat Sci. 77:474-481.

Piles M, Blasco A, Pla M. 2000. The effect of selection for growth rate on carcass composition and meat characteristic of rabbits. Meat Sci. 54:347-355.

Pla M, Hernández P, Blasco A. 1996. Carcass composition and meat characteristics of two rabbit breeds of different degrees of maturity. Meat Sci. 44: 85-92.

Pla M. 1996. Carcass composition and meat quality of rabbits selected from different criteria. In: Proceedings 6th World Rabbit Congress, Toulouse, 2. p. 347-350.

Prasetyo S. 1999. Kajian peluang pembentukan bangsa kelinci berbulu halus kilap melalui persilangan bangsa kelinci Rex dengan Satin. [Thesis S3]. (Bogor [Indonesia]): Fakultas Pasca Sarjana Institut Pertanian Bogor.

Raharjo YC, Gultom D. 2002. Peningkatan produktifitas dan mutu kulit-bulu kelinci melalui seleksi, kawin silang dan perbaikan nutrisi. Laporan Hasil Penelitian. Balitnak Ciawi-Bogor. 20 p.

Sartika T. 2005. Strategi pemuliaan sebagai alternative peningkatan produktivitas kelinci pedaging. Dalam: Raharjo YC, Yurmiati H, Diwyanto K, Inounu I, Priyanti A, Handiwirawan E, Rakhmani SIW, Brahmantiyo B, editor. Prosiding Lokakarya Nasional Potensi dan Peluang Pengembangan Usaha Kelinci. Bandung, 30 September 2005. Bogor (Indonesia): Kerjasama Puslitbangnak dan Fakultas Peternakan Universitas Padjadjaran. p. 93-98.

The Use of Cytochrome B Gene as A Marker for Meat Rabbit (*Oryctolagus* spp.) Authentication

Nuraini H, Brahmantiyo B[2], Sumantri C, Andreas E, Irine

[1]*Department of Animal Production and Technology, Faculty of Animal Science. Halal Science Center, Bogor Agricultural University, Jl. Agatis, Kampus IPB Darmaga, Bogor 16680*
[2]*Indonesian Research Institute for Animal Production, PO Box 221 Bogor 16002*
Corresponding e-mail: hennynuraini@ymail.com

ABSTRACT

Identification of origin species as meat source is very important to ensure the food safety. A suitable technique to identify the source of species was using multiplex PCR, with more than one primer used together for amplification of multiple target regions. This study was to develop specific primer derived from cytochrome b sequences in the Lagomorphs ordo, *Oryctolagus* spp. in order to be used as marker for authentication material. Sources of DNA used in this study were blood samples from cat (*Felis catus*), meat derived from rabbit (*Oryctolagus cuniculus*) and chickens (*Gallus gallus*), and the variety of meat products *i.e.* meatball, corned meat and sausage. DNA was extracted from meat samples using phenol-chloroform method. The detection of authentication through multiplex PCR approach using specific primer. Amplification of cyt b gene in three species of animals with a length of the different fragments indicated the specificity of cyt b gene sequences of each species. Amplified fragment length for rabbit, chickens and cat were 537, 227 and 568 bp, respectively. Test mixtures of DNA were prepared by adding 0.1, 1 and 5% levels of rabbit to chickens meat. The results indicated that the species of meat in various combinations can be accurately determined by PCR. It is concluded that primers from cyt b gene using multiplex PCR can be useful for fast, easy and reliable control of food safety and violation of labeling requirements

Key Words: Cytochrome B Gene, *Oryctolagus cuniculus*, Meat and Meat Products

INTRODUCTION

Increasing meat demand should be followed by a diversified source of meat other than conventional livestock, including rabbit meat. Rabbit (*Oryctolagus cuniculus*) is one of the pet animals, easy to maintain, prolific, has soft fur and a delicious flavor of meat. Rabbit meat is well known throughout the world, and in Indonesia it was part of a government program that aims to improve nutrition as a substitute for beef and chicken. However, the program is slowly progressing because it still has many problems, *i.e.* management, feeding, meat processing and culture of society.

At this time, rabbit meat is gaining popularity again as the need for meat and as a source of healthy food. According to various sources, rabbit meat provides benefits such as: having a higher protein content than other types of meat, low levels of cholesterol, rabbit liver for cure of asthma, rabbit brain believed to increase fertility. This various benefits cause rabbit meat gaining popularity among various other types of meat. On the other hand the continuity of rabbit meat supply is very low so there may be a process of substitution with other meats such as chicken, rat and cavy.

DNA sequences through a process of multiplication technique Polymerase Chain Reaction (PCR) is an alternative in determining the authenticity of a product. This method can use a universal marker or a specific marker that is only found in animal species. In pigs (Sus scrofa) and their relatives it has been found a specific sequence in which these sequences are repetitive sequences and is called with Porcine Repetitive Element 1 (PRE-1) (Nuraini 2004).

Cytochrome b gene is a gene that is often used in phylogenetics to compare multiple species in the same genus or family. The diversity of the cytochrome b gene has been used to detect the source of milk that comes from cows (Bos), sheep (Ovis), goats (Capra) or buffalo (Bubalus) (Lanzilao et al. 2005). Likewise, Pfeiffer et al. (2004) identified the cytochrome b gene diversity in species of cattle (*Bos taurus*), sheep (*Ovis aries*), goat (*Capra hircus*), roe buck (*Capreolus capreolus*) and red deer (*Cervus elaphus*), moose (Wolf et al.

1999), rat (*Rattus norvegicus*) (Nuraini et al. 2012) and guinea pigs (*Cavia porcellus*) (Primasari et al. 2011). Specificity of the cytochrome b gene is expected to be used to identify the presence of rabbit meat mixing with other types of white meat like chicken and cat.

In the present study the aim was to create a specific primer derived from cytochrome b sequences in the Lagomorphs ordo that can be used as a marker for the presence of mixture between rabbit meat with the other meat. The results could be used to assist in the decision-making process related to food security and labelling especially of animal origin, and to participate in efforts to protect the Indonesian people as consumers.

METHODS

Specific primers

Primers used for amplification of specific DNA fragments of chickens were designed as described by Matsunaga et al. (1999). Forward primer used for all 3 types of animals (rabbits, chickens and cats), the 5'-AGCT GACCT CCATCAAACATCT CATCTTG ATGAAA CCC-3 '. Reverse primers for amplification of specific fragments of rabbits were prepared using primer designing software tool (http://www.ncbi.nlm.nih.gov/tools/primerblast/index.cgi). Reverse primer sequences used are presented in Table 1.

Source of DNA

DNA was extracted from blood samples of cats and meat from rabbits and chickens. Meat products used were meatballs, sausage and corned meat coming from rabbits. DNA extraction process was performed using phenol-chloroform method (Sambrook & Russell 2001).

Amplification of specific DNA fragments

Amplification of specific DNA fragments was made by PCR (polymerase chain reaction). Reaction components used were as much as 25 mL, consisting of 35 pmol forward primer, reverse primer @ 5 pmol, 200 lm dNTP mix, 1 mM MgCl2, and 0.5 units of taq polymerase and bufer. Amplification process was run on a GeneAmp ® PCR System 9700 (Applied Biosystems ™) with the conditions of initial denaturation at 95°C for 5 min, 30 cycles consisting of denaturation at 95°C for 10 seconds, annealing at 60°C for 20 sec and elongation of new DNA at 72°C for 30 sec, and final elongation at a temperature of 72°C for 5 minutes

The interpretation results visualization and amplification

Visualization of the results of amplification performed on 2% agarose gel (v/w) were stained with EtBr (ethidium bromide) at UV transiluminator. Specific DNA fragments of chicken, rabbit and cat were demonstrated by DNA bands along the 227, 537 and 568 bp. Visualization results with two or more bands indicated the presence of a mixture of rabbit meat with other meat.

Table 1. PCR oligonucleotide primers

Species	Reverse primer (5'-3')	PCR products	Reference
Rabbit	GAG GAG GTG AAT TAA GAC TAA AGT	537 bp	
Chicken	AAG ATA CAG ATG AAG AAG AAT GAG GCG	227 bp	Matsunaga et al. (1999)
Cat	TGA AAC AGG ATC TAA CAA CCC CT	568 bp	

RESULTS AND DISCUSSION

The degree of similarity between specific primers

The degree of similarity, or often called the homology percentage, was carried out to determine the level of specificity of the DNA sequences. Testing the degree of similarity in specific primer sequences used in this study are presented in Table 2. Based on the testing, the forward primer has a relatively high degree of similarity to the sequences of chicken, rabbits and cats, ranging from 84.211 to 89.474% of the sequences of 38 bases. Reverse primer sequences have a high degree of homology to a certain animal species, so that it can be said that the reverse primer is specific for rabbit.

Amplification of specific fragments of cyt b gene on chicken, rabbit and cat

Successfully cytochrome b gene was amplified using primers for the three species of animals, chickens, rabbits and cats with fragment length of 227, 537 and 568 bp respectively. DNA samples derived from rabbit were successfully amplified using primers that were prepared using primer designing software tools based on the cytochrome b gene sequences in *Oryctolagus cuniculus*.

Visualization of specific DNA fragments of the cytochrome b gene amplification results in this study are presented in Figure 1. Column two and three were chicken and rabbit DNA derived from meat and the fourth column was the cat DNA bands derived from blood, three were positive control. Mixture of DNA to the three species were shown in columns 5 and 6. DNA derived from rabbit and cat were amplified in a separate tube because both have relatively adjacent fragments (537 and 568 bp).

Amplification of specific fragments of DNA cytochrome b at meat product and the DNA mixture

Processed meat products such as meatballs, sausages and corned meat are meat products that are well known by the public. Primary testing was conducted on these meat processed products. The results showed the success rate of rabbit meat and chickens specific primers for the cytochrome b gene amplified sequence on species-specific regions. The results of amplification of specific DNA fragments of cytochrome b in meat rabbit product samples are presented in Figure 1. In addition, the sensitivity of primers to identify particular DNA mixtures was determined by mixing rabbit DNA at the level of 0,1; 1 and 5%. The results of the cyt b gene amplification in the DNA mixture of rabbit DNA are presented in Figure 2. These results might be useful for effective control of authentication and violation of labeling requirements for meat products.

Table 2. Homology percentage of spesific reverse primers

Specific primer	*Gallus gallus* (227 bp)	*Oryctolagus cuniculus* (537 bp)	*Felis catus* (568 bp)
Forward (38 nt)	89.474	86.842	84.211
Chicken (27 nt)	100.000	62.963	62.963
Rabbit (24 nt)	50.000	100.000	58.333
Cat (23 nt)	78.261	78.261	100.000

Table 3. Sensitivity primers of Oryctolagus *cyt b* gene

Sample	Rabbit	Chickens
Sensitivity 5% (chickens 95% : rabbit 5%) (1 µl)	+++	+++
Sensitivity 5% (chickens 95% : rabbit 5%) (2 µl)	+++	+++
Sensitivity 1% (chickens 99% : rabbit 1%) (1 µl)	++	+++
Sensitivity 1% (chickens 99% : rabbit 1%) (2 µl)	++	+++
Sensitivity 0.1% (chickens 99.9% : rabbit 0.1%) (1 µl)	+	+++
Sensitivity 0.1% (chickens 99.9% : rabbit 0.1%) (2 µl)	+	+++

+: indicates the intensity of the thickness of the PCR product

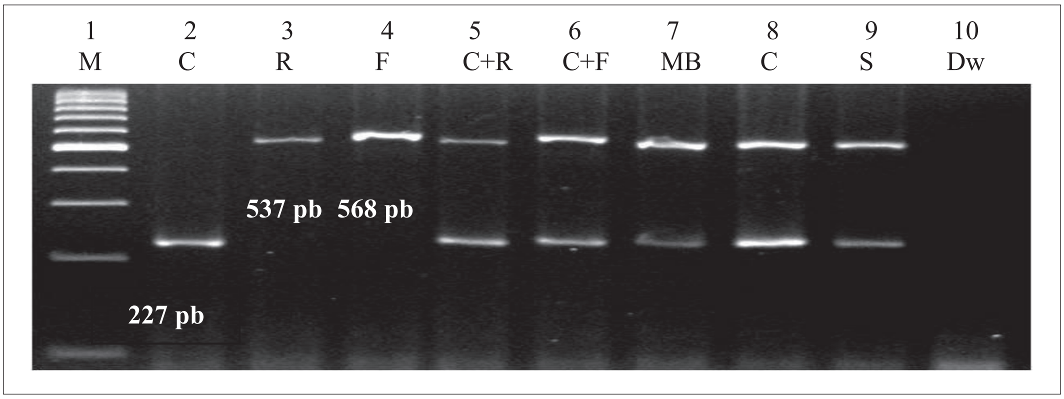


Figure 1. PCR product amplified with specific. M: marker 100 pb; C: chicken, R: rabbit; F: cat; C+R: chicken + rabbit; C+F: chicken + cat; MB: meatball; C: corned; S: sausage; Dw: water (negative control)

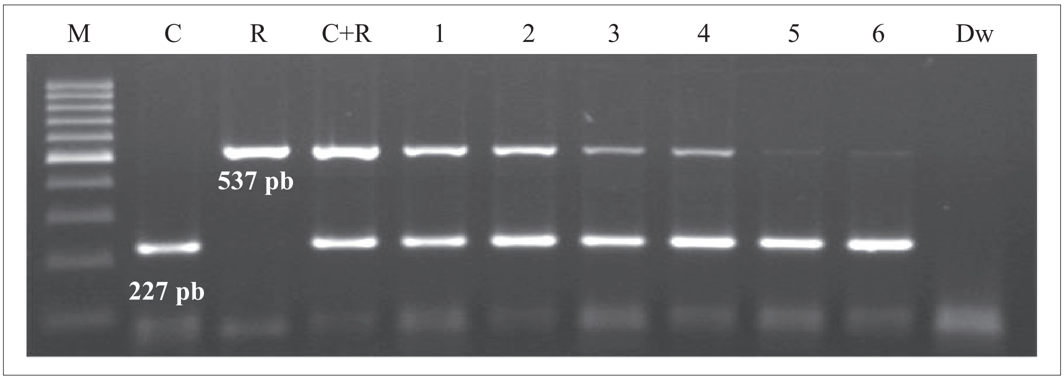


Figure 2. PCR products from mixtures of chicken and rabbit meat with rabbit-specific primer. M: marker 100 bp; C: chicken; R: rabbit; (1); 5% rabbit meat (1 μl); (2) 5% rabbit meat (2 μl); (3) 1% rabbit meat (1 μl); (4) 1% rabbit meat (2 μl); (5) 0.1% rabbit meat (1 μl); (6) 0,1% rabbit meat (2 μl); Dw: water (negative control)

CONCLUSION

The authentication of meat's origin is important for the protection of consumers, for this reason primer from cyt b gene using multiplex PCR can be useful as fast, easy and reliable method.

ACKNOWLEDGMENTS

The authors would like to thank the Head of the Laboratory of Animal Breeding and Genetics, Department of Animal Production and Technology, Faculty of Animal Science. Thanks are also extended to the Head of Halal Science Center, Bogor Agricultural University who has allowed to use the laboratory, the undergraduate and graduate students who helped in preparation of samples.

REFERENCE

Lanzilao I, Burgalassi F, Fancelli S, Settimelli M, Fani R. 2005. Polymerase chain reaction-restriction fragment length polymorphism analysis of mitochondrial cyt b gene from species of dairy interest. J AOAC Int. 88:128-135

Matsunaga T, Chikuni K, Tanabe R, Muroya S, Shibata K, Yamamda J, Shinmura Y. 1999. A quick and simple method for the identification of meat species and meat products by PCR assay. Meat Sci. 51:143-148.

Nuraini H. 2004. Development of *Porcine Repetitive Element* (PRE-1) sequence as a marker for detection of swine material at meat products. [dissertation]. [Bogor (Indonesia)]: Postgraduate School Bogor Agricultural University.

Nuraini H, Primasari A, Andreas E, Sumantri C. 2012. The *cytochrome b* gene as a specific markers for the rat meat (*Rattus norvegicus*) on raw meat and processed meat product. J Anim Sci Technol. 35:15–20.

Pfeiffer I, Burger J, Brenig B. 2004. Diagnostic polymorphism in the mitochondrial *cytochrome b* gene allow discrimination between cattle, sheep, goat, roe buck and red deer by PCR-RFLP. BMC Genet. 5:30.

Primasari A, Sumantri C, Nuraini H, Maheswari RRA. 2011. Sensitivity of Cytochrome b (Cyt b) genes as a specific marker in *Rattus* and *Mus* for food safety of meat product. [Thesis]. (Bogor [Indonesia]): Postgraduate School Bogor Agricultural University.

Sambrook J, Russell D. 2001. Molecular Cloning: A Laboratory Manual, 3rd ed. Cold Spring Harbor (USA): Cold Spring Harbor Laboratory Press.

Wolf C, Rentsch J, Hübner P. 1999. PCR−RFLP Analysis of Mitochondrial DNA: A Reliable Method for Species Identification. J Agric Food Chem. 47:1350-1355.

VETERINARY AND MANAGEMENT

Comparative Proteome Analysis of Outer Membrane Proteins of *Bordetella bronchiseptica*

Liu Yan[1], Qin Feng-Yan[1,2], Bao Guo-Lian[1], Wei Qiang[1], Ji Quan-An[1], Yao Huo-Chun[2], Xiao Chen-Wen[1]

[1]Institute of Animal Husbandry and Veterinary Sciences, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China
[2]Nanjing Agricultural University, Nanjing 210095, China
Corresponding email: baoguolian@163.com

ABSTRACT

Bordetella bronchiseptica (Bb) is an important pathogen in rabbits and is associated with a respiratory infectious disease, which is long lasting, repeatable and difficult to cure. Serious economic losses in rabbit husbandry are caused by the disease. The outer membrane (OM) is the barrier between a bacteria and the environment. Bb OMPs possibly contain virulence factors associated with disease. Proteomics that combines 2-DE with mass spectrometry has become a powerful tool to study the virulence factors of pathogenic microorganisms. In this research, the outer membrane proteins (OMPs) proteomics profiles were compared in two Bordetella bronchiseptica (Bb) strains, HB and RB. Bb strains were isolated from an infectious rhinitis rabbit and a healthy rabbit, respectively. The 50% lethal dose value (LD50) in mice of strain HB was 2.42×106 cfu/ml, while mice infected with RB had low mortalities. The OMPs were extracted by sodium carbonate treatment, and analyzed with two-dimensional gel electrophoresis (2-DE). The 2-DE gels of OMPs showed mostly protein spots ranging from 40 kDa to 70 kDa. 140 protein spots in RB and 187 in HB gels were detected. Among these proteins, 14 spots of RB showed lower intensity than the corresponding spot of HB, while 5 spots showed higher intensity. Moreover, 5 protein spots were observed only in HB. Different Protein spots were cut out and identified by matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF-MS). Combined peptide mass fingerprinting PMF and MS/MS queries were carried out by the MASCOT search engine 2.2. The theoretical PI/Mw of proteins were computed by the PI/Mw tool (http://web.expasy.org/compute pi/), the functional categories of the identified proteins of Bb were sorted using COGnitor (http://www.ncbi.nlm.nih.gov/COG/old/ xognitor.html) and the subcellular location was predicted by PSORTb v.3.0 psort (http://www.psort.org/psortb/). These identified proteins belong to different classes: cell envelope biogenesis, outer membrane; cell motility and secretion; inorganic ion transport and metabolism; energy production and conversion; amino acid transport and metabolism; translation, ribosomal structure and biogenesis; posttranslational modification, protein turnover, chaperones; function unknown proteins and NO related COG. In conclusion, in our research, OMPs of two different virulence strains of Bb were analyzed via 2-DE and identified by MALDI-TOF-MS, in order to screen virulence proteins of Bb and find novel proteins associated with virulence. These identified proteins may be associated with virulence of Bb, however these findings still need further studies.

Key Words: *Bordetella bronchiseptica*, Outer Membrane Proteins, Virulence Factor, Proteomics

INTRODUCTION

Bordetella bronchiseptica (Bb) is an important pathogen in rabbits and is associated with a respiratory infectious disease, which is long lasting, occurs repeatedly and is difficult to cure. Serious economic losses are caused in rabbit husbandry by the disease. Moreover, Bb also can cause canine infectious tracheobronchitis and swine infectious atrophic rhinitis. Bb virulence were sorted into two types, the first includes adhesins, including filamentous hemagglutinin (FHA), pertactin (PRN), tracheal colonization factor (TCF) and fimbriae (FIM); the second includes toxins, including dermonecrotic toxin (DNT), tracheal cytotocin, adenylate cyclase toxin (AC-Hly), type-III secretion system and lipopolysaccharide (LPS). Bb colonizes in the cilia of the respiratory mucosa epithelial cells, and then proliferates and secretes virulence factors, such as DNT and AC-Hly, causing inflammation of the mucosal epithelial cells, hyperplasia, cilia loss and other degenerative diseases. The expression of these virulence factors is closely related to the environment of the pathogen and is regulated by two-component regulatory systems (TCSs). Bacteria can sense and respond to environmental stimuli by TCSs, and the expression of related genes is controlled by TCSs (Laub et al. 2007).

The outer membrane (OM) is the barrier between a bacteria and the environment. One of its functions is to protect bacteria against undesirable environment. A lipid bilayer covers the cell and 50% of its mass is composed of proteins (Koebnik et al. 2000). The OMPs of bacteria are the interface of the interaction between bacteria and extracellular environment, playing an important role in drug resistance, pathogenicity and immunogenicity (Cordwell et al. 2001). Many OMPs in *E. coli* have been identified, including bacteriophage receptors, resistance to antibiotics, structural functions as well as adhesion, and invasion proteins (Poetsch et al. 2008). Therefore, Bb OMPs possibly contain virulence factors associated with disease.

Proteomics that combine 2-DE with mass spectrometry has become a powerful tool to study the virulence factors of pathogenic microorganisms (Jungblut et al. 2000). Thus in our research, OMPs of two different virulence strains of Bb (HB and RB) were analyzed via 2-DE and identified by MALDI-TOF-MS, in order to screen virulence proteins of Bb and find novel antigenic proteins associated with virulence.

MATERIAL AND METHODS

Bacterial strains and culture conditions

Bb strain HB isolated from an infectious rhinitis rabbit and RB isolated from a healthy rabbit were used in this research. Bacteria of Bb were cultured on sheep blood agar (Hangzhou Tianhe Microganism Reagent Co, Ltd.) and also in tryptone soya broth (TSB, Oxoid) liquid medium containing 5% bovine calf serum in a rotary incubator shaker at a speed of 200 rpm at 37°C for the extraction of OMPs.

Extraction of OMPs sample

OMPs were extracted by the method of Molloy et al. with some modifications (Liao et al. 2009). Firstly, in the late phase of Bb (OD600~1.5), cells were centrifuged at 7000 × g (HITACHI, High-speed Refrigerated Centrifuge) for 10 min at 4°C. Secondly, the harvested pellets were washed 4 times with low salt PBS(3 mM KCI, 68 mM NaCI, 1.5 mM KH2PO4, 9 mM NaH2PO4) and the pellets were suspended in Tris-Cl [50 mM, pH 7.5, containing 1% protease inhibitor (GE Healthcare)]. Thirdly, the mixture prepared in the second step were ruptured at 2 W; pulse on, 2 s; pulse off, 2 s (MISONIX, sonicator® 3000) by sonication, till the OD600 decreased to 1/10 of the original. Cells and cellular debris unbroken were removed by centrifugation, at 9000×g for 10 min at 4°C. The supernatant was diluted 10-fold with ice cold Na_2CO_3 (0.1 M, pH 11), and stirred slowly in ice bath for 1 h. OMPs were collected by ultracentrifugation at 4°C in a ultracentrifuge (HITACHI) running at 100000×g for 1 h. The supernatant was removed, and the pellets were resuspended and washed in Tris-Cl (50 mM, pH 7.5) twice. The pellets were gained by centrifugation at 100000×g for 1 h at 4°C. Finally, the pellets were solubilized in a lysis buffer [5 M Urea, 2 M Thiourea, 2% (W/ V) CHAPS, 2% (W/ V) SB3~ 10]. The concentration of proteins was detected using GE Healthcare 2-D Quant Kit. The protein samples were packaged and stored at -70°C.

2-DE and Image Analysis

The OMPs samples (750 μg/strip) were mixed with lysis buffer (5 M Urea, 2 M Thiourea, 2% CHAPS, 2% SB3-10), containing 1% DTT, 0.5% IPG buffer and 0.002% bromophenol blue, and loaded on 13 cm Immobiline DryStrip™ IPG strips (linear 4-7 pH gradient, GE Healthcare, USA). The strips with OMPs samples were focused for 410 kVHrs on the Ettan IPGphor III system. Then the IPG strips were equilibrated for 15 min with 1% DTT and 2.5% IAA in equilibration buffer (6 M urea, 75 mM pH 8.8 Tris-HCl, 29.3% v/v glycerol, 2% w/v SDS, 0.002% w/v bromophenol blue). After equilibration, the 2-DE was carried out on a 12.5% SDS polyacrylamide gel with the SE600 Ruby system (GE Healthcare, USA). Gels were stained with Coomassie Brilliant Blue G250. Gels were evaluated and analyzed by software of Imagemaster 2D Platinum 7.0 (GE Healthcare, USA). Spots of each gel of RB and HB were matched and the percent volume of spots was compared. The protein spot levels were considered to have higher or lower volume when there was at least a 1.5-fold difference (Paes et al. 2008). At a minimum, triplicate gels of each sample were analyzed to check reproducibility.

Protein In-gel digestion

Protein spots were picked out from gels, destained in 200~ 400 µl 100 mmol/l NH_4HCO_3/30% CAN for 20 min, and washed in distilled water. Then these spots were lyophilized after kept in 0.2 M NH_4HCO_3 for 20 min. Each spot was digested overnight at 37°C, the ratio of the mass of trypsin and proteins analyzed was 1 : 20~1 : 100. The solution was transferred to a new tube, 60% CAN/0.1% TFA added, ruptured by sonication, lyophilized and desalted by Ziptip.

Analysis of MALDI-TOF MS and database searches

Protein identification was performed on a MALDI-TOF-TOF instrument (4800 proteomics analyzer, Applied Biosystems), whose parameters were set using the 4000 Series Explorer software (Applied Biosystems). Combined peptide mass fingerprinting PMF and MS/MS queries were carried out by the MASCOT search engine 2.2 (Matrix Science, Ltd.), with MS/MS fragment tolerance setting to 0.4 Da. GPS Explorer protein confidence index ≥ 95% were used for further manual validation.

Bioinformatics tools

The theoretical PI/Mw of proteins were computed by the PI/Mw tool (http://web.expasy.org/compute pi/), the functional categories of the identified proteins of Bb were sorted using COGnitor (http://www.ncbi.nlm.nih.gov/COG/old/xognitor.html) and the subcellular location was predicted via PSORT b v.3.0 psort (http://www.psort.org/psortb/).

RESULTS

Comparison of OMPs Profiles by 2-DE

The gels were submitted to image analysis using Imagemaster 2D Platinum 7.0. The 2-DE gels of OMPs showed mostly protein spots ranging from 40 kDa to 70 kDa. 140 protein spots in RB and 187 in RB gels were detected. Using analysis parameters as ratio >1.5, 14 spots of RB showed lower intensity than the corresponding spot of HB, while 5 spots showed a somewhat higher intensity. Moreover, 5 protein spots were observed only in HB (Figure 1 B).

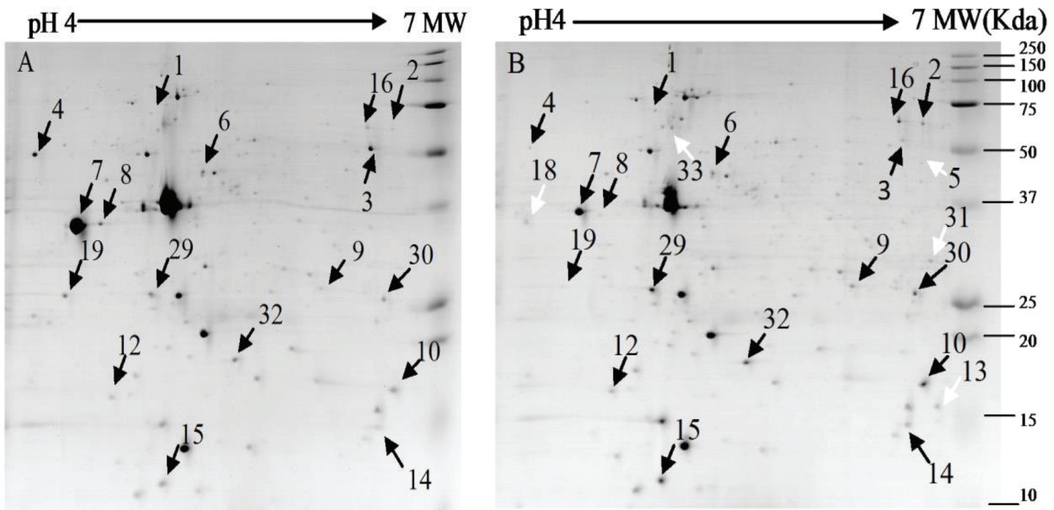


Figure 1. Two-dimensional maps (PH4-7) of Bb strain RB and HB OMPs2-DE profile of RB OMPs stained with CBB (B) 2-DE profile of HB OMPs stained with CBB

Protein identification

For protein identification, 23 protein spots were picked out from 2-DE gels and submitted to in-gel trypsin digestion for MS identification. These spots included proteins observed only in the HB gel, and proteins observed in both gels with different expression levels. The result showed that 21 spots were successfully identified, corresponding to 19 proteins. Among these proteins, five were observed only in HB (5, 13, 18, 31 and 33) , fourteen were present in both gels, but the majority showed higher expression levels in HB except five protein spots (3, 4, 7, 8 and 19). All differential protein sequences of the proteins identified were submitted to PSORT to predict protein localization and the results are shown in Table 1. Functional categories of the identified proteins of Bb were sorted using COGnitor. These identified proteins belong to different classes (Table 2).

Table 1. Protein spots identified by MALDI-TOF-MS or MALDI-TOF-TOF-MS

Spot ID	Database ID no.	Identified protein name	Theoretical MW(Da)/PI	MASCOT score	Peptides matched	Location
2,16	gi|33577555	putative outer membrane protein 1	69310.3/7.72	1,010	36	Outer Membrane
3	gi|33567775	putative outer membrane protein 2	54883.9/7.7	923	37	Outer Membrane
4	gi|33575977	flagellar hook protein FlgE	49037.9/4.28	287	8	Extracellular
8	gi|33576000	flagellar motor switch protein FliG	36594.7/4.67	755	18	Cytoplasmic
19	gi|33575979	flagellar basal-body rod protein	27716.9/4.5	636	9	Extracellular
5	gi|33577084	2-oxoglutarate dehydrogenase complex, E3 component	50357.2/6.33	173	14	Cytoplasmic
7	gi|33577259	outer membrane porin protein precursor	41278/5.51	608	16	Outer Membrane
9	gi|257696710	unnamed protein product 1	27822/	612	18	Cytoplasmic Membrane
1	gi|47115747	Chaperone protein htpG	71295.6/5.01	801	30	Cytoplasmic
6	gi|33599950	chaperonin GroEL	57447.4/5.09	287	13	Cytoplasmic
33	gi|33567547	60 kDa chaperonin	57447.4/5.09	766	25	Cytoplasmic
29	gi|33576210	putative amino acid ABC transporter solute-binding protein	28311.7/5.47	769	18	Periplasmic
30	gi|33577543	putative amino acid ABC transporter ATP-binding protein	28254.3/6.25	729	19	Cytoplasmic Membrane
31	gi|33576018	30S ribosomal protein S2	27550.2/6.4	461	16	Cytoplasmic
15	gi|33567094	putative membrane protein 1	19407.1/6.15	156	6	Unknown
32	gi|33576588	putative membrane protein 2	22788.8/5.55	787	17	Unknown
10	gi|33577008	conserved hypothetical protein 1	21632.6/6.59	678	10	Unknown
12	gi|33568581	conserved hypothetical protein 2	19819.2/5.26	656	10	Unknown
13,14	gi|33577188	putative lipoprotein	19868.9/8.74	297	9	Unknown

Table 2. The functional category of identified proteins

Functional category	The number of protein
Cell motility and secretion (N)	3
Posttranslational modification, protein turnover, chaperones (O)	3
Energy production and conversion (C)	3
Amino acid transport and metabolism (E)	1
Inorganic ion transport and metabolis (P)	1
Cell envelope biogenesis, outer membrane (M)	2
Translation, ribosomal structure and biogenesis (J)	1
Function unknown (S)	2
NO related COG[a]	3

[a] This message appears if the query protein is not predicted to belong to any of the currently-defined COGs, or if the protein is not predicted to belong to a COG composed of the minimum number of clades indicated

DISCUSSION

In our research, the profiles of OMPs of HB and RB strains were analyzed by 2-DE. The choice of the two strains was based on their virulence. HB and RB were isolated from an infectious rhinitis rabbit and a healthy rabbit, respectively. A total of 19 proteins were successfully identified by a comparative proteomics approach. In the 19 differential proteins, protein number 3, 4, 7, 8, 19 had a higher expression level in RB strain. Proteins 4, 8 and 19 were identified to be flagellin associated proteins, proteins 3 and 7 were identified to be a putative OMP and outer membrane porin protein precursor respectively. Some proteins predicted other than OMP were involved in, including extracellular, periplasmic, cytoplasmic membrane and cytoplasmic proteins. These proteins may be present in OMPs extracts (Liu et al. 2008), though sodium carbonate treatment had a higher rate of OMPs extraction (Suh et al. 2008).

The research results showed that flagellin-associated proteins were both indentified in the two strains and RB strain had a higher expression of these proteins. Infection with a Bb strain which expresses flagellin could result in a strong antibody response to flagellin and reduce the colonization of Bb in the trachea, which indicates that flagellin repression is important for *Bordetella* sp. Infection (Akerley et al. 1995). A 40kD outer membrane porin is present in both the virulent strain and avirulent strain of Bb. The expression of this protein had a higher level in RB than in HB strains in our research. This protein usually forms anion-selective, small channels in lipid bilayer membranes. The other 14 proteins had a higher expression level in HB strain, in which, four proteins (5, 13, 31, 33) were proved to exist only in the HB strain. Protein 5 was identified to be 2-oxoglutarate dehydrogenase complex, E3 component. It is an important protein in the tricarboxylic acid cycle. Protein 31 was identified to be the 30S ribosomal protein S2. The 30S ribosomal subunit and tRNA binding is a key step in protein synthesis. These two proteins are predicted to locate in the cytoplasm, relate to energy production and conversion. In our study, three proteins were identified to be chaperones, which belong to a member of the heat shock protein family. Protein 1 was identified to be chaperone protein htpG, belonging to the heat shock protein90 (HSP90) family members. Protein 6 was identified to be chaperonin GroEL, and protein 33 was identified to be 60KD chaperonin. These two proteins both belong to the heat shock protein HSP60 family members. Chaperones play an important role in the polypeptide folding process. Hsp60 is displayed on the surface of bacteria, and is universally expressed in inflammation. Hsp60 is well recognized by the immune system and can affect the innate and acquired immune systems to generate humoral and cellular immunity. The expression of HSP90 doubles quickly to protect the cells against endogenous attack, enhance cell repair and improve the tolerance of cells against stimulation. GroEL can influence probiotic properties of some bacterium, including biofilm formation, tolerance to acid, etc (Lemos et al. 2007).

Seven putative proteins and two hypothetical proteins were identified in our research. Some of them were not related to OMPs, by the predicted cellular location analysis, but they may be related to the virulence or phenotypic features because that they are located in membrane, and may be the first step in host interaction (Taddei et al. 2011). For example, putative amino acid ABC transporter which had a higher expression level in the virulent strain HB, also had a higher expression level in Mycobacterium.

In conclusion, 19 proteins were identified by comparative proteome analysis of OMPs of two different virulent Bb strains. These proteins may be associated with virulence of Bb, however these findings still need further studies.

ACKNOWLEDGEMENTS

Thanks for the supporting of the China Agricultural Research System (Code No. nycytx-44-3-2) and the Zhejiang Key Project on Agricultural Development through Science and Technology (No. 2011C12028) in this work.

REFERENCES

Akerley BJ, Cotter PA, Miller JF. 1995. Ectopic expression of the flagellar regulon alters development of the Bordetella-host interaction. Cell. 80:611-620.

Cordwell SJ, Nouwens AS, Walsh BJ. 2001. Comparative proteomics of bacterial pathogens. Proteomics. 1:461-472.

Jungblut PR. 2001. Proteome analysis of bacterial pathogens. Microbes Infect. 3:831-840.

Koebnik R, Locher KP, van Gelder P. 2000. Structure and function of bacterial outer membrane proteins: barrels in a nutshell. Mol Microbiol. 37:239-253.

Laub MT, Goulian M. 2007. Specificity in two-component signal transduction pathways. Annu Rev Genet. 41:121-145.

Lemos JA, Luzardo Y, Burne RA, 2007. Physiologic effects of forced down-regulation of dnaK and groEL expression in Streptococcus mutans. J Bacteriol. 189:1582-1588.

Liao Y, Deng J, Zhang A, Zhou M, Hu Y, Chen H, Jin M. 2009. Immunoproteomic analysis of outer membrane proteins and extracellular proteins of *Actinobacillus pleuropneumoniae* JL03 serotype 3 . BMC Microbiol. 9:172.

Liu GY, Nie P, Zhang J, Li N. 2008. Proteomic analysis of the sarcosine-insoluble outer membrane fraction of Flavobacterium columnare. J Fish Dis. 31:269-276.

Paes Leme AF, Bedi CM, Cury AA, Koo H, Cury JA. 2008. Effects of sucrose on the extracellular matrix of plaque-like biofilm formed in vivo studied by proteomic analysis. Caries Res. 42:435-443.

Poetsch A, Wolters D. 2008. Bacterial membrane proteomics. Proteomics. 8:4100-4122.

Suh MJ, Alami H, Clark DJ, Parmar PP, Robinson JM, Huang ST, Fleischmann RD, Peterson SN, Pieper R. 2008. Widespread occurrence of non-enzymatic deamidations of asparagine residues in Yersinia pestis proteins resulting from alkaline pH membrane extraction conditions. Open Proteomics J. 1:106-115.

Taddei CR, Oliveira FF, Piazza RM, Paes Leme AF, Klitzke CF, Serrano SM, Martinez MB, Elias WP, Sant Anna OA. 2011. A comparative study of the outer membrane proteome from a atypical and a typical enteropathogenic *Escherichia coli*. Open Microbiol J. 5:83-90.

Comparative Advantages and Competitiveness of Chinese Rabbit Sector

Laping Wu[1], Ronghua Ju[1], Longxian Liu[2]

[1]College of Economics and Management, China Agricultural University, Qinghua, East Road, Haidian District, Beijing, 100083, PR China
[2]Library, China Agricultural University, Qinghua, East Road, Haidian District, Beijing, 100083, PR China
Corresponding email: wulp@cau.edu.cn

ABSTRACT

Since the 1990s, Chinese rabbit industry has been experiencing a fast growth. Due to saving land and feed grain, less investment and easy to manage, rabbit farms have attracted more and more farmers, in consequence, the rabbit industry keeps high in growth rate. From 2001 to 2010, Chinese rabbit meat production surged from 406 thousand tons to 690 thousand tons, the growth rate reaches 70%, while pork production increased only by 25%, beef by 28% and poultry by 37%. Based on the theory of comparative advantages and competitiveness, by cost-benefit analysis and the market share analysis, this paper analyzed the rabbit industrial competitiveness in both domestic and international markets. Theoretically, the rabbit industrial competitiveness includes potential competitiveness and revealed competitiveness. The potential competitiveness, also referring to the comparative advantages, mainly comes from the superiorities of rabbit meat, rabbit fur and rabbit skin, resource endowment and technological progress. Revealed competitiveness refers to performance in markets. It shows that there is a relatively large increase in rabbit meat production. The production growth is mainly driven by demand, and the increased demand is mainly caused by preference change due to the food safety problems of other meats. It shows that the profit margin of rabbit-raising is higher than others except for pig, however, if taking government subsidy into account, it would be higher than pig-raising. From the international perspective, this paper used data from UN-Comtrade database to study market share of Chinese rabbit meat. It shows that Chinese rabbit industries possess stronger competitiveness. The prices of live rabbit and rabbit meat in China are the lowest among major rabbit producing countries, thus China has significant price advantage in rabbit industry. In conclusion, rabbit meat has incomparable nutritional advantages when compared with other animal products (pork, beef and poultry). As to rabbit technology and productivity, China has been achieving great progress. From perspective of international competitiveness, Chinese rabbit stock accounted for more than 30% of the world total In recent years, the slaughter rabbit and rabbit meat output both accounted for more than 40% of world total, with meat output reached 45%. Compared with the developed EU countries, Chinese rabbit industry is still in its early stage, it still faces certain challenges, including the increasing cost of feed and labor, slow advances in technology and less developed processing and marketing ability of rabbit processing countries and traders. Finally, some policy suggestions are provided to improve rabbit industry development.

Key Words: Comparative Advantage, Competitiveness, Rabbit Sector, China

INTRODUCTION

Industrial competitiveness is an important driver of industrial development. The industrial competitiveness is not only affected by technology and investment from the production perspective, but also by the market demands. Under the background of the market orientation and internationalization, market demand plays more and more important role. This paper will analyze the Chinese rabbit sector from both the domestic and international perspectives.

THE DOMESTIC COMPETITIVENESS OF RABBIT SECTOR IN CHINA

China has a long history of rabbit raising, the earliest record can be dated back to pre-Qin dynasty, more than 2000 years ago. Since 1990s, Chinese rabbit sector has entered a rapid development stage. Recently, rabbit farming has been paid more and more attention because of the characteristics of land saving, grain saving, less investment and easier to manage. Meanwhile the rabbit products are becoming more and more popular because they can satisfy the increasingly diversified consumer demand by providing fur-skin and healthy meat. Thus, it faces a promising future for rabbit sector in China (Laping Wu et al. 2012).

Potential competitiveness of rabbit sector

The advantages of rabbit products

Rabbit meat is highly nutritious, which is characterized by high protein, low fat, low cholesterol, easy to digest. Therefore, consumers praise rabbit meat as the meat of health, the meat of longevity. The annual per capita consumption of rabbit meat is about 3-5 kg in developed countries such as France, Italy, Spain, while the annual per capita consumption of rabbit meat in China is less than 1/10 of above countries. It can be found that there is huge space for rabbit sector; The rabbit can be prepared to make fur and leather, especially the Rex rabbit fur is short, fine, dense, flat, aesthetic and firm, its fur length is only about 1.6 cm. With bare bristle, neat hair, more than 20 kinds of color type, pure and shiny color, the tanned fur is soft and elastic. The fur clothing, hats, vests, shawls, gloves and other clothing have huge market. The rabbit fur is a kind of up-market raw textile material, which is white, light, soft, warm, aesthetic, and thus are favored by more and more people both at home and abroad. The insulation properties of rabbit fur are 31.7% higher than wool, 90.5% higher than that of cotton.

Because of the advantages which rabbit products have, the rabbit sector is drawing more and more attention. Currently, the rabbit sector has become an important part of China's livestock industry.

Fast increase in rabbit productivity

From the view of farms, the production performance of the rabbit has developed fast. The slaughter age of China's commercial rabbit shortened from 90-100 days to 80-90 days; at the same time, slaughter rate improved from 48% to 51%, close to the level of developed countries in Western Europe; The rabbit wool productivity increased from 600 grams per head to 900 grams per head, the high-yield group produced more than 1500 g, the superior leather proportion of rabbit has also improved from less than 20% to 40%.

According to field research in 401 rabbit farms, each female rabbit gave birth to 32 rabbits. Although this number is less than that in developed countries, it has been greatly improved compared to the past. From the national point of view, the rabbit production level can be reflected by slaughter rate and meat yield rate. Figure 1 shows that the slaughter rate has been increasing year by year from 1985, rising from 0.714 in 1985 to 2.161 in 2010 and reached 2.325 in 2011. As can be seen, meat yield rate of rabbit has also been rising since 1985. Over past decade, due to diversification of rabbit farming and the increasing number of Rex rabbit, Angora rabbit and pet rabbit farming, the proportion of meat rabbit (mainly produce meat) is becoming smaller, and the growth of meat yield is becoming slow. Rabbit meat yield is about 1.505 kg meats in 2011, compared to 0.948 kg in 1985.

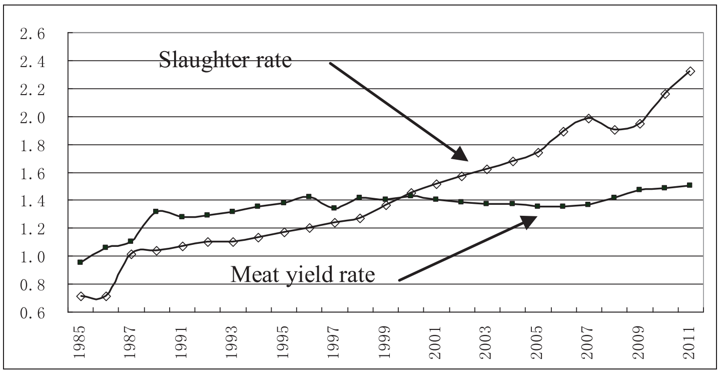


Figure 1. The rabbit slaughter rate and meat yield rate

Source: Calculated based on China Animal Husbandry Yearbook, Chinese Agricultural press

Revealed competitiveness of rabbit sector

Fast growth of rabbit meat output in China

Pork has been the dominated meat over the past several decades. The consumption of rabbit meat appears to be negligible when compared with pork. Rabbit meat output only accounts for 1% in the entire meat output in 2011. But the growth rate of rabbit meat is much higher than others, the output of rabbit meat surged from 406 thousand tons in 2001 to 731 thousand tons in 2011 (Table 1), with a growth rate of 80%, while the growth rate of pork, beef, mutton and poultry are respectively 24.7, 27.3, 44.6 and 41.2%. It's believable that the production and consumption of rabbit meat will continue to maintain fast growth due to the health awareness of consumer and market diversification.

High return of rabbit production

Comparing the cost of rabbit and other animal production (Table 2), it can be seen that the cost of rabbit is 2.24 $/kg, which is almost the same as hog (2.10$/kg), but lower than cattle (2.38$/kg) and sheep (3.15$/kg), only higher than broiler (1.65$/kg).

Profit-cost ratio is a key indicator to measure production effect. The Profit-cost ratio of rabbit in 2013 is 30.11%, which is only lower than 32.22% of hog, but higher than 28.57% of cattle, 22.12% of sheep and 12.54% of broiler. If taking the subsidies to hog production into consideration, the profit-cost ratio of rabbit should be the highest, which indicates that rabbit sector is the most attractive for farmers.

But so far, its potential advantages haven't become the real competitiveness. Rabbit meat production accounted for only about 1% of total meat output in 2011. The major reason is the constraint of processing and marketing, this need to do further research.

International competitiveness of Chinese rabbit sector

Rabbit meat production in China kept rising quickly in past two decades, which makes China a major rabbit producer in the world. The average annual rabbit meat output in China is 56,500 tons from 1978 to 1985, which maintains the stable share of 6-7% in the world market. In recent years, rabbit production in China ranked the first in the world, accounting for 45% of world total production. In addition, along with the increasing demand for processed products from rabbit, the trade on rabbit fur is also becoming increasingly active.

Table1. Meat output and growth rate from 2001 to 2011 (×100 tons)

Year	Pork	Beef	Mutton	Poultry	Rabbit meat
2001	4051.7	508.6	271.8	1210	40.6
2002	4123.1	521.9	283.5	1250	42.3
2003	4238.6	542.5	308.7	1312	43.8
2004	4341.0	560.4	332.9	1351	46.7
2005	4555.3	568.1	350.1	1464	51.1
2006	4650.5	576.7	363.8	1507	54.5
2007	4287.8	613.4	382.6	1448	60.2
2008	4620.5	613.2	380.3	1534	58.8
2009	4890.8	635.5	389.4	1595	63.6
2010	5071.2	653.1	398.9	1656	69.0
2011	5053.1	647.5	393.1	1709	73.1
Growth rate	24.7%	27.3%	44.6%	41.2%	80.0%

Source: China Rural Statistical Yearbook (various years), China Statistics Press

Table 2. Cost-benefit analysis of animal products in 2011 Kg, USD, %

Item	Rabbit (100 heads)	Hog (head)	Cattle (head)	Sheep (head)	Broiler (100 heads)
Product output (kg)	225.0	112.6	400.7	41.7	225.2
Total output value	656.4	312.5	1226.0	160.4	418.1
Main product value	647.5	310.2	1217.4	156.1	413.7
By-product value	8.9	2.3	8.6	4.4	4.4
Total cost (USD)	504.5	236.3	953.5	131.4	371.5
Material and services	438.0	218.8	863.4	93.6	346.8
Labor cost	57.5	17.1	89.9	37.8	23.8
Land cost	8.9	0.4	0.2	0.0	0.9
Profit (USD)	151.9	76.2	272.5	29.1	46.6
Average cost (USD)	2.24	2.10	2.38	3.15	1.65
Profit-cost ratio (%)	30.11	32.22	28.57	22.12	12.54

Source: Rabbit data from the estimation of survey data and also from National Agricultural Costs and Returns Series 2012

International competitiveness of rabbit products in China

There are different ways to calculate international competitiveness; the simplest and most intuitive one is market share (Lloyd & Toguchi 1996). International market share refers to the proportion of export value of one good of a country to the world total export of that good (Jensen et al. 1995; Klasra & Fidan 2004).

As can be seen from Figure 2, international market share of rabbit meat of China are all higher than 10%. It climbed from 11.65% in 2005 to 23.74% in 2011. The international market share of rabbit meat of China has risen from top 3 in 2006 to top one. Although there was a slight decline in 2010, it does not affect the position of the biggest rabbit products exporter. As the largest rabbit meat exporting country, France ever ranked at the top one with the market share of 18.85% in 2008 and had been declining since then, but still maintain the second position. The market share of Hungary had gone through a V-shaped period, gradually declined from 2006 to the trough in 2008, only ranked the fifth in the market with the share of 13.6%, then caught up and now at the fourth place.

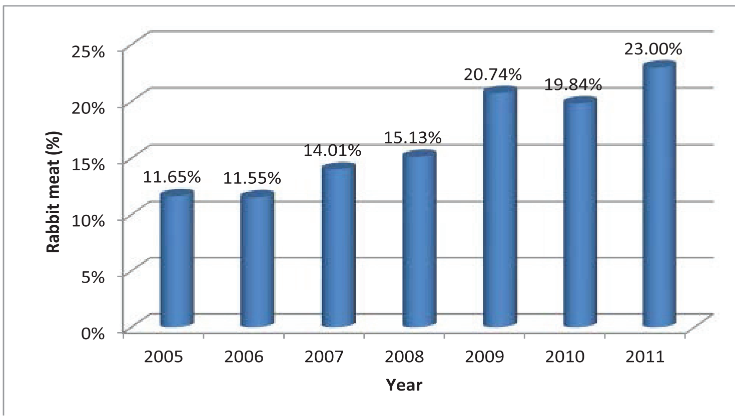


Figure 2. International market share of rabbit meat in China

Source: Uncomtrade (http://wits.worldbank.org/wits/)

Factors affecting the international competitiveness

Based on Michael Porter's Diamond Theory, the international industrial competitiveness of a country is mainly determined by four factors: First, production factor conditions, including both endowed factors (human resources, natural resources, capital and others) and developed factors by R&D investment; Second, related and supporting industries such as upstream rabbit breeding, feed mill and downstream processing etc.; Third, corporate strategy, structure and rivalry, such as marketing strategy, brand marketing etc. Fourth, demand situations, such as domestic demand. In addition, the role of government as well as opportunities also has significant influence (Michael 1990). Next part will mainly focus on production cost and demand to do detailed analysis.

Comparison between domestic and international cost

Firstly, feed cost. Based on the survey by us in 493 rabbit farms from 12 provinces in 2011, feed, labor, depreciation of fixed assets and death losses are major four parts of rabbit production costs, which respectively accounted for 69, 13.5, 5.1 and 4.9% respectively. The others only accounted for 7.4%. The biggest one is feed cost, which is close to 70% of total. It is obvious that feed cost will affect costs and benefits directly and significantly in different places. Limited to data, we use corn to represent for feed and average wage to represent labor cost to compare domestic and international production.

For corn cost, producer prices are collected from FAO database. As can be shown from Table 3, corn prices in each countries show fast growth from 2001 to 2010. Among them, United States and Argentina maintained low corn prices because they are major corn producing countries. However, China's corn prices has been higher than other countries, especially in 2006 it peaked at 252.1 U.S. dollars per ton, nearly twice higher than 93.3 U.S. dollars per ton in Argentina.

Thus, feed cost in China is lack of competitiveness, and China face big pressure on rabbit feed cost when compared to the main producing countries such as France, but with the gradual opening up of markets for agricultural products in China, the difference of corn price is shrinking gradually. Meanwhile, for many medium and small scale rabbit farms they often make full use of byproducts of agricultural production so as to save the use of feed grain, this can also save cost.

Secondly, Labor cost. Compared with other major countries, the labour cost in China is the lowest for many years (Table 4). However, due to the industrialization and urbanization, more and more rural labor migrate to urban area and find job in cities, this gradually raise the opportunity cost of rural labors. Rapid growth of labour intensive product export in past 10 years also greatly raised labour cost in China. Therefore, the gap between China and major countries are gradually narrowing, as shown in Figure 3.

Table 3. Corn price in major rabbit producer countries around world (USD/t)

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
China	155.9	146.2	213.8	189.7	189.2	252.1	193.4	218.3	243.0	273.3
France	94.7	93.5	149.0	116.2	128.6	164.9	256.7	180.6	175.4	251.7
Spain	122.1	128.9	167.0	182.8	168.2	190.7	280.3	266.6	200.3	240.5
Germany	103.7	101.6	141.1	170.3	119.6	164.5	260.4	193.4	154.2	227.6
Italy	124.5	120.8	152.9	179.5	156.6	168.4	262.8	273.8	182.4	220.9
USA	78.0	91.0	95.0	81.0	79.0	120.0	165.0	160.0	140.0	213.0
Hungary	68.5	82.7	133.8	116.1	108.8	124.7	249.5	174.0	145.4	181.4
Argentina	84.0	78.3	79.6	81.1	70.3	93.3	118.6	137.8	113.7	135.1

Source：FAO (http://faostat.fao.org/)

Table 4. Wage in major rabbit producing countries around the world Unit: USD/hour

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Argentina	0.98	0.99	1.02	1.16	1.44	1.74	2.22	-	-
Belgium	17.88	18.64	19.13	19.86	20.74	21.41	21.81	22.16	-
Canada	18.29	18.39	18.62	19.39	20.02	20.56	20.53	21.61	21.98
China	0.16	0.18	0.20	0.23	0.26	0.29	0.33	0.38	0.44
Czech	0.96	-	1.09	1.15	1.24	1.30	1.38	-	-
France	2.74	2.79	2.90	-	-	-	-	-	-
Hungary	0.56	0.64	0.72	0.79	0.86	0.93	0.99	1.08	1.16
Italy	15.08	11.89	12.33	12.40	12.90	13.60	13.70	14.87	14.54
Russian	-	-	-	-	-	0.40	0.48	0.61	0.76
Spain	13.39	13.95	14.63	15.34	16.01	16.54	17.21	17.81	18.74
USA	14.32	14.76	15.29	15.74	16.14	16.56	16.81	17.26	17.74

Source: International Labor Organization

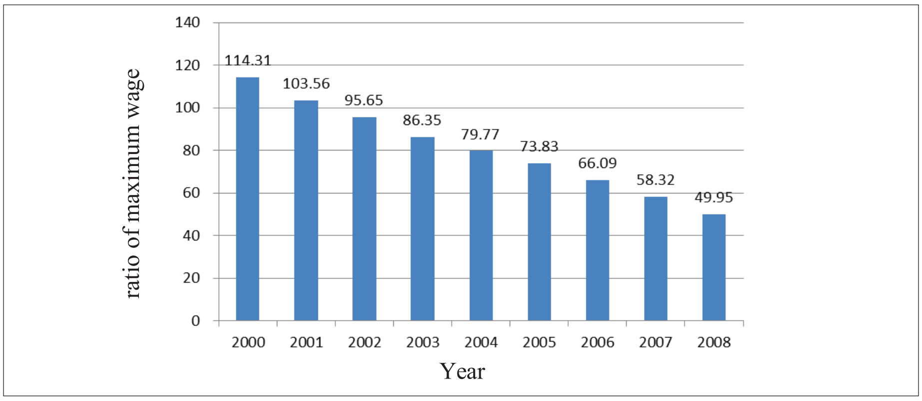


Figure 3. The ratio of maximum wage in major producer countries to that in China

Source: International Labor Organization

Price comparison

The cost difference will be eventually reflected in the price. In this part, we will analyze the prices of live rabbit and rabbit meat in domestic and international markets.

Firstly, live-rabbit price is a direct and important indicator to reflect the international competitiveness. This paper compares consumer prices from FAO database (Table 5) among major countries, it shows that live rabbit price from major rabbit producing countries such as China, France, Italy, Hungary has been increasing steadily from 2000 to 2010, except in 2009.

From the horizontal comparison among major countries, the prices of live rabbits in China have been the lowest, only one-fifth of that in France, with significant advantage in price. Live rabbit prices in France from 2000 to 2010 are higher than all other countries, which is mainly due to the slowdown in rabbit production.

Secondly, rabbit meat price. Table 5 shows that rabbit meat prices in China have been lower than other countries from 1991 to 2010. In comparison, rabbit meat prices of Argentina in 2000 and 2001 are the maximum among major countries, while France took the top one place from 2002 to 2006, followed by Germany replacing French. Therefore, in the process of competing with major rabbit meat exporting countries, China has significant advantage in prices.

Table 5. Live rabbit and rabbit meat price in major producing countries Unit: USD/t

Country	1991	1995	2000	2001	2005	2006	2007	2008	2009	2010
Live rabbit price										
China	415	389	460	441	538	577	715	354	363	960
France	3068	2918	2135	2261	2905	2959	3096	3408	3231	3064
Hungary	1404	1353	1005	1178	1535	1464	1678	2001	1828	1838
Italy	3013	2128	1680	1752	2637	2857	2906	-	-	-
Spain	1902	1330	1033	1157	1429	2188	1995	2597	2451	2249
Rabbit meat price										
China	747	943	1060	962	991	1062	1226	924	952	1270
France	4091	3891	2846	3015	3873	3946	4128	4543	4265	4032
Hungary	2527	2435	1809	2121	2790	2663	2796	3335	3046	3063
Italy	4018	2837	1927	1915	2434	2496	3875	-	-	-
Spain	2881	2016	1566	1754	2165	2188	1995	2597	2451	2249

Source: FAO (http://faostat.fao.org/)

Market demand

Even though the demand for rabbit products in China is continuously increasing with the development of economy and increase in income, it is still relatively small when compared with other animal products. The demand is constrained by consumer's habits, limited rabbit sales channel and lacking of cooking skills. Consumers in Sichuan, Chongqing consume more rabbit meat, while in most other regions consumers do not have the habit.

As regard for marketing, the modern circulation, marketing strategy, network marketing and chain operations all are not developed. For example, there are significant differences between rabbit meat and other meat in marketing. During field research, we found that in the same wholesale market, the broiler can be split into dozens of varieties because of the mature market system, while rabbit meat is still mainly sold in the form of whole rabbit.

Related industries and corporate development are also lagged, the major reason is the small scale of production. Now rabbit production mode in China includes: (1) backyard small farming (yearly slaughtered rabbits below 10000). It is the major style of rabbit production, which can make full use of by production of agricultural production so as to keep low feed cost, but this extensive production also cause many disease so as to increase lose cost; (2) large and medium-scale farming (known as intensive farming, standardized farming, *etc*. yearly slaughtered rabbits above 10000 and below 100000), and (3) modern factory farming (yearly slaughtered rabbits above 100000). The first two styles account for major part in rabbit production, at least 70%.

The lagged slaughtering and processing technology of rabbit products is another constraint for industry development. Rabbit slaughter and processing in China is still the traditional manual ways by small slaughtering and processing enterprises, which cause low productivity and poor quality. For processing, it is mainly dominated by whole cut, frozen, cold meat, less deep processing, such as small bags sauce, stewed, smoked, cured, dried, cooked food packaging products. As for the tanning technology it also lags behind, which decline the competitiveness. Compare rabbit fur to other wool fabrics, it is light, soft, warm, aesthetic and hygroscopic, but its pilling, lint and shrinkage are worldwide problems, which limited the expansion of markets.

In general, the shorter the industrial chain is, the more difficult to generate value-added. At present, rabbit meat trade in China is mainly primary products such as live rabbit. What is more, exported rabbit meat had only been simply slaughtered and processed. Primary products market is not conducive to long-distance transport, neither conducive to expansion of market. The rabbit sector is low value-added, especially the comprehensive utilization of rabbit (especially rabbit blood, internal organs, etc.) have not yet been solved. Hog, cattle, poultry processing technology has been developed, especially for poultry, while the emerging rabbit meat processing still need to be developed. This has caused low quality of rabbit meat, which in turn affects the development of rabbit sector.

CONCLUSIONS

Overall, compared with European countries, the rabbit sector in China is still in its early stages of development, but this also shows that the rabbit sector in China has huge potential.

For advantages of rabbit products, rabbit meat has incomparable nutritional advantages when compared with other meat products (pork, beef and sheep horse). From the perspective of rabbit technology and productivity, China has been achieving great progress. Therefore, among the domestic livestock industries, the rabbit sector has bright development prospects.

As to international competitiveness, rabbit stock in China accounted for more than 30% of world total in recent years, the rabbit slaughtered and meat output both account for more than 40% of world total, with meat output reached 45%. The exported rabbit meat from China accounted for more than 20% of world total export. The total trade of rabbit meat around the world is 43.0 thousand tons in 2011; the top five are respectively China, France, Belgium, Spain and Hungary, which accounted for 72.16% together, while China accounted for 23%.

Of course, there are certain challenges ahead of the rabbit sector of China, including rising resource costs, upgrading of the breeding patterns, technical progress, the less developed processing and marketing. All these require policy support from both central and local governments.

In 2013, China and Russia signed a memorandum of cooperation in rabbit sector. China gradually opened its door to the international market. It can be believed that the advantages of rabbit sector of China will be strengthened and rabbit sector will become highly competitive industry both at the quantity and quality sides since it has attracted more attention both from governments and consumers.

REFERENCES

Jensen HH,Voigt SW, Hayes DJ. 1995. Measuring international competitiveness in the pork sector. Agribusiness (New York). 11:169-177.

Klasra MA, Fidan H. 2004. Competitiveness and the trade of livestock products: a comparative study between Turkey and its neighbouring countries. J Applied Sci. 4:663–668.

Wu LP, Gu R, Li XF. 2012. The International Competitiveness of China’s Rabbit Sector. Paper presented at the 10th World Rabbit Congress. Held in Sharm El-Sheikh, Septembre 3-6, 2012. Sharm El-Sheikh (Egypt): World Rabbit Congress.

Lloyd PJ, Toguchi H. 1996. East Asian export competitiveness: new measures and policy implications. Asian Pacific Lit. 10:1-15.

Michael EP. 1990. Competitive Advantage of Nations. Harvard Bus Rev. March-April 73-91.

Single Nucleotide Polymorphisms in the Rabbit Toll-Like Receptor 4 Gene

Zhang Xy, Li CY, Zhang CX, Zheng J, Yang C, Li Q, Kuang LD, Ren YJ, Guo ZQ, Deng XD, Chen TB, Lei M, Huang DP, Xie XH

Research Institute of Rabbit, Sichuan Animal Science Academy, No. 7, Niusha Rd., 610066, Chengdu, China
Corresponding e-mail: *xiexiaohongL@sina.com*

ABSTRACT

TLR4 could detect Gram-negative bacteria by identifying lipopolysaccharide (LPS) or lipid A; therefore, we think that TLR4 is a significant candidate gene for rabbit diseases resistance research. In this study, we have detected the genetic polymorphisms of TLR4 of 13 meat rabbits of 4 different breeds. DNA samples of 13 unrelated rabbits from 4 breeds (New Zealand White, Californian, Flemish Giant and Fu Jian Yellow) were extracted from whole-venous blood and readily stored at -20°C. 4 were Californian, 4 were Fu Jian Yellow, 3 were New Zealand White, 2 were Flemish Giant. Comparative sequence analysis indicated that 6 SNPs were identified, 5 of which were non-synonymous SNPs. Four nonsynonymous SNPs (G563A, G628T, A653C and A654C) were located in the LRR domains of the predicted protein. The nonsynonymous SNPs in the LRR domains, especially related to leucine residues, may dramatically alter the ability to identified extracellular pathogens. Besides, it is possible that these replacements in amino acids in TLR4, which change the amino acid characteristics, will change their extracellular pathogen recognition capabilities. The identification of these polymorphisms reported here increases the resource of genetic markers useful for mapping and association analyses with disease resistance. And the future researches are needed to survey any potential associations.

Key Words: Toll-like Receptors, Single Nucleotide Polymorphism (SNP), Innate Immunity, Rabbit

INTRODUCTION

Toll-like receptors (TLRs) play important roles in recognizing "pathogen-associated molecular patterns (PAMPs)" of pathogens (such as viruses, bacteria and fungi). They may also initiate the early immune response in both innate and acquired immunity (Vasselon & Detmers 2002). TLR4 can identify various pathogenic microorganism components, induce the natural immunity and acquired immunity reaction of organism. TLR4 gene variance might influence the function of combining receptor with ligand and signal transduction capacity after combining with ligand, having an important influence on the pathogen recognition and disease resistance of the organism (Uenishi & Shinkai 2009). Researches indicate that there is a association between TLR4 gene polymorphism and inflammatory response to the host and susceptibility to the infectious diseases (Sharma et al. 2006). TRL4 is one of the important members of TLRs, belonging to cell-surface TLR with structure divided into extracellular region, transmembrane domain and intracellular region. There are 18-31 leucine-rich repeats (LRRs), while extracellular region is composed of Tolhomology domain (TH domain), and oll/L-1-receptor homologous region (TIR).

There have been more reports on research of correlation between cattle TLR4 gene structure and its polymorphism and mastitis, TLR4 might play an important role in the response reaction of host to the intramammary infection (Werling et al. 2004; White et al. 2003). Researches on human diseases show that there is a significant correlation between TLR4 polymorphism and disease of digestive system and respiratory system (Lien et al. 2002). One case-control study demonstrates that there are associations between polymorphisms of TLR4 of the rabbit and susceptibility of digestive disorders. In this study, we have detected the genetic polymorphisms of TLR4 of 13 meat rabbits of 4 different breeds.

MATERIAL AND METHODS

DNA samples and extraction

DNA which was extracted from muscle of a New Zealand White buck was used for primer optimization and identification of amplicon sequence could be identified via BLAST. Additional rabbit DNA samples of 13 unrelated rabbits from 4 breeds (New Zealand White, Californian, Felmish Giant and Fu Jian Yellow) were extracted from whole-venous blood and readily stored at -20. 4 were Californian, 4 were Fu Jian Yellow, 3 were New Zealand White, 2 were Flemish Giant. Genomic DNA was extracted using a Universal Genomic DNA Extraction Kit (TaKaRa, Dalian, China) according to the manufacturer's instructions.

PCR and sequencing

The coding sequence (CDs) of the TLR4 gene (NM_001082732) was used to design the PCR primers. Four PCR primer pairs that produced overlapping fragments within CDS of the TLR4 gene were designed using the Web interface for Primer3 (http://frodo.wi.mit.edu/primer3). PCR primers for amplification are presented in Table 1. All PCR amplicons were visualized via agarose electrophoresis and subsequently purified using the QIAquick PCR Purification Kit (Qiagen, Inc., Valencia, CA, USA) according to the manufacturer's recommendations. The PCR amplicons purified were sequenced using an ABI 3730XL sequencer (Applied Biosystems, Foster City, CA, USA).

Date from automated sequencers generally have low quality data which may include miscalled bases at the each side of the sequence. Sequence quality was evaluated by Sequencher4.7 (Gene Codes, Ann Arbor, MI, USA). Then, the low quality data at the ends of the sequence were trimmed by Sequencher4.7. Each sequence from a single DNA sample was assembled to generate a consensus sequence for that DNA sample and to detect polymorphisms within the sample. Sequencher 4.7 provided an overview of the differences with the same contig relative to a selected Reference Sequence. These differences could be candidate SNPs. The SNPs were automatically detected using Sequencer 4.7 and each of them was verified by manual identification of the chromatograms. All heterozygous nucleotides were annotated with the appropriate IUPAC-IUB code.

RESULT AND DISCUSSION

To identify nucleotide polymorphisms we designed primer pairs that amplified reciprocally overlapping fragments (Table 1). We obtained 4 fragments by PCR, and the length of these amplicons was 612-722 bp. Using these primers, 2080 bp corresponding to rabbit TLR4 were detected for 4 rabbt breeds and compared to the matched rabbit TLR4 reference sequences (NM_001082781). We detected 6 SNPs, of these, 83% (n = 5) were nonsynonymous SNPs, 17% (n = 1) were synonymous SNPs. Of the 6 SNPs, 50% (n = 3) were transitions (A ↔ G; C ↔ T) and 50% (n = 3) were transversions. In fact, the rate of occurrence (bp/ polymorphism) of nonsynonymous SNPs and synonymous SNPs in the coding sequence (CDS) were 416 and 2080, respectively. The genomic positions of all SNPs, SNP genotypes and amino acid positions are also provided in Table 2. Nonsynonymous SNPs were identified within most major protein domains predicted for rabbit TLR4, with predicted amino acid replacements observed within the LRR domains.

Table 1. PCR primers for amplification of rabbit TLR4

Fragment nos.	Forward primer(5′-3′)	Reverse primer (5′-3′)	Fragment size (bp)
1	tgtggcccataatcttatcca	cacctttgttggcagtgaaa	626
2	caaccaagaaatttttcctaaaga	gactccagtctggggagtga	612
3	atgctttccaggacaacagg	ttctcacccagtcctcatcc	621
4	tgtgcatcacacctccaaat	ggaagcccctcaggagtatt	722

Detection of polymorphisms

Table 2. Distribution of single nucleotide polymorphisms (SNPs) among 13 individuals from 4 rabbit breeds

Alleles[a]	Genomic Position[b]	Amino acid Position[c]	Amino Acid[d]	Character	(SNP genotype) rabbit breed[e]	Domain
G/A	563	188	S/N	-	R	LRR
G/T	628	210	A/S	Nonpolar/Polar	K	LRR
C/A	653	218	P/Q	Nonpolar/Polar	M	LRR
C/A	654	218	P/Q	Nonpolar/Polar	M	LRR
G/A	757	253	E/K	Anionic/Cationic	R	None
G/A	1095	365	R/R	-	R	None

[a]The NM_001082732 allele depicted in bold, underlined text
[b]Genomic position based on the first base of the start codon
[c]Amino acid position based on the start codon
[d]Amino acid(s) encoded by the alleles, with predicted amino acid replacements
[e]Heterozygous SNP genotypes are depicted using the IUPAC codes for heterozygosity

One nonsynonymous SNP that changed the charges on the amino acids was identified at bases 757 in TLR4. Moreover, polar changes of substitutions in amino acids was detected at bases 628, 653 and 654 in TLR4. It is possible that these replacements in amino acids in TLR4, which change the amino acid characteristics, will change their extracellular pathogen recognition capabilities. Furthermore, amino acid replacements that induce a subtle change of the amino acid characteristics might influence on the resistance to diseases. For example, A nonsynonymous SNP at A1775G (amino acid N592S) in human TLR5 is significantly associated with resistance to Legionnaires'disease (Hawn et al. 2003).

TLRs play critical roles in identification of invading PAMPs in host (Janeway Jr & Medzhitov 2002), with recent study providing further evidence for this conclusion in domestic animals (Bochud et al. 2007;). We detected 6 SNPs in rabbit TLR4, we anticipated that these SNPs attribute resistance to infection with particular pathogens. Polymorphisms in the sequences encoding the regions might have allowed TLR4 to adapt to various kind of PAMPs derived from the rapid mutations of microbes. The polymorphisms of the rabbit TLR4 gene indicated that SNPs were mainly located in the sequences encoding the ectodomains of TLR4. The comparison of the distribution of SNPs in the coding sequences of TLR genes in pigs, cattle, and humans showed that the nonsynonymous SNPs were mainly located in the sequences encoding ectodomains-especially the sequences encoding LRRs (Sherry et al. 2001; White et al. 2003; Shinkai et al. 2006).

The sequences encoding ectodomains of TLR4 played an important role in the recognition of pathogen associated molecular patterns. Polymorphisms in the sequences encoding ectodomains which involved in pattern recognition may improve the ability for recognition to various kinds of PAMPs originated by the rapid evolution of pathogeny. Nonsynonymous substitutions in the region directly binding to ligands may improve host immunity, thus, may increase the survival of the population (Carrington et al. 1999). It is generally known that the mutation of TLR4 coding sequences is likely to change the structure of protein encoded. And then, the structural alteration affects the function of identification. The nonsynonymous SNPs in the LRR domains, especially related to leucine residues, may dramatically alter the ability to identified extracellular pathogens (Fujita et al. 2003). The nonsynonymous SNPs which modified the amino acid polarity in rabbit TLR4 may affect binding to ligands. Furthermore, amino acid substitutions that alter the amino acid polarity might also impact the host immune responses and resistance to diseases. Three SNPs which changed the polarity of the amino acid residue were detected in rabbit TLR4. There were characteristic polymorphisms, such as G628T, C653A, C654A and G757A in TLR4. G628T, C653A and C654A, which located within the LRR domains predicted, might have a functional effect on rabbit TLR4, such as ligand recognition. However, some SNPs have been found in human's TLR4, most of which are unfavorable to the individual diseases-resistance (Smirnova et al. 2001). TLR4 identifies the target molecules by the combined action of such adaptor proteins as CD14 and MD-2. The structural changes of extracellular region caused by mutation might have disadvantageous effects to the interaction between TLR4 and the adaptor proteins.

TLR4 recognizes molecules generated by Gram-negative bacteria. TLR4 plays a role in the recognition of various molecules, such as lipopolysaccharide (LPS) and lipid A. C3H/HeJ strain mice have a high tolerance to lipopolysaccharide (LPS), while C57BL/10ScCr strain wild mice are highly susceptible to Gram-negative bacterial infection, the former is a missense mutation resulting from the transformation of an amino acid from proline to histidine caused by a point mutation in TRL4 gene cytoplasm area, while the latter is defected in TRLS, indicating that TLR4 gene is the key point of LPS signal transmission (Poltorak et al. 1998). There is a correlation between TLR4 polymorphic site and infection of Pasteur pneumococcal. A study indicated that mutation of TLR4 protein site 259 associated with respiratory syncytial virus (RSV), the two haplotypes of TLR4 are also correlated with the infection of RSV (Puthothu et al. 2006). In addition, TLR4 gene is related with the diseases generated by sepsis, systemic lupus erythematosus, rheumatic arthritis, asthma etc. and microbial infection such as enteritis (Beuder 2002). Studies on association between TLR4 gene polymorphism (Asp299Gly and Thr399Ilen) and gastritis showed that TLR4 gene Thr 399 Ileu polymorphic site might be a pathogenic factor for gastritis, TLR4 gene might be related with chronic inflammation (Achyut et al. 2007).

At present, in TLR4 gene coding sequence, the polymorphisms of two mononucleotides Asp299Gly and Thr399Ile were researched most and it has been demonstrated that they were closely related with infectious diseases. The mutation of TLR4 allele Asp299Gly may increase the susceptibility of group to Gram-negative bacteria. It is generally believed that Asp299Gly and Thr399Ile of TLR4 associate with the inflammatory reaction. TLR4 allele polymorphism Asp299Gly is related with the susceptibility of Gram-negative bacteria and sepsis, the carriers of this site are easier to infect Gram-negative bacteria and suffer from sepsis and the death rate is extremely high (Lorenz et al. 2002). The gene knockout mice experiment demonstrated that both TLR4 and MyD88 participated in the pathological process of atherosclerosis and there exists a correlation between Asp299Gly and atherosclerosis (Bjorkbacka et al. 2004; Michelsen et al. 2004). Further research indicated that compared with Thr399Ile, Asp299Gly might be easier to influence the function of TLR4 (Arbour et al. 2000).

CONCLUSION

Our work is aimed to identify the polymorphisms of rabbit TLR4 gene so as to provide ideal candidate polymorphisms for the next association analysis and signal transduction research. Finally, 6 SNPs were detected. The identification of these polymorphisms reported here increases the resource of the genetic markers useful for mapping and association analyses with disease resistance. Further researches are needed to survey any potential associations, but these nonsynonymous SNPs are the best candidates to conduct such studies.

REFERENCES

Achyut BR. 2007. Association of Toll-like receptor-4 (Asp299Gly and Thr399Ileu) gene polymorphisms with gastritis and precancerous lesions. Hum Immunol. 10:1-7.

Arbour NC, Lorenz E, Schutte BC, Zabner J, Kline JN, Jones M, Frees K, Watt JL, Schwartz DA. 2000. TLR4 mutations are associated with endotoxin hyporesponsiveness in humans. Nat Genet. 25:187-191.

Beuder B. 2002. Toll-like receptors:how they work and what they do. Curr Opin Hematol. 9:2-10.

Bjorkbacka H, Kunjathoor VV, Moore KJ, Koehn S, Ordija CM, Lee MA, Means T, Halmen K, Luster AD, Golenbock DT. 2004. Reduced atherosclerosis in MyD88-null mice links elevated serum cholesterol levels to activation of innate immunity signaling path ways. Nat Med. 10:416-421.

Bochud PY, Hersberger M, Taffé P, Bochud M, Stein CM, Rodrigues SD, Calandra T, Francioli P, Telenti A, Speck RF, Aderem A. 2007. Polymorphisms in Toll-like receptor 9 influence the clinical course of HIV-1 infection. AIDS. 21:441-446.

Carrington M, Nelson GW, Martin MP, Kissner T, Vlahov D, Goedert JJ, Kaslow R, Buchbinder S, Hoots K, O'Brien SJ. 1999. HLA and HIV-1: heterozygote advantage and B*35-Cw*04 disadvantage. Science. 283:1748-1752.

Fujita M, Into T, Yasuda M, Okusawa T, Hamahira S, Kuroki Y, Eto A, Nisizawa T, Morita M, Shibata K. 2003. Involvement of leucine residues at positions 107, 112, and 115 in a leucine-rich repeat motif of human Toll-like receptor 2 in the recognition of diacylated lipoproteins and lipopeptides and *Staphylococcus aureus* peptidoglycans. J Immunol. 171:3675-3683.

Hawn TR, Misch EA, Dunstan SJ, Thwaites GE, Lan NTN, Quy HT, Chau TTH, Rodrigues S, Nachman A, Janer M, Hien TT. 2003. A common dominant TLR5 stop codon polymorphism abolishes flagellin signaling and is associated with susceptibility to legionnaires' disease. J Exp Med. 198:1563-1572.

Janeway Jr. CA, Medzhitov R. 2002. Innate immune recognition. Annu Rev Immunol. 20:197-216.

Lien E, Ingalls RR. 2002. Toll-like receptors. Crit Care Med. 30:1-11.

Lorenz E, Mira JP, Frees KL, Schwartz DA. 2002. Relevance of mutations in the TLR4 receptor in patients with gram-negative septic shock. Arch Intern Med.162:1028-1032.

Michelsen KS, Wong MH, Shah PK, Zhang WX, Yano JL, Doherty TM, Akira S. Rajavashisth TB, Arditi M.. 2004. Lack of Toll-like receptor 4 or myeloid differentiation factor 88 reduces atherosclerosis and alters plaque phenotype in mice deficient in apolipoprotein E. Proc Natl Acad Sci USA. 101:10679-10684.

Poltorak A, Smirnova. 1998. Defective LPS signaling in C3H/HeJ and C57BL /10Sc crmice: Mutations in TLR4 gene. Science. 282:2085-2088.

Puthothu B, Forster J, Heinzmann A, Krueger M. 2006. TLR4 and CD14 polymorphisms in respiratory syncytial virus associated disease. Dis Markers. 22:303-308.

Sharma BS, Leyva I, Schenkel F, Karrow NA. 2006. Association of toll like receptor 4 polymorphisms with somatic cell score and lactation persistency in Holstein bulls. J Dairy Sci. 89:3626-3635.

Sherry ST, Ward MH, Kholodov M, Baker J, Phan L, Smigielski EM, Sirotkin K. 2001. dbSNP: The NCBI database of genetic variation. Nucl Acids Res. 29:308-311.

Shinkai H, Tanaka M, Morozumi T, Eguchi-Ogawa T, Okumura N, Muneta Y, Awata T, Uenishi H. 2006. Biased distribution of single nucleotide polymorphisms (SNPs) in porcine Toll-like receptor 1 (TLR1), TLR2, TLR4, TLR5, and TLR6 genes. Immunogenetics. 58:324-330.

Smirnova I, Hamblin MT, McBride C, Beutler B, Di Rienzo A. 2001. Excess of rare amino acid polymorphisms in the Toll-like receptor 4 in humans. Genetics. 158:1657-1664.

Uenishi H, Shinkai H. 2009. Porcine Toll-like receptors: The front line of pathogen monitoring and possible implications for disease resistance. Dev Comp Immunol. 33:353-361.

Vasselon T, Detmers PA. 2002. Toll receptors: a central element in innate immune responses. Infect Immun. 70:1033-1041.

Werling D, Hope JC, Howard CJ, Chris J, Jungi TW. 2004. Differential production of cytokines, reactive oxygen and nitrogen by bovine macrophages and dendritic cells stimulated with toll-like receptor agonists. Immunology. 111:41-52.

White SN, Kata SR, Womack JE. 2003. Comparative fine maps of bovine toll-like receptor 4 and toll-like receptor 2 regions. Mammal Genome. 14:149-155.

White SN, Taylor KH, Abbey CA, Gill CA, Womack JE. 2003. Haplotype variation in bovine Toll-like receptor 4 and computational prediction of a positively selected ligand-binding domain. Proc Natl Acad Sci. 100:10364-103649.

Effect of the Different Dressing Procedures and Tanning Methods on Breaking Strength of Rabbit Hair

Lian W[1], Fanhua W[1], Yao L[2], Zongcai Z[2]

[1]*Key Laboratory of Leather Chemistry and Engineering of Ministry of Education, Sichuan University*
[2]*National Engineering Laboratory for Clean Technology of Leather Manufacture*
Sichuan University, Chengdu 610065, PR China
Corresponding e-mail: zhang508@scu.edu.cn

ABSTRACT

Hair keratin is a type of keratin that is a structural protein found in hair and nails. A mass of chemical reagent are used for different processes and tanning methods, including acid, alkali and oxidizing agent and reducing agent, which can react with keratin, consequently, altering the structure of hair. This article measures the breaking strength and breaking elongation rate of rabbit hair by different processing procedures and tanning methods. The results show that the different processing procedures reduced the breaking strength of rabbit hair. The extent of the devastation was different from the procedures. Bating and pickling process was the most important effect. The different tanning methods could improve the breaking strength of guard hair. The effect of chrome tanning and fatty aldehyde tanning was significant. Subsequently these results provide a theoretical basis for effective modification to rabbit hair, which could help to reduce the damage to hair during tanned process.

Key Words: Process; Tanning; Rabbit Hair; Breaking Strength

INTRODUCTION

With the rapid development of rabbit industry in China, the major processing and utilization of rabbit skins have become more economically important. The rabbit skins is a kind of advanced natural animal fiber, with the white, soft, smooth, breathable, moisture absorption, insulation and other excellent characteristics, which is one of precious animal fiber in Chinese unique (Liu 2005). As its softness and good appearance, rabbit skins used to make hats, bags, gloves, scarf, collar and the coat of children and women, which get the favour of people. However, during the processing of rabbit skin, including traditional soaking, degreasing, bating, picking and tanning *etc*., addition of the chemical and mechanical factors will cause the rabbit hair shedding from skin plat easily. Especially in the softening and picking process, the acid and enzyme have different degree effects on fastness and fiber strength of hair and skin plate. The fiber fracture of rabbit hair is also affected by absorbent, the elongation at break of guard hair of rabbit was declined compared to the dry one (Xi et al. 2005).

Rabbit hair is composed of hair keratin, which is one of the important structural proteins. There are two types of hair keratin: the acidic type I hair keratin and the basic type II hair keratin (McKittrick & Chen 2012). It is well known that proteins could react with acid, alkali and oxidizing agent. Low concentration acid mainly affect salt bond, but do not damage chemical structure and physical properties of hair. However, high concentration acid may hydrolyze peptide bond, along with reducing the mechanical strength of keratin (Xu et al. 2009). Because of alkaline can hydrolysis disulfide bond, alkaline will still further damage the keratin with temperature increasing and time extending. Reductant and oxidant, which can hydrolyze disulfide bond, will make keratin dissolved. A lot of experimental data indicate that one of the reasons regarding losing hair is rabbit hair breakage itself.

So far, domestic and international scholars have done few studies with broken-hair of rabbit. This paper investigated the effect of the different processing procedures and tanning methods on breaking strength of rabbit hair. Subsequently these results provide a theoretical basis for effective modification to rabbit hair, which could help to reduce the damage to hair during tanned process.

MATERIALS AND METHODS

Chemical reagent and materials

All chemicals used included: salt, soda ash, baking soda, formic acid, sulfuric acid, a preservative, formaldehyde, FB (a kind of fatty aldehyde from clariant company), alum, chromium salt, NM enzyme (used during soaking process), degreasing agent (JA-50 and TS-80), bating enzyme (ARS), and a wetting agent (HAC).

Dry-salted Sichuan rabbit skins which were bought from traditional agri-product market were chosen as raw material.

Equipment

A GI-heat pump cycle stainless steel control temperature drum (Wuxi Xinda light industry machinery limited company), fully-automatic flip oscillator (Changzhou Boke Test Equipment Institute), YG001A-electronic single fiber strength tester.

Methods and procedures

Two Sichuan rabbit skins of 6 × 12 cm were marked as 1# and 2#. All of them were kept as the original primary processing technology, including soaking, degreasing, bating and picking. The guard hair of the samples which were cut from rabbit skins by the end of each working procedure was put in the cool and ventilate place to make them dry naturally. Then the samples were transferred into YG001A-electronic single fiber strength tester to measure the breaking strength.

In Table 1, the conditions for the primary processing technology method for white rabbit skins are shown.

Table 1. The primary process for tanning rabbit skins

Processes	Materials	Amount	Temperature	Time (min.)	Remarks
Soaking					Dry-salted hide
	Water	1 : 20			
	Wetting agent HAC	0.5 g/l			
	Salt	25 g/l		30	
	Sulfuric acid	0.25 g/l			pH = 5~6
	NM enzyme	0.5 g/l		60	Run for 1 hour, over night, fleshing
Degreasing			35°C		
	Water	1 : 20			
	JA-50	1 ml/l			
	TS-80	3 ml/l			
	Soda	0.5 g/l		60	After running for 1 hour, washing
Bating and pickling			32°C		
	Water	1 : 20			
	Salt	60 g/l			Baume degree is 5~7
	Formic acid	3 ml/l		30	pH 3.0
	Bating enzyme ARS	0.5 g/l		120	Over night
	Formic acid	4 ml/l		30	
	Sulfuric acid	1 ml/l		60	pH 2.0, after running for 1 hour, over night

Cut the middle of the harvested acid skins to divide into four pieces. Eight samples obtained from cutting the two acid skins were divided into four groups, which were tanned by formaldehyde, formaldehyde-Al, chromium salt and FB-Al, being numbered 1 through 4, respectively. The guard hair of the samples which were cut from rabbit skins by the end of each working procedure was put in the cool and ventilate place to make them dry naturally. Then the samples were transferred into YG001A-electronic single fiber strength tester to measure the breaking strength.

YG001A-electronic single fiber strength tester was used to determine the breaking strength and elongation of guard hair. Control the clamping length 10 mm, and tensile rate 8 mm / min. Each sample was measured 12 times to retain average (Zhang 2000).

RESULTS AND DISCUSSION

The structure of rabbit hair

The large number of guard hair is distributed on the surface of rabbit skin. From hair root to top, guard hair coarsens and shapes a spindle structure. The special structure is one of the reasons that guard hair is easy to be broken.

Effect of the different processing procedures on breaking strength of rabbit hair

The properties including breaking elongation rate and breaking strength of the guard hair were tested under the different conditions. The results are shown in Figure 1 and Figure 2.

From Figure 1 and Figure 2, it is quite clear that breaking elongation rate ranged from 2.50 to 3.97, and variation range was small. With the machining processing, breaking strength of the guard hair had a sharp decreased. In addition, bating and pickling process was the most important effect. The PI of the Keratin is 5-7. In bating and pickling process, solution pH was 2.5-3. Acid could directly make the keratin disulfide bond and salt bond cleaved, which was one of the most important reasons that led to reduce the breaking strength of the guard hair. Acids tend to cause less damage to the keratin, under the condition of low concentration of acid and low temperature.

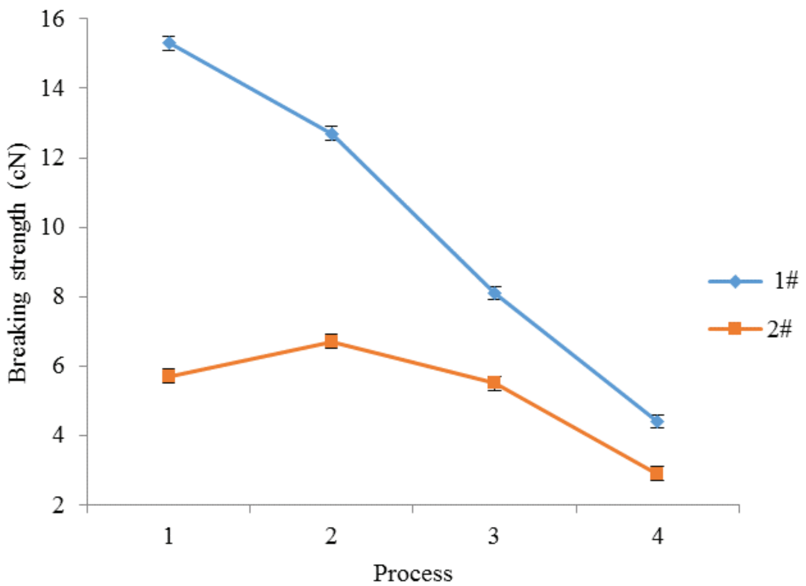
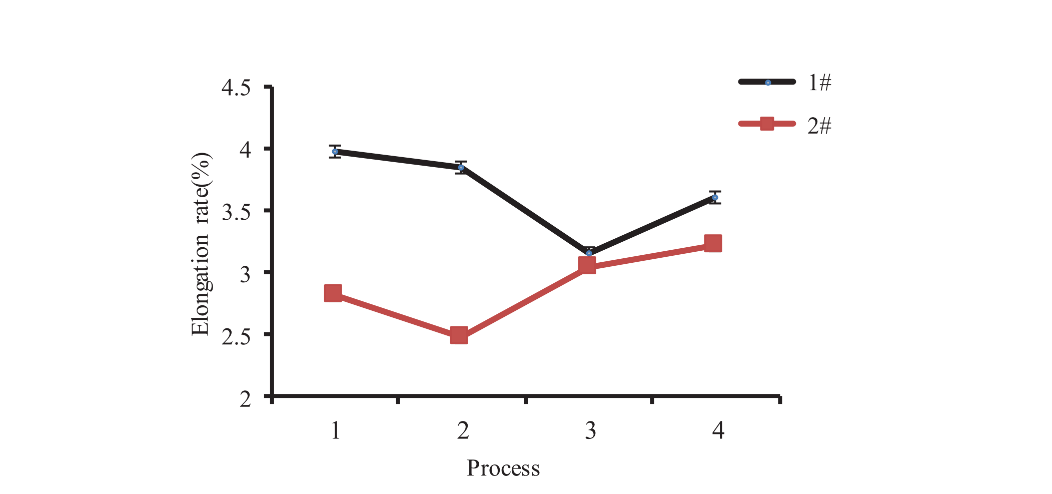


Figure 1. Effect of the different processing procedures on breaking strength of rabbit hair



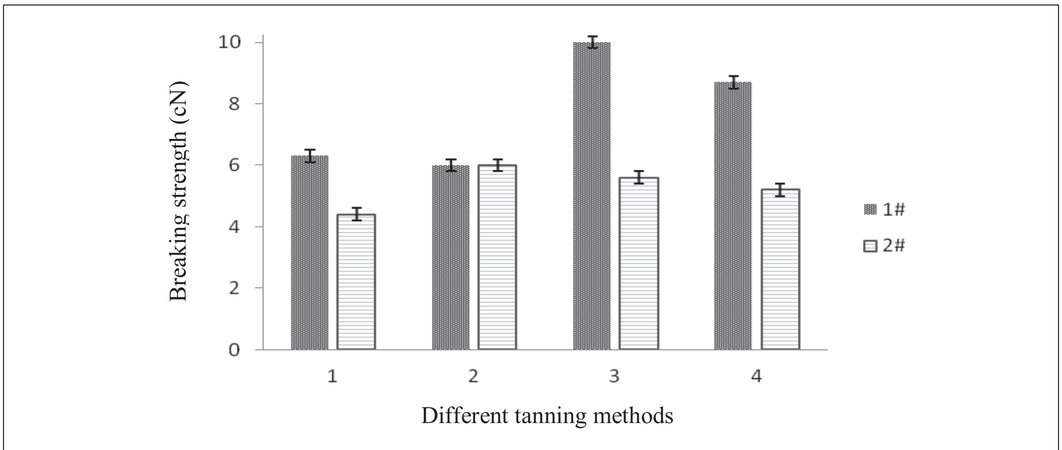
*The x axis from 1 to 4 stand for rabbit skins pre-treated by soaking, degreasing, bating and picking, respectively

Figure 2. Effect of the different processing procedures on elongation rate of rabbit hair

Thus, during the bating and pickling process, the temperature and the dosage of acid minimized to reduce the hair damage. Effectively manage function time which may reduce the damage. The numbers also demonstrate that individual difference existed in breaking strength. 1# was significantly higher than 2#. From soaking to pickling, breaking strength of sample 1# induced 10.9cN. Despite the extent of the decreased breaking strength of sample 2# was smaller than sample 1#, both of them could reflect that the different processing procedures reduced the breaking strength of rabbit hair.

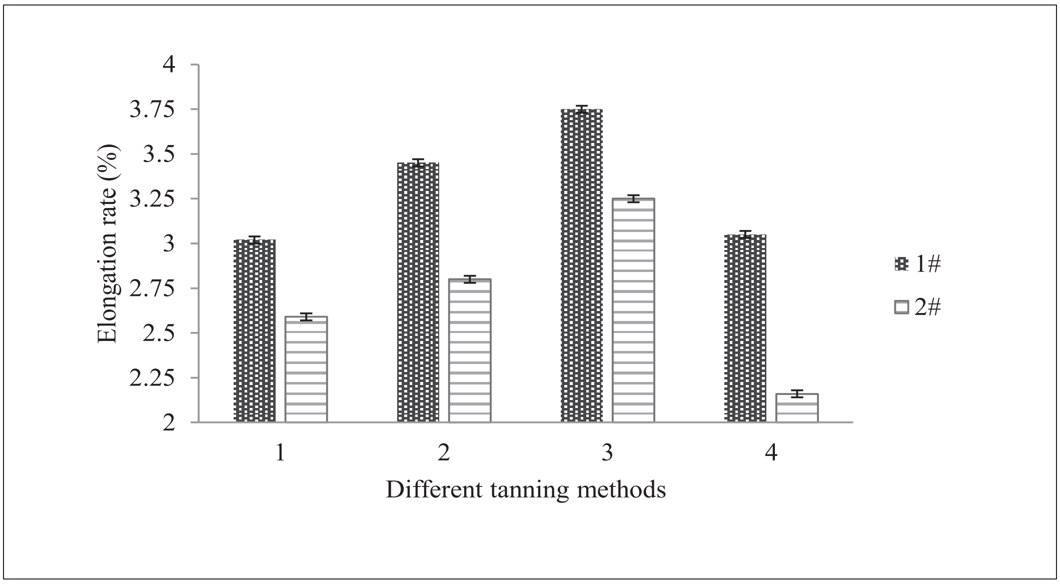
Effect of the different tanning methods on breaking strength of rabbit hair.

The properties including breaking elongation rate and breaking strength of the guard hair were tested under the different tanning methods. Results are shown in Figure 3 and Figure 4.



*The x axis from 1 to 4 stands for rabbit skins tanned by formaldehyde, formaldehyde-Al, chrome, FB-Al respectively

Figure 3. Effect of the different tanning methods on breaking strength of rabbit hair



*The x axis from 1 to 4 stands for rabbit skins tanned by formaldehyde, formaldehyde-Al, chrome, FB-Al respectively

Figure 4. Effect of the different tanning methods on elongation rate of rabbit hair

It can be clearly seen from Figure 3 and Figure 4 that breaking elongation rate of four tanning methods was controlled in certain scale. The results showed the significant differences among four tanning methods. When comparing Figure 1 with Figure 3, the breaking strength of all rabbit hairs was obviously improved after tanning. Chrome tanning and combination FB-Al tanning seriously increased the breaking strength of sample 1#, which was much higher than sample 2#. Although the breaking elongation rate exist obviously difference between the two skins, the changing trend is similar. Those results indicated that tanning process could improve the breaking strength of guard hair of rabbit. However, the breaking strength could not recover exactly to the beginning of fur wet-processing.

CONCLUSIONS

During rabbit wet processing, guard hair that was produced with the different processing procedures was broken. The extent of the devastation was different from the procedures. A very small amount of the chemical reagent which could react with keratin from soaking and degreasing made the degree of damage to the guard hair low. On the contrary, enzyme and acid from processes of bating and pickling did the large damage to guard hair.

The different tanning methods could improve the breaking strength of guard hair. The effect of chrome tanning and fatty aldehyde tanning was significant.

As a double-edged sword, the chemical reagent could be used to modify guard hair to reduce the damage.

REFERENCES

Liu J. 2005. Modification of rabbit hairs and its property analysis. J Tianjin Inst Text Sci Technol. 24:37-43.

McKittrick J, Chen PY. 2012. The structure, functions, and mechanical properties of keratin. JOM. 64:449-467.

Xi B, Caiqian Z, Zhichen H. 2005. Study on the effect of bio-enzymatic treatment on rabbit hair. Knitt Ind. 9:54-56.

Xu W, Jiang L, Li-fen H. 2009. Influencing factor of bating processing for rabbit skins. Leather Chem. 26: 4-6.

Zhang J. 2000. Mechanical properties of lyocell fibre. J Textile Res. 21:71-73.

A Rapid Method of Detecting *Pasteurella multocida* in Rabbits from Nasal Swabs Using PCR

Hojjat H, Parikh B, Grobner M

Department of Biological Sciences, California State University, Stanislaus
Corresponding e-mail:

ABSTRACT

Pasteurella multocida is a Gram-negative, non-motile, facultative anaerobic coccobacillus that is an important pathogen in rabbits. Current methods for detecting *P. multocida* infection in rabbits involves culturing nasal swabs on blood agar followed by biochemical analysis for definitive identification. PCR has been used to identify *P. multocida* from colonies grown on plates. A rapid PCR test involving direct PCR of nasal swabs was investigated. Nasopharyngeal cultures were streaked onto TSA with 5% sheep blood and incubated for 24 hours for biochemical identification of *P. multocida*. The swab was then digested in Buccal Amp® and extended using Brilliant® SYBR® Green QPCR Master Mix. We found a strong correlation between PCR positive and culture positive identification for *P. multocida*. PCR positive was indicated by a green florescence at 584 nm. while individual colonies were positive for a biochemical panel specific to *P. multocida*. Based on these data, we conclude that PCR of nasopharyngeal swabs can be used as a rapid, direct method for detecting *P. multocida*.

Key Words: *Pasteurella multocida*, Rabbits, Nasal Swab, PCR

INTRODUCTION

Pasteurella multocida is a Gram-negative, nonmotile, facultative coccobacillus bacterium of considerable historic, economic and scientific importance. In rabbits, *P. multocida* has been implicated in pneumonia, otitis media, conjunctivitis, pyometra, orchitis, abscesses and a generalized septicemia (Flatt & Weisbroth 1990). These diseases are collectively referred to as Pasteurellosis. Pasteurellosis is considered one of the most important diseases in rabbits and is a leading cause of mortality and morbidity. Carrier rates among adult rabbits range from 30-90% and it is generally agreed that *Pasteurella multocida* is universal among conventional rabbitries.

Current methods diagnosing pasteurellosis include nasal cultures, an ELISA (Enzyme-linked immunosorbent assay) test and the use of the Polymerase Chain Reaction (PCR) to detect DNA specific to *P. multocida*. Culture techniques entail taking a nasal or nasopharyngeal swabs and culturing on blood agar. After incubation for 24-48 hours, these cultures are examined for suspected colonies of *P. multocida*. Suspect colonies are re-plated to obtain pure cultures and these cultures are subjected to biochemical tests to identify *P. multocida*. Testing can take 72 or more hours from the receipt of the swab before a definitive diagnosis can be made. In cases where *P. multocida* is present in low numbers, culturing may fail to detect its presence.

In an attempt to overcome the limitations of culturing, an ELISA test (Enzyme-linked immunosorbent assay) was developed. The Elisa tests for the presence of antibodies to *P. multocida* in a blood sample taken from the animal to be tested. Infected animals will produce antibodies to *P. multocida* that can be detected in the blood. While this test greatly reduces the time involved in testing, ELISA tests tend to be expensive and require extensive training in the technique. Another drawback to the ELISA is that it only detects antibodies to *P. multocida* and doesn't tell if the animal is actively infected or merely expressing antibodies to a previous infection. In other words, a rabbit once exposed to *P. multocida* will carry antibodies even when the infection has passed.

The most recent addition to techniques for diagnosing infection by *P. multocida* is the use of the Polymerase Chain Reaction (PCR) to detect the presence of DNA from *P. multocida*. The use of PCR provides a definitive diagnosis. The current use of PCR entails nasal or nasopharyngeal cultures to isolate bacteria to be tested. The suspected bacterial colonies are subjected to PCR amplification, which will increase the copies of DNA from a pre-determined template. If *P. multocida* is present, the DNA will be amplified to a concentration that can then be detected when the DNA is separated using gel electrophoresis. While being extremely specific, the current use requires the initial culture and the running of gel electrophoresis to visualize the DNA.

In an attempt to speed up the diagnosis using PCR techniques, a direct amplification technique has been tested. This procedure involves the direct amplification of DNA from culture swabs, eliminating the need for pre-culture to obtain colonies for testing. This procedure will allow results to be obtained in a few hours as opposed to days.

METHODS AND MATERIALS

One hundred mature New Zealand White rabbits (*Oryctolagus cunniculus*) were cultured at random from a conventional rabbitry. Cultures were obtained by passing a Calgiswab Type 4 (calcium alginate swab) through the nasal passages to a depth of 4-5 cm (Figure 1). Swabs were immediately streaked onto trypticase soy blood agar containing 5% sheep blood and incubated in a 5% carbon dioxide atmosphere at 37°C for 24-48 hours. *P. multocida* was identified by standard biochemical characteristics. After steaking, the swabs were placed in 50 µl of Buccal Amp® (Epicentre) in 0.5 ml PCR tubes. Swabs were swirled in the Buccal Amp for 10 seconds and the tip of the swab was squeezed against the edge of the tube to extract as much of the supernatant as possible. Template DNA was prepared by digesting at 65°C for 10 min followed by a 3 min cycle at 98°C. PCR assays were run using 12.5 µl aliquots of template DNA in a 25 µl reaction volumes. Commercial mastermix (Brilliant® SYBR® Green QPCR, Strategene, La Jolla, CA) and commercially synthesized primers PM0762 and PM1231 (25 pmol each F/R) were used to amplify the DNA. DNA template amplification conditions designed for the primers and short double-stranded DNA amplification were run after a denaturing at 95°C for 10 min for 40 cycles of elongation of 95°C for 30 sec, annealing at 55-60°C for 1 min, and extending at72°C for 45 sec. Amplified samples were detected under UV light.

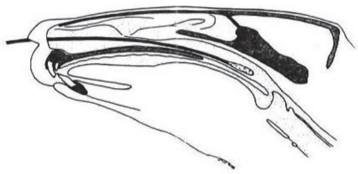


Figure 1. Illustration of the appropriate positioning of a calcium alginate swab for culturing the nasopharynx

RESULTS AND DISCUSSION

Results presented in Table 1 suggest that nasopharyngeal swabs can be used for direct detection of rabbits harboring *P. multocida* in their respiratory tracts. Nasopharyngeal cultures streaked on blood agar have shown to be 38% more effective in detecting carriers of *P. multocida* over conventional nasal cultures while ELISA results proved 20% more effective in detecting infection (Holmes et al. 1987). While ELISA is more effective, it has the disadvantage of being unable to detect active infections vs. previous exposed animals. The PCR of nasopharyngeal swabs was 45% more effective on initial culture at detecting infected animals. Those rabbits PCR positive and culture negative were recultured, and in all cases but one, *P. multocida* was isolated. The need for multiple cultures to find positive animals is eliminated using the PCR technique.

Table 1. Culture and PCR results for the detection of *Pasteurella multocida* in clinically normal rabbits

Position	Negative	Positive
Culture	22	78
PCR	40	60
*Total	40	60

*Total includes rabbits that were positive by culture, PCR or both

REFERENCES

Holmes HT, Matsumoto M, Patton NM, Harris DJ. 1987. A method for culturing the nasopharyngeal area of rabbits. Lab Anim. 21:353-355.

SOCIOECONOMIC, POLICY, AND POST HARVEST

Carcass and Non-Carcass Composition of Fryer Fattened with Pellets Containing of Bean Sprouts' Waste

Baihaqi M, Kurniawan Y, Rahayu S, Nuraini H

Department of Animal Production and Technology, Faculty of Animal Science, Bogor Agricultural University
Jl. Agatis Kampus IPB Darmaga 16680 Indonesia
Corresponding e-mail: haqi_nen@yahoo.com

ABSTRACT

Bean sprouts are vegetable that common as cuisine in some Asia countries. The product is made from the greenish-capped mung beans. The byproduct of bean sprouts process is commonly useless and disposed as waste. This research was conducted to study carcass and non carcass composition of local rabbit fryer fattened with feed containing of beans sprouts waste (BSW) for substitute commercial feed. Twelve kits were fattened for eight weeks with treatments of commercial feed (control), 15, 30 and 45% of BSW. The trials feed were blended with commercial feed and formed as pellets. The observed variables of carcass consist of slaughter weight, carcass percentage, weight and percentage of rabbit commercial cuts and non carcass components. The results showed that addition of BSW until 45% did not significantly affected on both carcass and non carcass composition (P>0.05). Weight and percentage of commercial rabbit cut carcass were also not significant in all commercial cut (foreleg, rack, loin and hind leg). Distribution of carcass components (muscle, fat and bone) were also not significantly among treatments (P>0.05). It could be concluded that bean sprouts' waste could be substitute commercial rabbit feed until 45% without decreasing carcass and non carcass quality.

Key Words: Rabbit, Bean Sprouts Waste, Carcass, Non-Carcass

INTRODUCTION

Bean sprouts are vegetable that is common in some Asia countries. The product is made from the greenish-capped mung beans. The byproduct of bean sprouts process is disposed as waste. Actually, the waste could be used as protein and fiber sources of feed for fattening sheep (Ifafah et al. 2011). Rahayu et al. (2010) reported that total bean sprouts' waste (BSW) in Bogor's traditional market reach until 1.5 ton/day. On the other hand, some limiting factors for smallholder farmer for raising rabbit are high mortality rate and poor management such as feed quality.

The utilization of BSW as protein source for local rabbit production was rarely found, although these byproducts have high protein content up to 13.63% of DM (Ifafah et al. 2011). Trocino et al. (2010) mentioned that the replacement of feed protein source did not affect on growth and carcass percentage of rabbit. Berchiche et al. (2000) used wheat by product up to 50% of the feed mix without detecting any significant reduction in growth performance of rabbit. Meanwhile, Lakabi-ioualitene et al. (2008) also reported that using wheat by product up to 67% did not affect rabbit carcass characteristic. The aim of this study was to use beans sprouts' waste (BSW) to substitute commercial feed on carcass and non carcass composition of local rabbit fryer.

MATERIAL AND METHODS

Animals and diets

The study was conducted in the Laboratory of Small Ruminant Production, Faculty of Animal Science, Bogor Agricultural University (IPB) Indonesia. Twelve kits age 12 weeks were fattened in individual cage until slaughtered for eight weeks. Four diets were formulated as follows: commercial feed (control/P0), 15% (P1), 30% (P2) and 45% (P3) substitution of BSW to commercial feed (Table 1). Each treatment had three replications. The BSW was blended with commercial feed and formed as pellets. *Ad libitum* water was allowed to all animals during treatments. Individual live weight and feed intake were recorded weekly.

Tabel 1. Chemical composition of experimental diets

Feed	Nutrient (%)					
	DM	CProtein	CFiber	CFat	Ash	NFE
BSW	22.91	14.73	42.27	0.11	3.09	39.80
P0	88.12	19.13	20.09	3.37	9.66	47.75
P1	85.82	17.94	25.08	2.71	9.02	45.25
P2	85.83	16.54	26.89	2.81	7.92	45.84
P3	84.76	15.95	30.49	1.13	7.03	45.40

BSW: Bran Sprout Waste; P0: control; P1: P0 + 15% BSW; P2: P0 +30% BSW; P3: P0 + 45% BSW

Carcass and non-carcass quality recording

The rabbits were slaughtered after eight weeks of experiment. Animals were fasted for seven hours before slaughtered. Slaughtering was done according to standard halal methods at the slaughter house plant in Laboratory of Small Ruminant, Department of Animal Production and Technology, Faculty of Animal Science, Bogor Agricultural University. Blood was collected, weighed and recorded as blood weight. After the animal was skinned off, the other parts of the body were weighed in hot condition before was chilled. Carcass was weighed and recorded as hot carcass weight. Dressing percentage was calculated from slaughter weight. After carcass was chilled at 5°C for 24 hours, the carcass was dissected and recorded for carcass tissue (muscle, fat and bone). The weight of the gastro-intestinal tract contents was estimated by subtracting the weight of the empty digestive tract from the weight of full gastro-intestinal tract. Empty body weight was calculated by subtracting the weight of gastro-intestinal contents from slaughter weight. The observed variables of carcass consist of slaughter weight, carcass percentage, weight and percentage of rabbit commercial cuts and non carcass components.

Statistical analyses

The data were analyzed using analyses of covariance (ANCOVA) (Steel & Torrie 1980). Slaughter weight was used as co variable for carcass and non carcass component. The GLM procedure by SAS was used.

RESULTS AND DISCUSSION

Growth performance

The average daily body weight gain of all animals in this trial was no significantly affected by different of feed regime (P>0.05) (Table 2). This means that the bean sprouts waste at ration 15, 30 and 45% resulted in similar daily weight gain rabbit with complete commercial rations. So that, the utilization of beans sprouts waste of 15, 30 and 45% in the diet did not negatively affect body weight gain of rabbits.

Table 2 shows that the average daily body weight gain of local rabbits in this study was relatively higher than the study conducted by Rasyid (2009), Gaol (2012) that resulted 13.88±1.60; 12.63±0.63 and 11.53±1.33 g/d, respectively. It means that the addition of BSW relatively produce high performance of rabbits.

Table 2. Daily body weight gain of rabbit

Treatment	BWG (g/d)
Commercial feed (P0)	17.14±1.45
Commercial feed + 15% BSW (P1)	12.14±5.16
Commercial feed + 30% BSW (P2)	17.40±0.70
Commercial feed + 45% BSW (P3)	14.21±4.62
P-value	0.40

Carcass and non carcass characteristics

Slaughter weight in this study was at an average of 1.78 kg. This weight was relatively small because this study used local rabbits that have small mature body weight. Table 3 shows that there is no significantly different of each trial on slaughter weight of local rabbit (P>0.05). Increasing percentage of BSW in diets did not affect rabbit performance either on carcass or non carcass performance. It can be assumed that the average composition of the experimental diet was not a limiting factor in the growth rate of local rabbits. Carcass percentage in this study relatively similar to study conducted by Farrel & Raharjo (1984) (46-50 vs 43-52%) but relatively higher than Sitepu (2001) (46 vs 41%). Carcass percentage is correlated with feed quality and intake (Cheeke et al. 1987).

Distribution of carcass components (muscle, fat, and bone) was also not significantly among treatments (P>0.05). Figure 1 shows that the average tissue composition of each feed trial statistically was not differ on muscle, fat and bone (P>0.05). Muscle ration in this study ranged between 69-71% of carcass. Nevertheless, rabbits fed by BSW tend to have more muscle and less fat. This experiment showed that commercial rabbit feed could be partially replaced by BSW without impairing growth performance and carcass composition.

Table 3. Carcass and non carcass characteristics of rabbit

Variable	Treatment				P-value
	P0	P1	P2	P3	
Slaughter weight* (kg)	1.68±0.09	1.62±0.09	1.82±0.11	1.80±0.12	0.49
Carcass weight** (g)	781.00±51.00	803.00±52.00	866.00±58.00	900.00±57.00	0.39
Non carcass weight** (g)	751.00±51.00	783.00±50.00	837.00±57.00	873.00±57.00	0.83
Carcass percentage (%)	46.10±2.50	49.10±2.50	47.50±2.80	50.40±2.80	0.73

* Data was corrected based on initial body weight at 1.06 kg
**Data was corrected based on slaughter weight at 1.78 kg. P0: Commercial feed; P1: Commercial feed+15% BSW; P2: Commercial feed+30% BSW; P3: Commercial feed+45% BSW

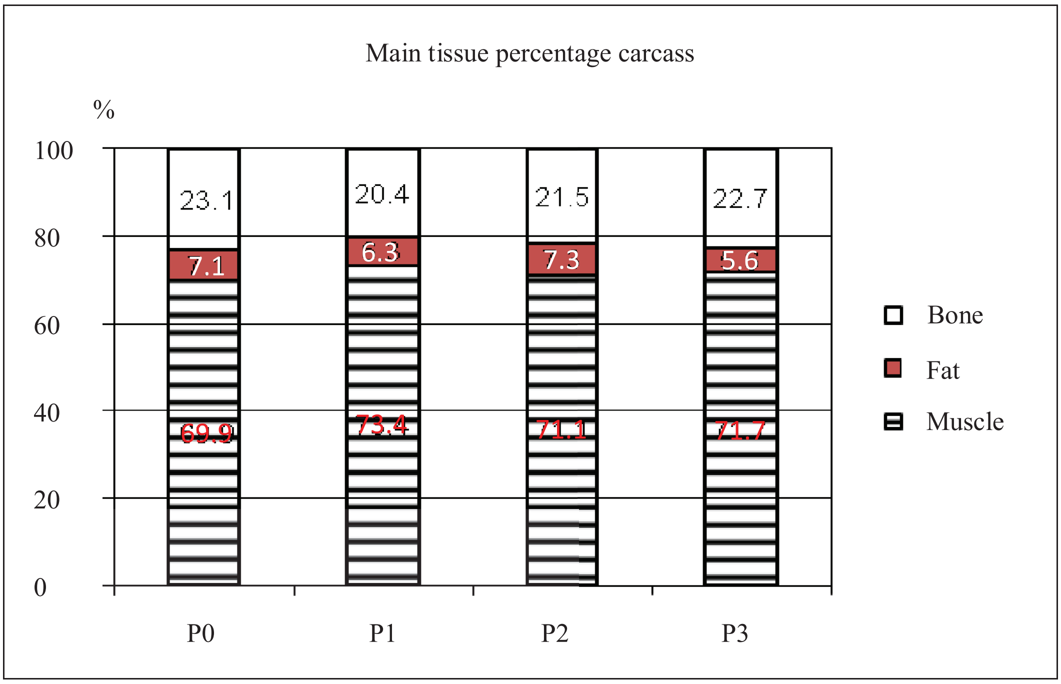


Figure 1. Tissue composition of rabbit carcass for each feed trials

CONCLUSION

Bean sprouts' waste could substitute commercial rabbit feed until 45% without decreasing carcass and non carcass quality. The daily body weight gain of local rabbit by its treatment reached 17.4 g/day with dressing percentage until 50% and muscle ration in carcass ranged between 69.9-73.4%.

REFERENCES

Berchiche M, Kadi SA, Lebas F. 2000. Valorisation of wheat by-products by growing rabbits of local Algerian population. Proceedings of 7th World Rabbit Congress. Valencia, Spain 4-7 July, 2000. Volume C. Valencia (Spain): World Rabbit Congress. p. 119-124.

Cheeke PR, Patton NM, Lukefahr SD, McNitt JL. 1987. Rabbit Production. 6th Ed. Danville (USA): The Interstate Printers and Publishers Inc.

Farrel DJ, Raharjo YC. 1984. The potential of rabbit for meat production. Bogor (Indonesia): Central Research Institute for Animal Science.

Gaol VMSL. 2012. Performa produksi kelinci lokal yang dipelihara pada jenis lantai kandang yang berbeda. [Skripsi]. [Bogor (Indonesia)]: Fakultas Peternakan Institut Pertanian Bogor.

Ifafah WW, Rahayu S, Diapari D, Baihaqi M. 2011. The utilization of bean sprout waste as a sheep feed in order to reduce waste pollution in Indonesian traditional market. In: Proceedings of the 18th Tri-University International Joint Seminar and Symposium. Jiangsu University, China, October 26-31, 2011. Jiangsu (China): Jiangsu University.

Lakabi-ioualitene D, Lounaouci-ouyed G, Berchiche M, Lebas F, Fortun-lamothe L. 2008. The effects of the complete replacement of barley and soybean meal with hard wheat by-products on diet digestibility, growth and slaughter traits of a local Algerian rabbit population. World Rabbit Sci. 16:99-106.

Rahayu SS, Wandito, Ifafah WW. 2010. Survey the potential availability of bean sprouts waste as an alternative fodder in Bogor. Research Report. Bogor (Indonesia): Faculty of Animal Science, Bogor Agricultural University.

Rasyid H. 2009. Performa produksi kelinci lokal jantan pada pemberian rumput lapang dan berbagai level ampas tahu. [Skripsi]. [Bogor (Indonesia)]: Fakultas Peternakan Institut Pertanian Bogor.

Sitepu R. 2001. The effect of banana peel as feed on local rabbit at 16 weeks of age. [Thesis]. [Medan (Indonesia)]: Faculty of Animal Science, North Sumatra University.

Steel RGD, Torrie JH. (1980) Principles and Procedures of Statistics: A Biometrical Approach. 2nd Edition. New York (USA): McGraw Hill Book Co.

Trocino A, Fragkiadakis M, Radaelli G, Xiccato G. 2010. Effect of dietary soluble fibre level and protein source on growth, digestion, caecal activity and health of fattening rabbits. World Rabbit Sci. 18:199-210.

Electric Stimulation of Rabbit Carcass Toward Meat Pshysical Characteristic on Various Aging Time

Suradi K, Yurmiati H, Mikusuma T

Faculty of Animal Husbandry, Padjadjaran University, Bandung, Indonesia
Corresponding e-mail: kusmajadi@gmail.com

ABSTRACT

Rabbit which was slaughtered at old age would produce less tender meat. Aging is one of the ways to increase meat tenderness and one of them is through electric stimulation The aim of this research is to know the effect of long aging of rabbit carcass which stimulated by electric on meat physical characteristics. The measured variables were pH, water holding capacity, cooking loss and tenderness. This research was done using 30 male Flemish Giant rabbits with the age of 1.5 years. Rabbit was slaughtered and the carcass was stimulated by electric. Then the carcass was kept at refrigeration temperature of aging for 0 hour (without aging as control), 2, 4, 6, 8, 10 hours as treatment in a Completely Randomized Design experiment with 4 replicates. The result of this research showed that the best physical characteristic (pH, water holding capacity, cooking loss and tenderness) was obtained in 10 hours aging.

Key Words: Stimulation, Aging, Physical Characteristics, Rabbit Meat

INTRODUCTION

Meat from older rabbit has lower tenderness than meat of younger rabbit. There are many ways to increase meat tenderness and one of them is through electric stimulation. It has been proved by Savell et al. (1977), that electric stimulation can increase tenderness of beef and lamb.

Tenderness is one of important physical characters of meat to determine meat quality. Tenderness has closely related with other physical characteristics of meat, such as pH, cooking loss and water holding capacity. Decrease speed of pH until the ultimate pH will affect rigor speed and release protease enzyme. This enzyme will break down meat protein which cause meat become tender and in the end will affect cooking loss and meat ability to hold water.

Physicochemical changing would on meat appear after slaughter, *e.g.* pre rigor, rigor mortis, and post rigor (Lawrie 1995). Pre rigor phase is the best meat condition to be consumed, because in this phase, meat still tender, but this phase was short as it is for several hours only. Meat would become tender again in post rigor phase. To reach this phase, and meat does not rot, it would be better to keep in low temperature which is called aging.

Meat aging right after slaughter will cause cold shortening, it is muscle shortening which cause meat become hard. This is happening because muscle is in pre rigor condition (Soeparno 2005). This situation can be avoided by fast meat refrigeration until 15°C, and maintained until it is in rigor mortis condition (Soeparno 2005).

Electric stimulation will speed up the process of glycolysis postmortem, which is happening during muscle conversion to meat, and it is accelerate pH decline. The best giving of electric stimulation was done on impulse 50 postmortem, indicated by significant decreasing of rabbit meat pH but if the given of impulse was increased to 75, it did not give a significant effect to decrease of rabbit meat pH (Yurmiati et al. 2010). It was the same with sheep carcass which was stimulated by electric, it will enter rigor mortis phase earlier and reached pH 5.7 in 3 hours (Pearson & Dutson 1985). Accelerate pH decline means broken troponin T and myosin component faster, so that neutral proteinase enzyme will inactive and cathepsin enzyme would be released by muscle lysozome, that tenderness will increase (Yates et al. 1983; Soeparno 2005).

Process of meat storage in long time at low temperature will cause more lactic acid, so that meat pH will be low and will increase the activity of proteolytic acidofilic enzyme from lysozome (Lawrie 1995). Therefore, long meat storage in low temperature must be noted in order that no damage by microbes occurred. Therefore, this aim of this research is to know the effect of aging time of rabbit carcass which was stimulated by electric on meat physical characteristics.

MATERIAL AND METHODS

The research was done in the laboratory using a completely randomized design with treatment of aging time 2, 4, 6, 8 and 10 hours and one without aging with 4 replications. Variables of physical characteristic that observed were pH, tenderness, water holding capacity, and cooking loss of rabbit meat.

Carcasses were produced by slaughtering rabbits using the Kosher method, followed by removal head, skin, internal organs, and lower legs. Carcasses were hung by the two back legs in a gallow. Electrical stimulation was applied by placing the positive electrode in the two thigh muscles, and the negative electrode at the end of the collar bone. After stimulation, carcasses were kept at the temperature of 15-18°C for 2 hours, 4 hours, 6 hours, 8 hours, 10 hours, and without storage.

Measurement protocols:

The pH of muscle was measured using a handheld pH-meter calibrated with pH 4 and 7 buffer solution. Tenderness of the meat was measured using a penetrometer (Muchtadi & Sugiyono 1992**.** Thigh meat was cut 5 × 2,5 × 1,5 cm^3, then steamed for 30 minutes and for about 80-82°C. After the sample reached the room temperatue, it was placed under penetrometer needle with horizontal fiber direction. The chuck of the penetrometer was released for 10 second, each time at different locations. Tenderness of the samples was read on the scale (gram/10 second).

Water holding capacity was measured using the filter Paper Press Method according to the procedure described by Honikel & Hamm (1994). Initially, the free water content of the meat was determined. A sample of 300 mg was placed on a Whatman 41 filter paper and pressed between two glass plates for 5 minutes under 35 kg weight. Then, the wet meat and area on the filter paper was drawn on a transparent plastic. The size of wet area was determined by a millimeter block paper, and free water content (mg H_2O) was calculated as wet area divided by 0.0948 minus 8.0. Secondly, the water content of meat sample was determined using oven. A porcelain cup was dried in an oven at 100°C for 30 minutes, cooled in a desiccator and weighed. Meat from thigh part (5 g) was placed in the cup and weighed. The cup with sample was dried under temperature of 100-102°C for 16-18 hours. The cup and sample was weighed after cooled in the desiccator. The water content of the meat was the loss of weight after drying and expressed in percent. Finally, water holding capacity was calculated using the following formula:

$$\text{Water holding capacity} = \%\ \text{water content} - \frac{\text{Mg } H_2O}{300} \times 100\%$$

Cooking losses of the meat was determined using the procedures described by Soeparno (1994). Meat sample was weighed, then placed in pot for one hour. Cooling was done by placing the plastic bag with sample ethylene plastic bag. Then, the plastic and sample was placed in a waterbath at 80°C for one hour. Cooling was done by placing the platic bag with sample in a glass cup filled with cold water (10°C) for 15 minutes. Meat sample was removed from the bag, drained and dried using tissue papers. Meat sample was reweighed. Cooking losses (in percent) were calculated as the loss of weight after cooking divided by sample weight multiplied by 100.

RESULTS AND DISCUSSION

Result of the effect of the experiment aging time on the physical characteristics of rabbit meat is on Table 1.

Table 1. The effect of treatment on rabbit meat physical characteristic

Variables	Aging time (hours)					
	0	2	4	6	8	10
Meat pH	6.96^{a}	6.49^{b}	6.10^{c}	5.81^{d}	5.71^{de}	5.59^{e}
Tenderness (gram/10 seconds)	96.20^{a}	124.15^{b}	127.03^{b}	127.95^{b}	134.63^{c}	154.81^{d}
Water holding capacity (%)	67.34^{a}	25.63^{b}	23.90^{b}	18.44^{c}	17.43^{cd}	14.70^{d}
Cooking losses (%)	18.50^{a}	16.76^{a}	19.75^{bc}	23.50^{c}	26.72^{cd}	29.75^{d}

Values bearing different superscript at the same row differ significantly ($P<0.05$)

Data in table 1 shows that the highest pH meat was on meat pH without aging, next there is a significant decrease in meat pH ($P<0.05$) after 2 hours aging, and the longer the aging time, more decrease the pH meat. After rabbit was dead, a glycogen renovation process occurred and it became lactic acid through anaerobic glycolysis, which caused pH meat decrease (Swatland 1984). According to Buckle et al. (2009) amount of pH changes depended on amount of glycogen reserves before the cattle was slaughtered and will be changed become lactic acid. Change of muscle glycogen into lactic acid would stop if muscle glycogen run out or after glycolytic enzyme become inactive.

The lowest meat tenderness in meat before aging, and is not significantly different compared with 2 hours aging time. The tenderness will increase with longer aging time, and the best tenderness is in 10 hours aging time significantly different with other treatments ($P<0.05$). This is because pH in 8 hours aging treatment is not significantly different with 10 hours aging time, it is suspected that lysosome enzyme activity increase, so that the tenderness is increased. Bouton et al. (1971) said that relation between pH and meat tenderness is in the same direction. Meat with high pH has high tenderness, and on the other side meat with low pH will have low tenderness. This pH decrease will be followed with protease enzyme released. This protease enzyme will degrade muscle protein, so that meat more tender (Pearson & Dutson 1985).

Meat cooking loss on 2 hours thawing is not significantly different compared with without thawing, but both is significantly ($P<0.05$) lower compared with other treatments. Cooking loss will be more increase with more longer aging time, and different significant ($P<0.05$) occurs after meat is in storage for 8 hours is not significantly different with 10 hours aging time. This is because 8 and 10 hours aging produce lowest pH and not significantly different between both treatment. According to Soeparno (2009), that pH value is connected with meat cooking loss, more lower value pH of meat , more increase meat cooking loss. Meat cooking loss is also connected with meat water holding capacity, more lower meat water holding capacity, more bigger it cooking loss, and vice versa. High meat water holding capacity will cause the water that came a little so that meat cooking loss become low (Bouton et al. 1971).

CONCLUSION

Long aging time of rabbit carcass which was stimulated by electric in refrigeration temperature affect pH, tenderness, water holding capacity and meat cooking loss. To produce rabbit meat with optimum physical characteristic, the use of aging with 10 hour is recommended.

REFERENCES

Bouton PE, Harris PV, Shorthose WR. 1971. Effect of ultimate pH upon the water-holding-capacity and tenderness of mutton. J Food Sci. 36:435.

Buckle KA, Edward RA, Fleet GH, Wootton W. 2009. Ilmu Pangan. Diterjemahkan oleh Hari Purnomo dan Adiono. Jakarta (Indonesia): UI Press. hlm. 227-267.

Honikel KO, Hamm R. 1994. Measurement of water holding capacity and juiceness. In: Quality attributes and their measurement in meat, poultry and their measurement in meat, poultry and fish products. In: Pearson AM, Dutson TR, editors Advances in meat research. Glasgow (UK): Blackie Academic & Professional.

Muchtadi TR, Sugiyono. 1992. Ilmu Pengetahuan Bahan Pangan. Depdikbud. Dirjen DIKTI. Pusat Antar Universitas Pangan dan Gizi. Bogor (Indonesia): Institut Pertanian Bogor. hlm. 19-35; 46-49.

Pearson AM, Dutson TR. 1985. Scientific Basis for Electrical Stimulation. In: Pearson AM, Dutson TR, editors. Advance in Meat Research, Vol 1, Electrical Stimulation. Connecticut (USA): The Avi Publishing Company Inc. p. 45-72.

Savell JW, Smith GC, Dutson TR, Carpenter ZL, Sutter DA. 1977. Effect of Electrical Stimulation on Palatability of Beef, Lamb and Goat Meat. J Food Sci. 42:702-706.

Soeparno. 1994. Ilmu dan Teknologi Daging Cetakan ke-2. (Indonesia): Gadjah Mada University Press.

Soeparno. 2005. Ilmu dan Teknologi Daging Cetakan III. Yogyakarta (Indonesia): Gadjah Mada University Press.

Soeparno. 2009. Ilmu dan Teknologi Daging. Yogyakarta (Indonesia): Gadjah Mada University Press. p. 6; 152-156; 289-290; 297-299.

Swatland HJ. 1984. Structure and Development of Meat Animals. Englewood Cliffs (USA): Prentice-Hall Inc. p. 3-5.

Yurmiati H, Wiedy G, Kusmajadi S. 2010. Effects of electrical stimulation with different impulses on physical characteristics of rabbit meat. J Product. 12:1411-2017.

Correlation Between Consumer Characteristics and Preferences of Rabbit Meat Consumption

Tati Herawati

Indonesian Research Intitute for Animal Production
Jl. Veteran III PO Box 221 Ciawi, Bogor, Indonesia
Corresponding e-mail: herawati_tati@yahoo.com

ABSTRACT

Food security is one of the pillars of the power of a country. But now, there has been a significant increase in the price of some food. Therefore, it is important to accept the suggestion of research results indicate the presence of some food choices that have good nutrition for human health. One of them is a rabbit meat that has been known to have the characteristics of nutrient levels better than other animal protein sources. The problem is that the number of rabbit meat consumers are still low. Therefore, research has been conducted to determine the factors that affect the level of preference in the rabbit meat. Factors that observed consumer characteristics that X_1. Gender/Sex; X_2. Age; X_3. Ethnic; X_4.Type of Work; X_5. Religion; X_6. Education; X_7. Married or not; X_8 Willing to eat meat rabbits. Respondents consisted of a variety of people with different chracteristics. The seventh factor of X_1 to X_7 had been tested whether has high correlation with X_8, using factors analysis and eigen value. Results showed that all of variables has MSA value 0.618> 0.5 and Chi-square value of Bartlett's test of Sphericity 206.043 with a significance level of <0.05. Furthermore, the eigenvalues obtained three variables that play a role in determining the level of preference on rabbit meat that X_1 Gender may explain the diversity of 43.9%, X_2 Age 17.8% and Ethnic 14.4%. While variables Work, Religion, Education, or Married or not has no effect on the consumption of rabbit meat.

Key Words: Rabbit, Preferences, Consumer Characteristics

INTRODUCTION

Food security is one of the pillars of the power of a country. But now, there has been a significant increase in the price of some food. Therefore, it is important to accept the suggestion of research results indicate the presence of some food choices that have good nutrition for human health. The efforts to increase the availability of nutritious food, especially meat need maximum support, one of the efforts among other things explores the potential of livestock that have high reproductive ability and the effort of processing so that it can be accepted by the Community (Suradi 2005a). One of them is a rabbit meat that has been known to have the characteristics of nutrient levels better than other animal nutrient sources. The interesting aspect in rabbit meat is high protein and low cholesterol. It can be promoted as a healthy meat. But there are many constraints to be faced, e.g. the difficulty of marketing – rabbit meat has not popular in society yet (Suradi 2005b). The consumer is very interested in the healthiness of meat, hedonistic quality, sensory properties, cooking easiness and swiftness, and price (Zotte 2002). This is equivalent to be said by Zotte and Szendrő (2011) that increasing consumer knowledge of the link between diet and health has raised the awareness and demand for functional food ingredients. Meat and its derivatives may be considered functional foods to the extent that they contain numerous compounds thought to be functional.

Rabbit is a beautiful and cute furry animals is indeed said to have the good quality meat for consumption. Besides delicious, it turns out rabbit meat contains less fat and rich in protein. In addition, rabbit meat also contains a compound called ketotifen are efficacious relieve asthma. In Indonesia alone, the rabbit is much more popular than cultivated as an ornamental rabbit. Indeed, the level of consumption of rabbit meat in Indonesia is low. This is due to the lack of information on rabbit meat as a cheap alternative to meat (Kusmayadi 2012). Therefore, the problem is that the number of rabbit meat consumers are still low.

According Sumarwan et al. (2012), diet is a human behaviour to meet their needs that includes attitudes, beliefs, and the selection of food. The attitude of people towards food can be both positive and negative. Positive or negative attitude sourced on affective values derived from the environment (natural, cultural, social and economic) in which human that is growing. Similarly, the confidence in the food-related cognitive values are good or bad quality, attractive or unattractive. Selection is the process of psychomotor to choose food according to the attitudes and beliefs. A diet can be defined as the way of people in choosing foods and eating in response to the influence of psychology, physiology, culture, and social. Hernandez (2008) said that nutritional value and safety have gained great importance among the factors that determine meat quality. The close relationship between diet and health has lead to changes in consumer habits, demanding products that meet their dietary and nutritional preferences. Rabbit meat is highly valued for its nutritional and dietary properties; it is alean meat with a low-fat content and less saturated fatty acids and cholesterol than other meats.

Young (2014) revealed that the protein in rabbit meat is very high, whereas low calorie. Rabbit meat is very nutritious for humans, especially in the growth age of child. Therefore rabbit meat are beneficial to health. United States Department of Agriculture (USDA) has conducted research on rabbit meat and officially declared that rabbit meat is healthy meat to eat. In fact, the USDA also recommends to consump rabbit meat because it is the most nutritious and healthy meat for humans. Furthermore, according to the USDA's own, taking three and a half ounces of rabbit contains 173 calories a little less than three and a half ounces of white chicken meat and beef. Rabbit meat is also low in saturated fat than veal. There are about four grams of fat in three ounces of rabbits compared to about 22 grams of fat in saturated fat in beef. Another fact, the level of cholesterol contained in rabbit meat is very low when compared with other animals such as cows, chickens, pigs and turkeys. Cholesterol in the rabbit around 164 mg per 1000 g of meat. While the beef, pork, lamb and chicken with cholesterol levels between 22-250 mg per 1000 g of meat. Actually a lot of people already has known the benefits of this rabbit meat, but not much use as a source of protein. Therefore, research has been conducted to determine the characteristic of consumers which influence the level of preferences in the rabbit meat.

MATERIAL AND METHOD

In the form of quasi-experimental study in which treatment was not made yet been observed in a state that has occurred. The data obtained through interviews with respondents randomly who have different backgrounds in terms of Sex (X_1), Age (X_2), Ethnic (X_3), Work (X_4), Religion (X_5), Education (X_6), Married (X_7) and Consumer rabbit meat (X_8). Consumer characteristics, namely X_1 to X_7 were tested whether correlated or not with X_8. The analysis factor was used to selec factors among independent variables X_1 to X_7 most influenced in explaining the diversity of variables X8. Factor analysis is a statistical data reduction technique used to explain variability among observed random variables in terms of fewer unobserved random variables called factors. It is useful to reduce the number of variables, by combining two or more variables into a single factor, thus “simplifying” the original dataset. A first step in a factor analysis is determining the number of factors using a SCREE option to plot the eigenvalues. This plot is a two-dimensional graph with factors on the x-axis (bottom) and eigenvalues on the y-axis (vertical). The eigenvalues are produced by principal components analysis (PCA) and they represent the variance accounted for by each underlying factor. By looking at the highest eigenvalues and their variance, factors can be selected that has high influence in the level of consuming rabbit meat preference.

RESULT AND DISCUSSION

Characteristics of respondents

Respondents consisted of a few people with the characteristics or different backgrounds. Characteristics of respondents who obtained consists of men and women (X1), where men more than women; covering all ranges of age, but that many are in adolescents and the elderly (X2); coming from 10 different regions but

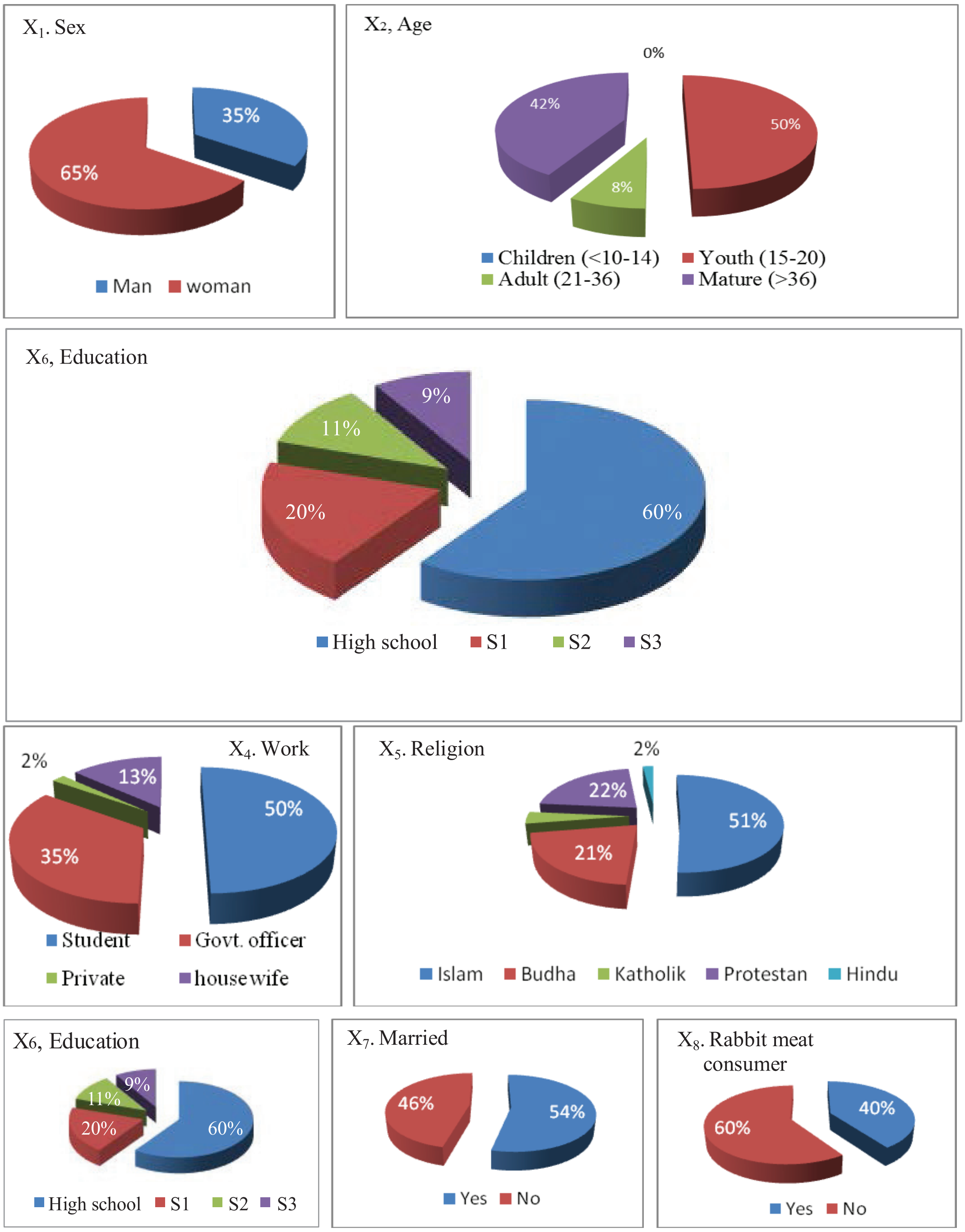


Figure 1. Persentage of respondent in each consumer characteristic

most of Borneo, Java, and Batak (X3); have different jobs there are private employees, government officials, housewives and some are students (X4) which dominated by government officials and student; all religions in Indonesia (X5); education ranging from high school to S3 (X6); marital status (X7) are almost equally between those who are married and who have not; A rabbit meat preferences, where as who are liked more than those unlike (X8) (Figure 1).

The influence of consumer characteristic on the level of rabbit meat preference

Consumer consists of a variety of different backgrounds to see its influence on the possibility of eating rabbit meat. With different backgrounds was seen that there were respondents who are not willing to answer or that do not have an understanding of rabbit meat (Figure 2). This case shows that there are people who do not like meat rabbits or do not have experience in consuming rabbit meat.

If seen the model graph 1, the number of consumer understanding of the rabbit shows that many people are not able to comment at all if she would like it or not (13.2%), most do not even want to answer at all as much as 34%. However, if the answers are listed on the chart from left to right conveniently indicates a positive opportunity, then the peak of the answers contained in the positive response that states that rabbit meat seems tasty, savory, soft, smooth and like a chicken meat. From this condition indicates that there is a chance of rabbit meat will be favored by consumers depends on how to cook it and depending on how socialize the benefits of rabbit meat.

Consumer characteristics that contribute to the preference level of the rabbit can be seen from the value of MSA. Table 1 shows that the MSA value (Measure of Sampling Adequacy) is 0.618> 0.6 indicates that these variables can be predicted without error by the other variables, which can be analyzed further. While the value of Bartlett's Test of Sphericity of 206.043 with a significance level of 0.00<0.05, then H0 that there is no correlation between the variables in the population is rejected. which shows the H1 factor analysis can be used. When the value of KMO and significancy of Bartlett’s Test of Sphericity

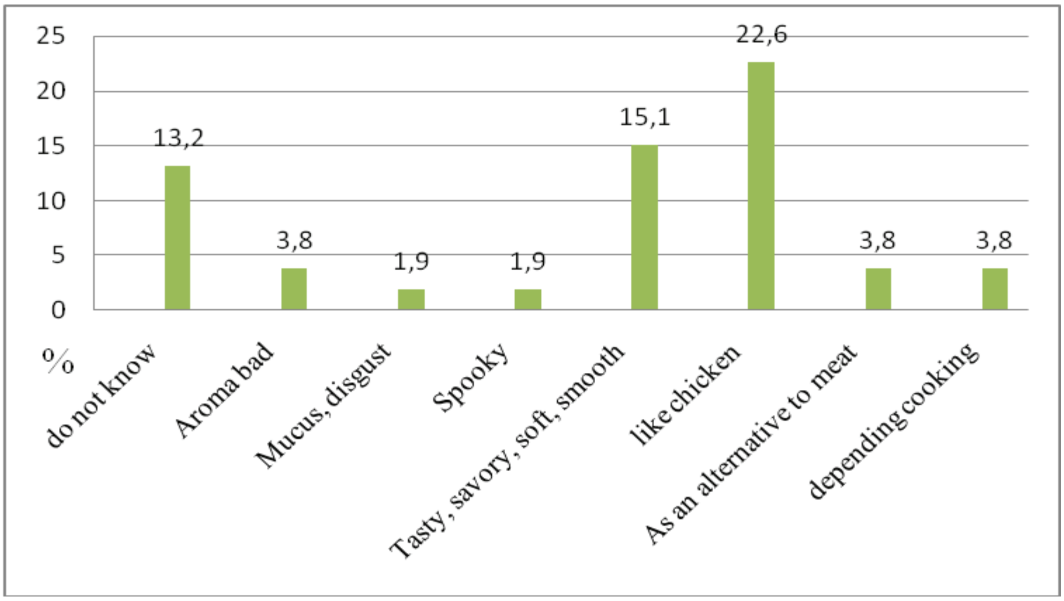


Figure 2. Respondent Perception on rabbit

Table 1. KMO and Bartlett's test

Test	Variable	Score
Kaiser-Meyer-Olkin	Measure of sampling adequacy (MSA)	0.618
Bartlett's Test of Sphericity	Approximately chi-square	206.043
	Degrees of freedom (df)	28.000
	Significancy	0.000

over 0.6 and under 0.05 respectively, then an extraction method was used. Factor analysis examines the inter-correlations that exist between a large number of items (questionnaire responses) and in doing so reduces the items into smaller groups, known as factors. These factors contain correlated variables and are typically quite similar in terms of content or meaning. (Hooper 2012). This analysis was used for selecting multiple factors that play a role in a relationship. In this data, which sought variables of X_1, X_2, X_3, X_4, X_5, X_6, X_7 or X_8 can explain the diversity of variables. That is, among the independent variables are searched factor most responsible X_8 as the dependent variable.

The results of factor analysis showed that there are five variables are X_1, X_2, X_3, X_4, X_5, are correlated with the X_8. Obtained in Table 2 that the gender effect on the level of preference in the rabbit where it appears that women are more prefer in consuming rabbit meat than men. This is somewhat different from the opinions Kim Terakes, author of The Great Aussie Bloke's Cookbook, that many men feel not eat if they do not eat protein in large portions. While women have had enough with little carbohydrate or salad at mealtime (Anna 2013). Further conveyed to him that when viewed from the sense of taste, men are not too sensitive to the bitter taste. In contrast to women who are more sensitive to bitter taste so much like something sweet. As well as by research results Sumarwan et al. (2012) also showed that gender and treatment (P>0.05) did not significantly influence the formation of preferences, as well as the interaction between gender and treatment had no significant effect (P>0.05) in preferences. Educational background and has been married or not was not correlated with fondness on rabbit meat. This is a bit different to the results of research on the degree of buffalo meat preferences by Burhanuddin et al (2002) showed that personal characteristic like age, education level and amount of member household have significant correlation with preference level of buffalo's meat.

Furthermore, the five factors that correlated to the X_8, further selected seen from the eigenvalues. The resulting Scree plot is shown below along with additional information include the importance of components (Figure 3).

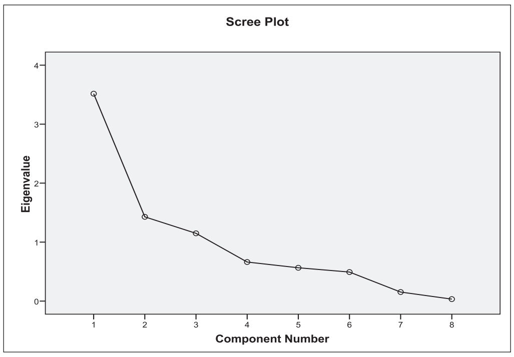


Figure 3. Scree plot of the consumer characters

Table 2. Principal Component Analysis for the X_i (i=1 . . . 7) with X_8

Factors	Name	Pearson correlation	Significancy	Result
X_1	Sex	57,632	0,000	Women > men
X_2	Age	57,190	0,000	Youngth > mature > adult
X_3	Etnic	35,186	0,019	China > Jawa > Sunda Padang, Batak, Kalimantan > NTB Bali = Sumsel = Aceh
X_4	Work	54,995	0,000	Student>government official House wife = private official
X_5	Religion	31,928	0,001	Islam > Budha Katholik=Protestan=Hindu
X_6	Education	7,147	0,521	not significant
X_7	Married			not significant
X_8	Consume rabbit meat			

From scree plot of the graph can be seen easily factors that have the higher value of eigen value, they are X1, X2 and X3. The next graph slope looks flat. The third factor contributing value greater diversity than the other factors of diversity X8 (Table 3). From that table shows that by using variables X1 can explain the diversity of 43%, if added X2 added 17, if added X3 plus 14%. Total %, other variables do not add of eigenvalues values are only 3 that X1, X2 and X3. This means that consumer characteristics that influence the level of consumption of rabbit meat is sex, age and ethnic. It can be used as a basis for the promotion of rabbit meat as an alternative source of protein that is cheap but has excellent nutritional value. This is in accordance with the opinion Rahayuningsih (2008) that the product selection items, namely supplies determining factor is determined in part by personal characteristics (age and stage of life cycle, jobs, economy, lifestyle, personality and self-concept). The expectations and preferences of the different respondents regarding rabbit meat is an important factor to be considered in the marketing thereof (Hoffman et al. 2004). Rabbit meat consumption could be a good way to provide bioactive compounds to human consumers, since manipulation of rabbit's diet is very effective in increasing the levels of ω 3 PUFA, CLA or Vitamin E (Hernandez 2008). In addition, as submitted by Qoriah (2008) who stated that sufficiency of food determines the quality of human resources and the resilience of a people. Therefore efforts to achieve food sufficiency should be done in a sincere manner. To form a quality human food must be available at all times in adequate amounts, equitable, secure, high quality, nutritious, varied and at an affordable price. Realization of food security is not only a responsibility of the Government but all of society.

Table 3. Total variance explained/principal component analysis (PCA) for the consumer characteristic data

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative (%)	Total	% of Variance	Cumulative (%)
X_1	3,516	43,953	43,953	3,516	43,953	43,953
X_2	1,428	17,856	61,809	1,428	17,856	61,809
X_3	1,149	14,365	76,174	1,149	14,365	76,174
X_4	0,662	8,280	84,454			
X_5	0,565	7,061	91,515			
X_6	0,492	6,153	97,668			
X_7	0,153	1,916	99,584			
X_8	0,033	0,416	100,000			

Extraction method: Principal Component Analysis

CONCLUSION

All variables that X_1 (Gender/Sex), X_2 (Age), X_3 (Ethnic), X_4 (Type of Work), X_5 (Religion), X_6 (Education), X_7. (Married or not) and X_8 (Willing to eat meat rabbits) have MSA value 0.618> 0.5 and Chi-square value of Bartlett's test of Sphericity 206.043 with a significance level of <0.05. Furthermore, the eigenvalues obtained three variables that play a role in determining the level of preference on rabbit meat that X_1 Gender may explain the diversity of 43.9%, X_2 Age 17.8% and Ethnic 14.4%. While variables Work, Religion, Education, or Married have no effect on the consumption of rabbit meat.

REFERENCES

Anna LK. 2013. Pengaruh Jenis Kelamin pada Pilihan Makanan. Health. Kompas.com. tersedia pada http://health.kompas.com/read/2013/04/23/11241497/Pengaruh.Jenis.Kelamin.pada.Pilihan.Makanan.

Burhanuddin, Masithoh S, Atmakusuma J. 2002. Analisis preferensi dan pola konsumsi daging kerbau pada konsumen rumah tangga di kabupaten Pandeglang. Med Vet. 25(1).

Hernández P. 2008. Enhancement of nutritional quality and safety in rabbit meat. Meat Quality and Safety. In: Xiccato G, Trocino A, Lukefahr SD, editors.. Proceedings of 9th World Rabbit Congress. Verona, June 10th, 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche E Zootecniche. p. 1287-1299.

Hoffman LC, Nkhabutlane P, Schutte, De W Vosloo. 2004. Factors affecting the purchasing of rabbit meat: a study of ethnic groups in the Western Cape. J Family Ecol Consum Sci. 32:26-35.

Hooper D. 2012. Exploratory Factor Analysis. Education, Technology. Dublin (Ireland): Dublin Institute of Technology, College of Business.

Qoriah SN. 2008. Analisis Gender dalam Program Desa Mandiri Pangan (Studi Kasus Desa Jambakan, Kecamatan Bayat, Klaten-Jawa Tengah). [Skripsi]. [Bogor (Indonesia)]: Institut Pertanian Bogor.

Rahayuningsih F. 2008. Analisis preferensi konsumen terhadap Sabun kecantikan. [Skripsi]. [Jakarta (Indonesia)]: Fakultas Ekonomi Universitas Pembangunan Nasional “Veteran” Jakarta.

Sumarwan U, Simanjuntak M, Yurita. 2012. Persepsi dan preferensi iklan mempengaruhi niat beli anak pada produk makanan ringan. J Ilmu Kel Kons. 5:185-192.

Suradi K. 2005a. Upaya peningkatan gizi masyarakat melalui teknologi pengolahan daging kelinci Paper presented on International conference “Seminar Internasional Simposium Kebudayaan Indonesia Malaysia IX”. Bandung, 10-12 Mei 2005. Bandung (Indonesia): Fakultas Peternakan Universitas Padjadjaran.

Suradi K. 2005b. Potential and oportunity in processing rabbit’s Product technology. Paper presented in National Workshop: Potential and Opportunity in Rabbit Agribusiness Development. Bandung, September 30, 2005. Bandung (Indonesia): Animal Husbandry Faculty Padjadjaran University.

Young L. 2014. Daging kelinci kaya Protein. The Portion Teler Plan. [Internet]. [cited 5 June 2013]. Available from http://wartakota. tribunnews.com/2014/08/25/daging-kelinci-kaya-protein.

Zotte AD, Szendrő Z. 2011. The role of rabbit meat as functional food. Meat Sci. 88:319-331.

Zotte AD. 2002. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Livest Prod Sci. 75:11-32.

Roles of Rabbit Meat in Strengthening Food Supply in an Attempt to Alleviate Food Shortage for Parents and Children

Pujo Hartono

Direktorat Gizi, Kementerian Kesehatan

ABSTRACT

Data from Riset Kesehatan Dasar shows that Indonesia still have four major nutrition problems: protein-calorie malnutrition (PCM), vitamin A deficiency, iodine deficiency, and nutritional anemia. These problems are widespread throughout Indonesia, although regional, ecological and cultural differences that affect food availability and consumption. The most basic is inadequate intake of protein and calories, causing under nutrition problems like: wasting, stunting and under weight. Lack of protein in Indonesia is the result of a combination of factors, mainly inadequate production; availability and inequitable distribution of foods and insufficient awareness of nutritional needs, and poor food habits, due lack of nutritional education. BPS survey (2012) shows that food consumption of sereals in Indonesia reach 91.9% of recommended dietarry allowances (RDA) and fat 116% (more than RDA), protein and vegetable consumption less than RDA. Low purchasing power to buy a good quality of protein with low cost price compounded with low education and knowledge make the malnutrition problem in Indonesia became worst. In the same time some Indonesian people currently getting over weight till obese, due lack of nutrition education and wrong nutritional behavior (nutritional double burden problem). Nevertheless Indonesian community has a good habitual on consumption of carbohydrate, protein and vegetable, but less on quantity and quality – especially the protein and vegetable. Income, knowledge and food availability is the factors influence to the consumption. We have an opportunity to promote rabbit meat as high quality animal sources food as an alternative to overcome the high cost of beef meat. Rabbit meat is very good for health. Efficacy of rabbit meat can lower cholesterol and heart disease. Rabbit meat is an alternative food for people who have heart disease or high cholesterol relative. However, the rabbit has not been so popular. "In fact, the nutritional quality better than other meat," said Dr. Yono C Raharjo of Ciawi Livestock Research Center, Bogor. Low cholesterol and sodium content makes rabbit meat is highly recommended as a food for patients with heart disease, the elderly, and those with problems with excess weight.

Key Words: PCM, Deficiency, Rabbit Meat, Cholesterol

THE BENEFITS OF RABBIT MEAT

1. The meat has a high percentage of easily digestible protein, good for elderly group and children on develop ages.
2. It contains the least amount of fat and cholesterol among all the other available meats.
3. Rabbit meat contains less calorie value than other meats, good for diet of overweight and obese people.
4. Rabbit meat is almost cholesterol free and therefore heart patient friendly.
5. The natrium content of rabbit meat is comparatively less than other meats.
6. The calcium and phosphorus contents of this meat or more than any other meats.
7. Rabbit meat with the many health benefits, likes increase men and women vitality; prevent from cancer and alleviate the asthma syndrome.
8. Can overcome some health problems, like: infertility; increasing fertility and asthma medications.
9. Halal meat.

There are many health benefits to eating rabbit meat. It is healthy and cheap to produce.

NUTRITIONAL FACTS

A 100 g portion of rabbit has an average of 150 kcal, is rich in vitamin B12 and high-quality proteins and is a good source of iron. Many women have iron deficiencies. Proteins are important building and maintenance materials for our bodies at any age.

A leg of rabbit has the leanest meat (about 4 g of fat per 100 g). The saddle and shoulders have slightly more fat (about 8 and 12 g of fat per 100 g respectively). With an average of around 8 g of fat per 100 g, rabbit is one of the leanest type of meat. In accordance with the guidelines for healthy food that is good for your figure, the leanest variants are preferred. It is best to limit the fat content by removing any fat you can see. Rabbit that is bought in cuts has already had the fat removed.

The limited amount of fat in rabbit consists for one third of saturated fatty acids and for almost two thirds out of cholesterol-friendly unsaturated fatty acids. Compared to many other types of meat, rabbit furthermore contains more heart-friendly omega-3 fatty acids. The favourable composition of the fats and the delicate flavour of rabbit meat is partly the result of the balanced feed of the animals containing amongst other things alfalfa and linseed.

Bred rabbits are slaughtered young, when they are 12 to 13 weeks old. The meat of these young animals contains little collagen and is therefore tender, juicy and easy to digest. The meat also remains tender during preparation. That is why rabbit is an easily digestible piece of meat.

Since malnutrition become a problem in Indonesia and also food intake especially protein in Indonesia less than Indonesian standard, reach only 62,1% of Recommended Dietarry Allowances (RDA). So rabbit meat is one of the good alternative protein, appropriate for parents and children.

Rabbits Business Program of Rural Farmers in Indonesia
(Preliminary Study for the Economic Empowerment)

Sumanto, Juarini E, Raharjo YC, Herawati T

Indonesian Research Intitute for Animal Production
Jl. Veteran III PO Box 221 Ciawi, Bogor, Indonesia
Corresponding e-mail: sumanto_d@ymail.com

ABSTRACT

Various models of farmer empowering program have a significant role in the improvement of the economic conditions of farmers in rural areas. Indonesian Research Institute for Animal Production (IRIAP) has conducted "demonstration plot" of technology innovation of rabbits to selected groups of farmers in the village breeding centers, in Jambi, North Sulawesi, and Bali in 2012. To support the demonstration plot, rabbit breeds (150 does and 20 bucks), feed and some other equipment were given to each location. Training to the groups of farmers on feeding, breeding, housing, institutional groups was conducted before rabbits delivered. The farmer groups also participate in supporting the animal house building. All of the demonstration sites are located at an altitude of 800-1400 m above sea level and potentially producing vegetables and grass for ensuring the availability of feed. The rabbit breeds given in each location are New Zealand White, Rex, Crossing rabbits. The development of the rabbit population cannot all be monitored properly in each location, because of various delivering time for instance due to the administration problem in Bali, that only held recently in December 2012. In North Sulawesi rabbit mortality rate seems quite high mostly occurred during the delivery time: 2-16 head and after birth 56 head dead (before weaning) although a high birth rate (120 head) occurred. Economic empowerment of farmers in three locations seem unreal yet and need time- except in Jambi, because there are many issues to be addressed, such as technical issues, location, and other management problems. It seems that technology assistance is still needed, as well as apprentice for management and also monitoring and evaluation activities.

Key Words: Rabbit, Business Programs, Empowerment of Farmers

INTRODUCTION

As an agricultural country Indonesia has enormous land resources, including the potential of agricultural resources which, if it can be managed and utilized optimally, it would be able to support the improvement of people's income, especially small farmers in rural areas. Livestock commonly reared in Indonesia are beef cattle, dairy cattle, buffalo, sheep, goats, chickens village, ducks and pigs, which are generally reared complementary of each ather the farmer's farm as a sideline business, even though sometimes have a big roles for the household economy. It has been realized that rabbit is not commonly kept by farmers in all regions in Indonesia, which is usually only reared spread around tourist sites and generally at moderate or high plains region. Mostly the goals of raising rabbits are to be slaughter to provid meat or sold for ornamental or pet animals, sometimes farmer use the urine and feces of rabbits for fertilizer. Rabbits' farming is often found in various locations of medium or high plateau, generally vegetable farming communities that use the abundant vegetable waste product as its feed, in addition to forage grass, this waste can be potentially used as forage for rabbits.

Rabbits are able to grow and multiply rapidly from forage and crop waste. In traditional farming system, the productivity of a doe in a period of 1 year is able to produce as many as 16 heads youngsters aged of 4.5 months with the average weight of 2.5 kg, so that the total weight of live rabbits ready for slaughter is 40 kg (Raharjo 2008b). Potential productivity rabbits ready for slaughter weight can be increased in intensive rearing conditions (Maertens 2007). Other benefits that can earn money or to be beneficial is produced from manure and urine of rabbits. It should be noted that the rabbits are susceptible to bloating and diarrhea diseases with highly potential to cause death and this needs an extremely attention especially by the novice breeders who are unfamiliar and inexperienced in rabbit rearing.

The potential productivity of rabbit ready to be slaughtered (about 4 month of age) comparing with models of fattened cattle or sheep shows that the meat production of 5 does are comparable with 1 cow and 2 does are comparable with 1 sheep (Raharjo et al. 2012). Government's or ather's aid on ruminants or poultry is generally given to rural communities, which is not guaranteed to be successful and this is greatly influenced by the commitment of the beneficiaries. For this reason a rabbit farm assistance programs can potentially be used as an alternative to increase revenue, of the community empowerment in the sense of participation (UI Sociology Lab 2007) and economic growth in rural communities. Through this assistance program, it is expected to promote the establishment and development of "rabbit village" that covers such a large group of farmers which have business oriented.

SCOPE OF PROGRAM IMPLEMENTATION

In order to implement the assistance programs in rural empowerment rabbit breeders, the scope of its activities consist of:

1. Dissemination and presentation of the stage of the activity, determining the location and farmer groups. The mean of the presentation is to expose the scope and phases of activity to the Ministry of Agriculture, relevant agencies, farmers, to determin the location and the group of farmers. An agreement of cooperation between investors, managers (group) and supervisors. 3 districts chosen as location of the observation were: Kerinci district (The Province of Jambi), sub district of Tondano, district of Minahasa (The Province of North Sulawesi), and Tabanan district (The Province of Bali). This assistance was pursued to be a stimulant so that (hopefully) an additional funds as a form of partnership of farmers and local governments to increase the number of population and can further accelerate its distribution to members who require a breeder
2. Training of officer candidates at Breeding Center and prospective breeders. Training materials for staff and breeders are: about breeding, reproduction, production and environmental management, and the manufacture of feed rations, disease, waste processing, meat, promotion and marketing
3. Establishment of Rabbit Breeding Center and Standard Operating Procedures Provision (SOP). In the respective districts, formed a central location breeding rabbits was built as a form of "demonstration farm". To fill this building infrastructure, it also has been agreed that: land, buildings, labor provided by the group. While the means derived from Balitnak are: rabbits (for initial assistance program, it consist of 150 does and 20 bucks) and 170 units of cages and equipment (made of wire, complete with automatic installation of drinking water supply and sewerage), most labor fees, and pelleted feed to the start of production, during $\leq$ 6 months. The type of rabbit which was distributed to the group is NZW, Rex, Angora, Fuzzy and ND. The proportion of the type of the rabbits given is dependent on the agreement and adapted to the needs of the group.
4. Group structuring, agreements and cooperation conditions. Members of the group (plasma) obtain rabbits from rabbit breeding center (core) as many as 15 does and 2 bucks. The rabbit raiser as a member of the farmer's group do a deal and work procedures between nurseries (breeding center), farmers groups and supervisors of the production, with a production-sharing agreement as follows: 35% for nurseries (breeding center), 65% for farmer' group and 10% for supervisor. Formulation of product sharing is not rigid, adjustable mutual agreement. Trustees (supervisors) are appointed by agreement between nurseries (breeding center) and farmers groups and the supervisors are expected to be from (staff of) the government agencies. The product of the rabbits can be sold through the breeding center or sold by them selves to follow certain rules of the breeding

center. There is an agreement to cultivate forage/vegetable plantation by farmers as backyard farming and there is an investment sanctions of withdrawn rabbits, if this agreement is not fulfilled)

5. Initiation of the promotion and marketing of production. Expected promotion and marketing rabbits administered and conducted by farmer's group and also composed by members of the group
6. Guidance and monitoring. To ensure the appropriate management of SOP rabbit, monitoring will be done during the first 6 months by trained technicians from Balitnak and Balitnak also train personnel in Rabbit Breeding Center. Monitoring also conducted by researchers Balitnak/ Ministry of Agriculture/Department of related local

RESULT AND DISCUSSION

Stage and realization implementation activities

All stages of the initial activities have been carried out in three locations (Table 1) conducted in 2012, but the delivery date of rabbits is not the same among the three locations, because the initial site preparation, rabbits and rabbit cage arrived at the farmers group's place in different times (table 2).

The three locations (all location) are regions with an altitude of 800-1400 m above sea level and sources of grass and vegetable crops as green feed material suitable for the growth of the rabbit. Only the obstacles in areas of high humidity is too high, which would have much effect on rabbit health and consequently low productivity. Support facilities, such as materials, infrastructure and training to managers of rabbits has been provided and expected to yield rabbit product successfully and continuously which is the purpose and hope. It is recognized that the rabbit meat is not yet widely consumed and not easily marketed as a product of "meat", there should be assistance for promotion in marketing, except for the purpose of rabbits for sale as "ornamental" or fancy animal.

Population dynamics of rabbits

After the rabbits were delivered in the three locations by means of appropriate management capabilities of each group of farmers, the growth information of rabbit population is shown in Table 3. The birth rate of rabbit is quite high in all three locations, but the rate mortality of bunny is also high, such as in Bali the number of birth were 40 head, but all of them died. One of the reason of death is that the does is still holding stress and also lacks the nature of "mother ability" besides the officer is still not proficient and less attention to how to look after rabbit (Minahasa, North Sulawesi.

Table 1. Stage of the program rabbits in 3 locations

Activity	Location		
	Minahasa, Sulut	Tabanan, Bali	Kerinci, Jambi
Socialization programs to the authorities	v	v	v
Determination of the location	v	v	v
Socialization activities to groups of farmers	v	v	v
Building for Cages	v	v	v
Delivery cages and equipment	v	v	v
Training	v	v	v
Rabbits and feed delivery	v	v	v
Preparation of compost/urine/biogas	v/v/v	v/v/v	v/v/v

Source: Raharjo (2012)
v: conducted

Table 2. Actual implementation rabbit programs in 3 locations

Activity	Location		
	Minahasa, Sulut	Tabanan, Bali	Kerinci, Jambi
Socialization programs to the authorities	March 2012. Sekda, Kadistannakbun, BPTP, Uni Sam Ratulangi	August 2012. BPTP, Dinas Peternakan Tabanan	July 2012. BPTP, Dinas Peternakan Jambi
Location of Breeding Center (LBC)	LCB: Totolan village, Kakas	LCB: Candikuning Village, baturiti	LCB: desa Pasar Sungai, Kayu Karo, Jambi
Socialization activities to farmer's groups	Edenta Group (23 members)	Karimaju Group (30 members), Chief: I Nyoman Suta.	Harapan Bersama Group (26 members)
Building for Cages	Distannakbun, only cover 130 unit of cages	Group of farmer, provide building of $120m^2$	Group of farmer, bunker for feces and urine fermentate
Delivery Time cages and equipment	August 2012. 150 unit cages and equipment	December 2012. Cages and equipmentmade in Bali.	Before November 2012. Rabbit cage (150 unit)
Training time SOP rabbit	September 2012. Disnakbun, BPTP, Farmer Group Edenta, Pelita, Karunia, Citawaya, Yeremia, Tetap Berusaha, andKinamang	September 2012 and 26-29 November 2012. Group Member Karimaju and Gapoktan Candi Catur Mandiri	November 2012. Group of farmer: 400 farmers
Rabbits and feed Delivery	September 2012. 110 pregnant does (40), 40 bucks	December 2012. 129 does and 31 bucks	November 2012 120 does, 30 bucks

Patronage farmers group development

Farmer groups in the respective target location was initially very enthusiastic in accepting the introduction of technology. They prepared the requirements that must be provided in order to realize once received help from Balitnak. First, there is the preparation of land to build a cage to put the cages of wire support of Balitnak. Then a prospective cooperator farmer groups must be encouraged to be able to handle the business of rabbits in groups.

Each group leader looks quite aggressive in receiving training and assistance, the reverse is also very responsive in doing business in accordance with the technological rabbit they receive. At the beginning of the training activities carried out, accompanied by officers from the Department of the local farms. Once in the event discussed all the things that need to be supported by animal husbandry department. Among others, is the existence of a special officer of the agency that monitors the development of each of the rabbit business in the group.

Patronage was focused more on the cultivation system for rabbits that were introduced at the same type of waste utilization of feces and urine that can be used for fertilizer as well as to the source of fuel gas or biogas. For further assistance in the form of livestock product processing and marketing is done in the next period. Responses were seen in all three locations of the farmer's group looks pretty good as well as the support of local authorities. But with the passage of time, some problems began to emerge.

Table 3. Development of rabbit populations in 3 locations

Items	Location		
	Minahasa, Sulut	Tabanan, Bali	Kerinci, Jambi
Total Rabbits born-head	120 (from 20 does)	40 (from 7 does)	140 head, 30 pregnant does
Mortality	bunnies (56), adult rabbit (36)	40 offspring	Low mortality (<10%)
Population 2012 (head)	Does (114), bunnies (35), post weaning(48)	Unrecorded	Unrecorded
Caused of death	-	Does stress on the way, Does lacked of "mother ability", so many bunnies died	-
Promotion of rabbit's' product	Manado, 22-29 Sept 2012. Product: sausage, hair, bag	-	-
Aim of rabbit raising	Breed stock (Novice for breeding) Consumption, Commercial Rabbit	Breed stock (Novice for breeding), Consumption, Commercial Rabbit, Fertilizer	Breed stock (Novice for breeding), Consumption, Commercial Rabbit
Obstacle of rabbit raising	No group empowerment, good rabbit farming and technologies were not understood, farmers do not know the cost of feed, no rabbit sales target.	No group empowerment, good rabbit farming was not understood, there are many visitors, so rabbit stress	Techniques prevention and treatment of disease, the availability of feed less and far away, death at birth 1 fairly high)
Estimation of rabbit raising's benefit	Untouched	Novice for breeding (breed stock): 20. Profit per year: IDR 2,5 mil. Growing (3 month): Breed stock: 20. Profit/3 month: IDR 818.000.	Novice for breeding (breed stock): 150 Profit per month: IDR 20 mil.

Source: Raharjo (2012)

Institutional of the farmer's group

At first the Institutional of farmer's group at three sites, seems quite active, but in its development only in Jambi is still going well. The board is active in accordance with their respective fields. Similarly, members of the group meeting activity done regularly once a month by inviting local extension workers. During the meeting discussed various aspects relating to the business of their rabbits.

Rabbit farmer's group in Bali and Minahasa is not functioning properly, because the rabbit population is not increasing and a high mortality was found there. Finally they work individually or members are not raising rabbit any more. The group abandoned the rabbits raising that resulting in not continuing the business of the group. Lodging in Minahasa, the Department initiated a local farm which still want to take advantage of the infrastructure that has been granted by Balitnak and bring back from them as many as 40 head (does and buck), so even slow but sure, have started increasing the rabbit population again.

Institutions that have emerged to support the development of new rabbit farming emergence of "middlemen" rabbit collector.

Other institutions such as drug store situated in the district that is located not far away, from where they can get medical material for the rabbits. While institutional feed does not appear because until now farmers do not use feed concentrate, vegetable waste from their own field are enough for their rabbits.

Rabbits business in non-supported farmer's group

Balitnak rabbit has developed quite well in Kerinci, Jambi and has expanded maintained in non-supported farmers. They get information from the instructor/local officer on the existence of a good quality of does, namely in the target group. In another villages with auxiliaries, there are already seen 3 groups of new farmers who are interested in rabbit farming. One group is already highly developed that have sold more than 1000 heads to earn revenues of more than 20 million/month. Rabbit (breed stock) were obtained from the supported group.

While in Minahasa District, there are some non-supported rabbit does farmer in Tonelet village, subdistrict Langoan West, which now has more than 57-90 and 10-20 bucks and more than 100 local young rabbit (bunny). Feed is provided in the form of agricultural waste and grass field. Housing system in this area is commonly used individual cages and separated kit from birth, only when breastfeeding the doc is inserted into the brooding cage. Breeders are able to sell the young rabbits (age 20-30 days) as "fancy" with the price of Rp 30,000-35,000/head per 3 weeks, 4 month of ages at Rp 125,000/pairs per month, and the adult rabbit Rp 150,000/head per 3 months. There are brokers who went around the village to collect/buy a rabbit from breeders. Pattern of non Balitnak rabbit breeders in Bali in general is almost the same as in Minahasa, where the number of requests for bunnies as "fancy" is still interesting in the community and still increased.

Problems and follow-up

Community empowerment is active when at least community participation has been actively participating in the following activities, but not related to the level of success. Common problems taked by farmers for not being successful on the development efforts are:

1. Rabbit breeders do not only think about the raising of rabbit, but also looking for a form of marketing their products (mainly sales rabbits), because the rabbit products (rabbit meat) are still not fully accepted by consumers, so that the number of requests is limited. While mastering the ability of farmers in marketing rabbits are generally minimal or low. So farmers need to be provided for training before starting a rabbit business, especially on the issue of how to raise rabbit, marketing opportunities, processing, and product promotion.
2. Rabbits productivity is good (as rabbit is a prolific animal), it give a lot of bunnies (litter size range from 8-12, in at least every 2 months), but its mortality rates are also high, so it requires good management.
3. Raising rabbits did not succeed due to lack of special attention from the rearer, for it is necessary to have time and accuracy of the farmer who raise them.
4. The level of knowledge of farmers on rabbit farming is still low, so the role of business for training, apprentice to an experienced breeder becomes important.

Results preliminary economic empowerment

Process of empowerment activities take a long time, depending on the nature of the activities carried out. Evaluation of the results of the empowerment of an activity is generally done at the beginning, middle and after the implementation of the activities completed. Although it is still early stages of development rabbit in three locations, but it has given a positive outlook for the economic empowerment of rural through aid package of rabbits, especially in Jambi location. The success of economic empowerment through an activity, is determined by the commitment and good coordination among the performers to get to the target to be achieved (Sumanto 2013). The positive prospect of initial economic empowerment in this locations can be seen in the following bench marks:

1. The level of development of the increase of rabbit population.
2. Group members play an active role in building of the sustainability of the farmer groups.
3. The number of group members increased.
4. Sales of rabbits out of the location has been done regularly, but still on a limited scale.
5. Revenue of the supported rabbit farmer increased.
6. Local government participates in promoting the rural economy through business assistance rabbit.

CONCLUSION

Rabbits have high productivity, at the initial stage showed activity can create income for farmers and the tipping point increasein the economic of the rural community.

REFERENCES

Lab Sosiologi UI. 2006. Proposal tinjauan sosial budaya terhadap P4MI di tiga Kabupaten. Pusat Kajian Sosiologi-FISIP UI.

Maertens L. 2007. Milk production in rabbits: Quantity and quality. In: Raharjo YC, Talib C, Herawati T, Brahmantyo B, Praharani L, Lukefahr SD, Maertens L, Handiwirawan E, Martindah E, editors. Proceedings International Conference of Rabbit Production. July 24-25, 2007. Bogor (Indonesia): Indonesian Center for Animal Research and Development. p. 101-115.

Raharjo YC. 2008b. Strategy on the development of small-and medium scale rabbir farming based on farmer cooperation. A case of rabbit production in Indonesia. In: Xiccato G, Trocino A, Lukefahr SD, editors. Proceedings 8th World Rabbit Congress. Verona, 10-13 June 2008. Brescia (Italy): Fondazione Iniziative Zooprofilattiche e Zootecniche. p. 1609-1614.

Raharjo YC. 2012. Dukungan inovasi teknologi untuk pengembangan agribisnis kelinci dalam rangka pemberdayaan ekonomi perdesaan dan peningkatan ketahanan pangan di 4 provinsi. Laporan Akhir Kegiatan Pengembangn Kelinci Tahun 2012. Balai Penelitian Ternak.

Sumanto. 2013. Empowering beef cattle farmers through profit sharing partnership in Kalimantan. In: Purwantari ND, Saepulloh M, Iskandar S, Anggraeni A, Ginting SP, Priyanti A, Wiedosari E, Yulistiani D, Inounu I, Bahri S, Puastuti P, editors. Inovasi Teknologi Peternakan dan Veteriner Berbasis Sumber Daya Lokal yang Adaptif dan Mitigatif terhadap Perubahan Iklim. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner. Medan, 3-5 September 2013. Bogor (Indonesia): Puslitbangnak. p. 250-258.

Financial Analysis of Rabbit Breeding in Various Scale

Sumanto

Indonesian Research Intitute for Animal Production
Jl. Veteran III PO Box 221 Ciawi, Bogor, Indonesia
Corresponding e-mail: sumanto_d@ymail.com

ABSTRACT

One of the business structure of the industry building is rabbits breeding, which is generally considered to be less profitable and the business is rarely taken seriously in demand by farmers, but other business areas such as fattening of rabbit, collectors, and post-harvest seems more desirable because it can provide a profit margin better. To see how far the rabbit breeding value gains in rural, financial analysis has been carried out by applying a factor of production values of the average laboratory and field results at several places in Indonesia in 2012. Important results of the technical aspects as follows: birth age to the first mating 6 months, calving interval 2 months, litter size 6 heads, productivity of does 65%, mortality by 4 months of age 20%. Aspect of feed is: parent or buck 100 g/head/days, pregnant does 125 g/head/days, lactating does 200 g/head/days and post weaning- 50 g/head/days. price of concentrate feed of IDR 4,500, -/kg, rabbits for breeds IDR 300,000,-/head, rabbits for meat IDR 50,000,-/head, pre-weaning rabbits IDR 25,000, -/head, candidate breed (4 months) IDR 100.000, -/head, disposed does IDR 70,000, -/head. Individual rabbit cage IDR 125.000, -/each. Labor is family. Business management is: a. Third born female candidates for its breeds and 20% for does replacement, the rest is sold, b. 4 months old rabbit male is sale, and c. The main feed is concentrates and grass used as feed supplement. Results obtained assuming from calculating all asset value and assuming all rabbits sold. By using the initial scale rabbit (20 does +3 bucks (Scale 1) to 130 does +20 bucks (scale 2)), then the population dynamics of rabbits for 2 years is: a. Scale 1: disposed rabbits are 22 head, bunnies 120 head, candidate breed are 29 head, for replacement stock are 15 heads and the number of sales are 504 heads candidates breeds and are 59 heads. b. Scale 2: disposed rabbits are 144 heads, bunnies 783 heads, candidat breed are 190 heads, for replacement stock are 95 heads and and the number of sales are 3,924 heads and candidates breeds are 348. By using Df = 12%, IRR results for scale 1 and 2 are 35.46% and 61.93% respectively, the B/C ratio scale 1 and 2 are: 1.09 and 1.23 respectively. The IRR dan B/C ratio result lead to the conclusion that rabbit business is still bankable at an interest rate above 12%.

Key Words: Financial Analysis, Breeding, Rabbit, Scale Business

INTRODUCTION

Indonesia is rich in natural resources that available abundantly, good for businesses in agriculture and non- agriculture. In agriculture, the role is quite prominent due to the existence of farm crops and livestock functions that are supporting each other to carry the lives of millions of farmers in the countryside. The existence of livestock in Indonesia is diverse and prominent and some of them have a business orientation such as cattle, buffalo, goat, sheep, chickens, ducks and rabbits

In the meant of rabbits deployment, it was not evenly distributed in all provinces in Indonesia. The existence of a prominent rabbits farming for food supply and hobby, generally found in the location - location of tourism. While specific breeds of rabbits for a hobby or contests is maintained in many urban and generally this kind of rabbits are more expensive (higher price) than another breed that are sold for meat.

The increasing population, income levels and many more tourist sites, the level of need of meat is also increased, including rabbits meat. Along with the increasing demand for rabbits breed and rabbits meat, so a good and profitable breeding practice on rabbits is needed to maintain the quality and number of the population.

One motive attractiveness to development in rabbits breeding, is to show that the business is beneficial and profitable in the specified cycle of time. Through the rationale and the determination of the input factors, the outputs and the rabbit breeding business feasibility, this means that the analysis in general should be done, with adequate technical assumptions, before the business is taken placed.

BENEFITS OF RABBIT

For human being, rabbits farming have quite a lot roles and a functions, such as:

1. High-quality food source in the form of meat: This product contains substances most complete foods in accordance with the needs of the human body that is for basic living, for growth and development.
2. As a means of improving the quality of the environment; through a socio-economic approach, it can be seen that the development of rural and urban areas, livestock can give new hope to improve the standard of live of farmers, and also to open up employment opportunities.
3. As an alternative means of storage of funds (savings); this can be achieved when the cattle are maintained and managed properly, and at times requires the animals to be sold to obtain the desired value for money.

COMPONENTS OF BUSINESS

Rabbit breeding business component type, consisting of:

1. Component input
2. Component output
3. Components of technical coefficients and prices
4. Technical feasibility analysis.

Component input

Input component consists of:

1. Livestock: types and amount
2. Feed: forages and concentrates
3. Cages and equipment: types and amount
4. Health: drugs
5. Labor: family & wages.

In this component, it is separated between the fix components (*e.g.*: cattle, cages) and unfix components (operationals) (*e.g.*: feed, medicine, labor).

Output component

Output components consisting of:

1. Sales of rabbits: breed, rabbits virgin or young
2. Sales of waste: dung and urine of rabbits
3. Asset: rabbits, cage and equipment

TECHNICAL FEASIBILITY ANALYSIS OF BUSINESS

Analysis of this business uses techniques: Analysis of Benefit and Cost (B/C Ratio), Net present Value and Internal Rate of Return (IRR), as described by Rangkuti (2012).

Benefit and cost analysis (B/C ratio)

Cost

Cost is everything that is invested, either in the form of money, land, and buildings, labor, and other assets required in the production process to produce a particular product (Pervaiz & Knipscheer 1989). Cost is classified:

Fixed costs

Fixed costs are the types of costs during the period of work is fixed, and does not always change. Fixed costs typically associated with time, or with the agreement. Fixed costs that are usually in the form: asset depreciation, salaries, insurance, rent, maintenance, interest and indirect costs more.

Understanding of depreciation

Depreciation: is a decrease in the value of a tool/goods as a result of the increase in service life. The things that lead to the reduced value of the tool among these parts - parts that are damaged or worn due to the length of time that the use of such a device does not work with capabilities like before. The cost of depreciation is a function of the time period then use the tools we need to know. The lifespan of device can be distinguished from the two terms, namely the economic life and service life.

1. Economic life is a tool from at the age of 100% new condition to the tools/items that are no longer economical when continuously used. At the end of the economic life of these tools still have value.

2. Service life is the life of the tool from the initial purchase in 100% new condition until the device dies (damaged) and items must be removed, so that the equipment/goods at the end of service life does not have value.

Model calculation of depreciation, there are several ways, but the most practical and convenient model is in a straight line. In this model the cost of depreciation is considered the same every year, or a decrease in the value of a device is fixed to the end of its economic lifespan. How to calculate is that initial price minus the final price divided by the economic life of its economic lifespan. The equation used is:

D = (P - S)/L,
D = depreciation expense per year,
P = initial price (IDR/unit)
S = final price (IDR/unit),
L = the estimated economic life (years)

Variable costs

Variable cost are costs incurred at the time (tool/item) operates, the amount depends on the number of units of consumption. These costs go up and down together with the volume of activity. Increased production is caused the increased variable costs and also the other way. The examples of the variable costs are: food, medicine, daily labor, equipment consumables, *etc*.

Revenue

Revenue is multiplying the price by the number of products produced. Results rabbits were obtained from the sale of breeding rabbits that can be life and other products dung, urine, *etc*.

Profit and benefit (B)/C ratio

Benefit (Z) is the difference between total revenue (TP) with the total cost (TB) is required from the production and marketing of a product. If the result of benefit is positive then called profit, but if the result of benefit is negative, it is called a loss. But, B/C ratio is divided by TB. Mathematically is described as follows:

Z = TP – TB
Benefit Ratio (B/C) = TP/TB
Z = 0, means no profit and no loss (break even) or the B/C = 1
Z = positive value means to gain profit or B/C >1
Z = negative value means to obtain damages or B/C <1

Internal rate of return (IRR)

Another measurement commonly used in the feasibility analysis of a business is "internal rate of return" (IRR), which is where the interest rate such that the net present value is equal to zero. In other words, income or Discounted Benefit is equal to the discounted cost. A project is said to have economic visibility if NPV >0 or Present Value Benefit (PVB) > Present Value Benefit (PVC). This analysis is often used to analyze the economic visibility of a long-term project. IRR is the rate of return on capital employed in the project, whose value is expressed in percent (%) per annum. A project is feasible, if the calculated IRR is greater than the prevailing bank interest rate. IRR calculation formula is:

$$IRR = I' + \frac{NPV'}{NPV' - NPV''} \times (I'' - I'),$$

I' : the interest rate on the positive value
I" : the interest rate on a negative value
NPV' : the NPV at an interest rate I'
NPV": the NPV at an interest rate I"

Assumption

Technical coefficient and unit price assumptions is presented in Table 1.

Table 1. Technical coefficient and unit price assumptions

Items	Technical coefficient	Note
Birth age (month)	6.000	
Calving Interval (month)	2.000	
Litter size (head)	6.000	
Productivity of does (%)	65.000	
Pre–weaning mortality (%)	10.000	
Mortality from weaning to slaughter age (%)	10.000	
Slaughter age (month)	4.000	
Slaughter weight (kg)	2.500	
Pre–weaning age (days)	30.000	
Sex ratio	0.500	
Mortality does or bucks (%) - 6 months	1.500	
Feed consumption (gram/head/day):		
Consentrate		
Does not pregnant	0.100	
Does pregnant	0.125	
Does weaning	0.200	
Bucks	0.100	
Young to slaughter age	0.050	
Price of input- output:		
Concentrate price (IDR 000 /kg)	4.500	
Rabbit breed (IDR 000 /head)	300.000	
Rabbit Sloughter (IDR 000/head)	50.000	@ IDR 20,000/kg
Pre weaning kid (IDR 000/head)	25.000	IDR 10,000-40,000
Age = 2 days kid (IDR 000 /head)	3.000	
Does rejected (age >2 years) IDR 000 /head	70.000	
Forage (IDR 000 /head/day)	0.150	
Labour	-	Family
Cages (IDR 000/head)	125.000	
Vaccines (IDR 000/head/periode)	0.100	
Candidate breed- age ± 4 months (IDR 000 /head)	100.000	

BUSINESS MANAGEMENT

Business financial analysis of rabbits using the following rules:

1. A Third parity of female for prospective breeding stock (20% for replacement stock and 80% sold as breeding stock).
2. Born male 4 months of age sold as breeding stock-price @ IDR 100,000/head. Analysis of 2 years.
3. The main feed is concentrate. Asset cage/facilities, feces and urine are not calculated.
4. Revenue is earned from selling of male rabbits-age 4 months, breeding stock 4 months of age.
5. The rabbit business is analysed in 2 years period.

RESULTS AND DISCUSSION

The use of assumptions and scenarios result from table as mentioned earlier, has made the results of a scenario analysis of breeding rabbits in the different scale businesses (from

20 does + 3 bucks to 130 does + 20 bucks). The results of rabbit population dynamics and the value of benefits, B/C ratio and IRR are described in the Table 2 and Table 3.

Rabbit population dynamics in different inittial scale

From Table 2 shows that the total assets of the rabbit at the end of 2 years of calculation, the scale increases with the number of initial ownership of the parent rabbits. Initial scale of rabbits farming consist of 20 does and 3 bucks will yield 164 individuals (22 culled, 120 young does, 29 buck and 15 does for replacement) and the number of rabbits sold were as much as 685 heads in various ages. The conditions of rabbit assets will be different when the initial scale of the rabbits business comprised 130 does and 20 bucks that will be yielding 1,067 individuals (144 of culled, 783 of young does, 190 of young bucks and 95 does of breeding tock for replacement) and the number of sales wiil be as much as 4,452 heads in a various of ages.

Benefits, B/C ratio and IRR

From the Table 3 shows that: (a). The value of the revenue is greater than the value of the cost in each of the different scales, so that the business in all scales shows a profit, although the condition has been included the discounting factor on degrees of 12% (bank interest); (b). The value of the benefits increases with the increasing scale of the initial population of rabbits reared in the farm (eg, profits reached IDR 5.91 million at the beginning of the rabbit population of 23 heads up to IDR 83.54 million of the profit in the initial population of 150 heads); (c). The B/C ratio >1 is in all condition scale, this mean that the business is feasible. These results indicate the same assessment of the opinion of previous researchers, such as Anonymous (2010a), Anonymous (2011b), Herawati & Juarini (2007), and Nur & Subagiyo (2011) that rabbits breeding at different scales is still favorable to the value of B/C ratio between 1.72-2.70; (d). Value of IRR in all scales condition is more than 12%, so that this business is called "bankable". It’s result is the same as reported by Sumanto et al. (2012); Sumanto & Juarini (2012).

Table 2. Rabbit population dynamics in different initial scale during 2 years

Initial rabbit population	Scale of business (head)						
	20♀+3♂	40♀+6♂	60♀+9♂	80♀+12♂	100♀+15♂	125♀+18♂	130♀+20♂
Rabbit population during 2 years (head):							
Rejected does/bucks	22	44	66	88	110	137	144
Young male/female	120	241	361	482	602	753	783
Candidate does	29	58	88	117	146	183	190
Replacement for does	15	29	44	58	73	91	95
Rabbit total asset	164	328	493	657	821	1.026	1.067
Rabbit selling during 2 years (head):							
Rabbit male-age 4 months	397	794	1.191	1.588	1.985	2.481	2.580
Young does-age 4 months	207	414	625	827	1.034	1.293	1.344
Does	59	118	177	236	296	370	384
Rejected does/bucks	22	44	66	88	110	137	144

Note: ♀: does, ♂: bucks

Table 3. The Value of Benefit, B/C Ratio and IRR in Different Initial Scale for 2 years

Initial Rabbit Population	Scale of Business (head)						
	20 ♀ + 3 ♂	40 ♀ + 6♂	60 ♀ + 9 ♂	80♀ + 12♂	100♀ + 15 ♂	125 ♀+ 18♂	130♀ +20♂
Total Cost (IDR 000):	73.124	135.982	198.839	261.696	324.554	402.009	419.584
Investasi (breed, cages)	24.150	48.300	72.450	96.600	120.750	150.150	157.500
Operasionals	48.974	87.682	126.389	165.096	203.804	251.859	264.084
Revenue (IDR 000):	83.746	167.528	252.292	335.055	418.819	523.317	544.603
Benefit (IDR 000)	10.640	31.546	52.453	73.359	94.265	121.308	125.019
NPV Cost (df =12%) (IDR 000)	62.687	117.073	171.459	225.846	280.232	347.218	362.476
NPV Revenue (df =12%) (IDR 000)	68.601	137.202	205.803	274.404	343.005	428.591	446.017
Benefit (df=12%) (IDR 000)	5.910	20.129	34.344	48.558	62.773	81.373	83.540
IRR (%)	35,46	53,35	57,93	60,02	61,22	62,73	61,93
B/C Ratio (df=12%)	1,09	1,17	1,20	1,22	1,22	1,23	1,23

Remarks: df = discount factor

CONCLUSIONS

All the scale of the rabbits business (23 up to 150 heads) are profitable. According to the B/C Ratio and the IRR value, the rabbits business is bankable.

REFERENCES

Anonymous. 2010 a. Kelinci Pedaging Untuk Usaha Ternak Yang Menghasilkan. (http://prestasikelinci.wordpress.com/2010/06/17/kelinci-pedaging-untuk-usaha-ternak-yang-menghasilkan).

Anonymous. 2011 b. Analisa Usaha Kelinci. (http://prestasikelinci.wordpress.com/2011/04/19/analisa -usaha-kelinci).

Pervaiz A, Knipscheer HC. 1989. Conducting On-Farm Animal Research: Procedure and Economic Analisis. Ottawa (Canada): Winrock International Institute, USA and IDRC-Canada.

Nur H, Subagiyo. 2011. Keuntungan Usaha dalam Agribisnis Kelinci dan Peluang Pengembangannya. Seminar Nasional Pemberdayaan Petani Melalui Inovasi Teknologi Spesifik Lokasi. BP2TP, BPTP Yogyakarta, STTP Magelang dan Jurusan Penyuluhan Pertanian Yogyakarta, hlm: 552-559.

Herawati T, Juarini E. 2007. Rabbit husbandry profile in Magelang. In Proc: International Seminar on Rabbit Production in Indonesia. Bogor, Jul 24-25.

Rangkuti Freddy. 2012. Study Kelayakan Bisnis dan Investasi. 376 hal. Gramedia.

Sumanto, Budiarsana IGM, Juarini E, Broto Wibowo. 2012. Proposal Rencana Pengembangan Peternakan di Jonggol. Balai Penelitian Ternak Ciawi.

Sumanto, Juarini E. 2012. Performance and financial analisys of rabbit farming under farmers' condition in Yogyakarta and Central Java. In: Wina E, Prasetyo LH, Inounu I, Priyanti A, Anggraeni A, Yulistiani D, Sinurat AP, Situmorang P, Wardhana AH, Dharmayanti NLPI, Ilham N, James P, Asnan Z, editors. Technology innovation in support of sustainable livestock development and food security. Proceedings International Conference on Livestock Production and Veterinary Technology. Bogor, 1-4 October 2012. Bogor (Indonesia): Puslitbang Peternakan. p. 359-363.

ABSTRACT

Dietary Fibres: Their Analysis in Animal Feeding, and Their Role in Rabbit Nutrition and Health

Thierry Gidenne

INRA, UMR1289 Tissus Animaux Nutrition Digestion Ecosystème et Métabolisme,
F-31326 Castanet-Tolosan, France
Corresponding e-mail: thierry.gidenne@toulouse.inra.fr

ABSTRACT

Two centuries ago, Heinrich Einhof develops the so-called Weende method, to first deals with the fibre content of the feeds for ruminants, and proposes to isolate a residue called the "crude fibre" (Van Soest & Mc Queen 1973). Then, dietary fibre concepts evolve and differ in animal feeding compared to human nutrition and health. Animal nutritionists deals with various fibre sources, often from whole plants (forages, by products of seeds processing, etc.), and recovers a larger range of polysaccharidic components, including other polymers, such polyphenolic (lignins, tannins) or polylipidic compounds (cutins). Dietary fibre is generally defined as the polysaccharides and associated substances resistant to mammal enzyme digestion and absorption that can be partially or totally fermented in the gut. However, today this topic is still subjected to very active research, because of the complexity of the physical structure and chemical composition of the plant cell walls, and in the wide and different physiological effects of the different constituents. The importance of dietary fibre in animal feeding is due to its influence on rate of passage, mucosa functionality and its role as substrate for gut microbiota that relates to performances and digestive health. Our review will consider briefly the definition and structure of the different classes of fibre and of cell wall constituents, followed by a description of some analytical methods employed for animal feeds. Secondly and as an example, the nutritional role and impact of fibre intake on digestive health will be described for the growing rabbit, since as a monogastric herbivore this animal is a very pertinent research model, and is of interest for meat production in western-Mediterranean and east countries.

Key Words: Dietary Fiber, Analysis, Nutrition, Health

Full text of paper published in Indonesian Bulletin of Animal and Veterinary Science "Wartazoa" 2013, Volume 23 Number 4

The Current Status and Development of Rabbit Industry in China

Yinghe Qin

College of Animal Science and Technology, China Agricultural University, No.2 Yuanmingyuan West Road, Haidian District, Beijing 100193, P.R.China
Corresponding email: qinyinghe@cau.edu.cn

ABSTRACT

With the rapid development of China's economy, rabbit farming has become an important measure to improve farming income, especially in impoverished areas. In recent years, the Chinese rabbit industry has achieved great progress, not only through the increase in the output of rabbit products, but also the significant improvements in rabbit farming technology. From 2001 to 2011, rabbit meat production in China increased from 406,000 tons to 731,000 tons, accounting for an average annual rabbit meat growth rate of 7.98% over ten years. Conversely, over the same time period, the average annual growth rate for pork, beef, poultry, and sheep meat were 2.47%, 2.73%, 4.12%, 4.50%, respectively. Consequently, the percentage of rabbit meat compared to all animal meat increased from 0.66% in 2001 to 0.92% in 2011. However, accompanying the good performance of China's rabbit industry, a number of realistic challenges must be faced. The global economic crisis of recent years has impacted the export of Chinese rabbit products, and the increase in the price of foodstuff and labor will inevitably affect the income and profit of those involved in the rabbit industry. In developed areas of China, strict emission controls require the construction of high standard rabbitries to meet environment requirements. In addition, the extreme temperature changes in northern and southern China during summer and winter negatively impact rabbit reproductive performance. The quality and supply of rough feed, as well as disproportionate rabbit production in different areas, causes dramatic product price fluctuations. These factors have motivated farmers and companies to search for effective solutions. Due to the diversity in local environments, feed material supplies, rabbit production organizations, even different economic cultural traditions, various provinces and areas have developed different strategies to deal with feed supply and the frequently changing market. Farmers and companies have adopted their own improvements and increased their flexibility to meet the needs of the consumer in order to realize their goals, such as high efficiency or high product quality to gain profit. The Chinese provinces of Sichuan, Shandong and Zhejiang represent three typical rabbit industry models. Rabbit science research, innovation and new technology play important roles in increasing the sustainability of rabbit farming and transforming it into a competitive industry. Problem-solution driven studies and development, cooperation in rabbit production and research, large scale training, and government encouragement and support are critical. Fostering and developing the Chinese domestic market is becoming increasingly important and should be a long-term mission of this industry.

Key Words: Status, Development, Rabbit Industry, China

Development of Rabbit Production in Costa Rica

Andrea Brenes Soto

Alternative Livestock and Zoo Animal Program, Animal Nutrition Research Center,
Animal Science Department, University of Costa Rica, San José, Costa Rica
Corresponding e-mail: brenes.andrea14@gmail.com

ABSTRACT

Usually rabbits are thought as pet so, there is little tradition in consuming rabbit meat, and thereafter a restricted number of slaughterhouses cause incipient meat distribution and market alternatives. The Costa Rican rabbit production is carried out through small/average farms. Farms raise crossbred animal, mainly involving New Zealand White breed with Californian, Chinchilla, Palomino, Rex and English Spot. Also, rabbits have been used as laboratory animals and even pets, which caused new breeds introduction and new production goals in the country. The lack of official slaughterhouses is another reason for the unexpressive rabbit meat commercialization. The producers sometimes feel discouraged to invest in the activity. The absence of an efficient productive chain causes small or average producers to commercialize their products in informal markets. Family rabbit production is a strategy at small and middle scale. The growing of backyard rabbit rearing was started back in the 1900´s. With this system, the farmer and his family can count on a better quality protein source and, at the same time, commercialize the surpluses in the markets and another part of the population mainly the urban has access to this. In 2000 was registered the largest export of rabbit meat in the entire decade, where the majority of the product was sent to Nicaragua and Hong Kong (38,05 and 26,58 ton per year respectively). By 2003, the commercialization of rabbit meat was controlled by one organized-group named Carnes Sanas, producing 300 kg meat/week and then increasing up to 25 ton/month. Therefore, another group, Ticonejo, made an alliance with Carnes Sanas and raised the production, but after one year the group stopped their activities. In 2008 the exports to Nicaragua were maintained with a volume of 16,67 ton, United States of America with 25,86 ton and small quantities to Colombia (1,82 ton) and Panama (0,85 ton). From that year to 2010, the producers started to abandon the production because of the lack of solutions to sustain the rabbit breeding activity. Several farms survived like small or mediums systems, and only one kept an important market in the country. Important difficulties related to the commercialization appeared because of the falling demand of rabbits for exportation and a domestic market without development. The target market in Costa Rica then changed trying to enhance the national consumption. At this moment, 20% of the total market belong to two big farms which sell meat to two big chains of supermarkets and keeping farms with an average of 300 does and a meat production around 450 kg meat/month; 60% of farms have between 25 to 60 does, distributing the product in restaurants, hotels and retail, meanwhile the remaining 20% belongs to small systems with 5-10 does. Medium and small farmers can obtain 20 -200 kg/month. Pet producers maintain from 30 to 240 does from different breeds, and genetics producers have from 20 to 60 does. The majority of rabbits` farms are located in rural areas far from San Jose, the capital. More than 80% of rabbit population is found in high lands of the country, characterized by moderate climates (except in the coast), fertile ground and agriculture based in small properties, predominantly familiar. Recently a flagrant demand from high cuisine and touristic industry claimed market organization and suggest production growth. Although there´s not a national policy established to stimulate the rabbit production, the government through the National Service of Animal Health (SENASA), has the responsibility to supervise these farms working on the sanitary control and the implementation of a unique register of producers and breeders. As a high percentage of the farms are medium, many of them use alternative forages to supplement the concentrate basis diets and low costs. Species used include tropical forage sources with high percentage of soluble or insoluble fiber, like nacedero (*Trichanthera gigantea*), morera (*Morus alba*), churristate (*Ipomoea purpurea*), poro (*Erhthrina* sp.) and grazes like kikuyo (*Pennisetum clandestinum*), estrella (*Cynodon plectostachium*), transvala (*Digitaria decumbens*). Almost all systems transform rabbit manure in compost high in organic matter, nitrogen, calcium, iron, copper, zinc and manganese, using the compost in crops` fertilization, for example coffee, cabbage and potato, among others. The Costa Rican rabbit production system is a viable alternative to the high quality meat production at small and middle scale, with ecological management quite useful due to its application in other regions of the continent. The Animal Science Department started the Alternative Livestock Program in 2008, and since then it is developing research and extension projects about rabbit production in Costa Rica, as well as stimulating the rabbit meat consumption through tasting session, giving information about meat nutritional characteristics, and showing to the consumers the differences between rabbits for meat production and rabbits for keeping as pets. Despite all the effective problems it is perfectly possible to exceed the current barriers starting with marketing politics for the sector and quality product improvement in the market, with added information for cooking. Rabbit production should be recognized as an activity with low ambient impact and that can be associated to other productive activities using agroindustry residues and other agricultural byproducts. In change, it will provide high speed of weight gain and expressive reproductive indices.

Key Words: Costa Rica, Rabbit, Meat, Pet, Production

Intake Growth and Digestion of The Growing Rabbit Fed Alfalfa Hay or Green Whole Carrot: First Results

Goby JP, Huck C, Fortun-Lamothe L, Gidenne T[2]

[1]Perpignan University, IUT, Ch. Passio Vella, 66860 Perpignan, France; [2]INRA, UMR1289 TANDEM, BP52627, 31326 Castanet-Tolosan, France
Corresponding e-mail: thierry.gidenne@toulouse.inra.fr

ABSTRACT

As an herbivorous animal, it is relevant to use plants or vegetable sources in rabbit rearing, and more particularly by vegetable products non concurrent of the human feeding. However most of the data on rabbit nutrition were obtained with pelleted feeds containing dehydrated and grinded raw materials. The carrot, as whole plant, is readily available in area producing carrots for human consumption, since over the half of the carrot production is not calibrated for canning factory and is considered as wastes. We thus aimed to measure, with the direct method, the digestibility for two fibre sources, either in a dried form (alfalfa hay) or under a green form (whole carrot discarding). We also aimed to measure the performances of the rabbit: growth, health and intake capacity. A trial was conducted at the experimental farm of the Perpignan University (IUT), to assess the performances and digestion (direct method) of the growing rabbit fed hay or green vegetable source: alfalfa hay (AH) and green whole carrot (GWC). The GWC was collected every two days, in fresh form from production wastes of one farm (area of Perpignan, France). The alfalfa hay (2d cut, sun dried) was produced in the area of Perpignan (Ariège). At weaning (40d), 3 groups of 5 rabbits (crossbred line, NZW.x Cal. x PS119) were housed individually in metabolism cages, and were fed ad libitum the pelleted feeds till 49d old, as an adaptation period to the cages. Then, two groups were fed either the alfalfa hay or the GWC as a sole feed, and one group remained to be fed with the pelleted diet (control group: C). Faecal collections were achieved individually after a 7d adaptation period to the feeds and lasted 11d, from 56 to 67d old. The dry matter content of the GWC is low compared to that of AH or to pellets (C). AH and GWC are well balanced feeds in terms of fibre and protein content, and could be given as a sole feed to the rabbit to measure directly their digestibility. The intake level of the control group (C) were in agreement with classical data obtained on a commercial pelleted feed. For the GWC, and after a 7 days adaptation period, the intake capacity of the 8 weeks old rabbit was very high, since they were able to ingest more than 600g of this green fodder per day and per rabbit, corresponding to 40% of their live-weight. Even, during this period, every morning, feeders of the group GWC were alway empty; thus suggesting that the maximum threshold for the intake capacity was not reached. In contrast, the intake capacity for the alfalfa hay was relatively low (84g/d), even after a 7d adaptation period. The bulking capacity of the hay (high for the rabbit) may explain this moderate intake. Expressed as DM intake, GWC ranged before the AH, but remained 40% below the intake of a pellets. Moreover, during the adaptation period (49 to 56d old), the feed intake was probably lower for GWC and AH. However, from 56 to 67 d old were registered a positive growth for the AH and GWC groups (12 and 15 g/d resp.), while the growth of the control group was meanly of 54 g/d. The DM digestibility of GWC averaged 86%. The digestion of AH was moderate (56%) and relatively variable. In conclusion, the rabbit showed a very high intake capacity for a green fodder such the whole carrot. The intake capacity for alfalfa hay was moderate and required and adaptation period.

Key Words: Rabbit, Alfalfa Hay, Green Whole Carrot, Intake, Growth

Effects of Dietary Arginine Supplementation During Whole Pregnancy on The Reproductive Performance and Plasma Biochemical Parameters of Rabbit Does

Wenpei Song, Wangping Li, Yinghe Qin

College of Animal Science and Technology, China Agricultural University, Bejing 100193, P.R. China
Corresponding e-mail: qinyinghe@cau.edu.cn

ABSTRACT

The effect of dietary arginine supplementation during whole pregnancy (from d 0 to 31 of gestation) on the reproductive performance and plasma biochemical parameters of rabbit does was studied. A total of 223 good body condition Hyla parent rabbit does with body weights of 4268 ± 206 g were assigned randomly into three groups based on body weight, representing the control, 0.4% Arg treatment, and 0.8% Arg treatment. The control rabbits were fed a basal diet, the 0.4% Arg rabbits were fed a basal diet supplemented with 0.4% L-arginine, and the 0.8% Arg rabbits were fed a basal diet supplemented with 0.8% L-arginine. Reproductive performance, feed intake and body weight changes in the rabbits, as well as plasma amino acids, urea, NO, T-NOS concentration on d 0, 10, 20 of gestation were measured. The results showed that dietary supplementation with L-arginine during the whole pregnancy markedly enhanced the reproductive performance of rabbit does. Compared with the control group, 0.4% Arg supplementation increased live-born kits by 1.28 per litter ($P>0.05$), litter birth weight of all kits born alive by 78.4 g per litter ($P>0.05$), litter birth weight of all kits born by 39.17 g per litter ($P>0.05$); For rabbits in the 0.8% Arg supplementation group, kits born alive increased by 2.21 per litter compared with the control group ($P<0.01$), litter birth weight of all kits born alive increased by 142.86 g per litter ($P<0.01$), litter birth weight of all kits born increased by 111.33 g per litter ($P<0.01$), and there was a significant improvement compared with the control group. There were no significant differences for the other parameters, such as total number of kits born, number of kits born dead, litter birth weight of all kits born dead, and average birth weight of kits born alive, between treatment groups ($P>0.05$). Moreover, compared with the control group, 0.8% Arg supplementation sharply increased the average daily feed intake of the rabbits by 20.89 g per day ($P>0.05$). On d 0 of gestation, the plasma indicators did not differ among the three treatment groups. On d 10 of gestation, 0.4% Arg supplementation markedly increased plasma arginine, glycine, hydroxyproline, NO, T-NOS concentrations ($P<0.05$), and 0.8% Arg supplementation markedly increased plasma arginine, isoleucine, methionine, threonine, glycine, ornithine, hydroxyproline, urea, NO, T-NOS concentrations ($P<0.05$), but both arginine supplementation groups showed a marked decrease in plasma phenylalanine concentration ($P<0.05$). On d 20 of gestation, 0.4% Arg supplementation markedly decreased plasma alanine concentration ($P = 0.004$), and 0.8% Arg supplementation markedly increased plasma arginine and ornithine concentrations ($P<0.05$), while other biochemical indexes did not differ ($P>0.05$). Therefore, dietary supplementation with arginine during whole pregnancy could improve the number of kits born alive, live litter birth weight and total litter birth weight, as well as the metabolism of amino acids in the blood and an increase in the synthesis of NO and the expression of T-NOS.

Key Words: Arginine, Rabbit Does, Number of Kits Born Alive, NO

A Review of Rabbit Diseases in Egypt

Hamed A. Mohammed[1], Amal AM Eid[2] and El-BakreyRMM[2]

[1]*Department of Animal Medicine*
[2]*Department of Avian and Rabbit Medicine Faculty of Veterinary Medicine, Zagazig University, Egypt*
Corresponding e-mail: info@zu.eu.eg

ABSTRACT

Promising approaches of the Egyptian governmental as well as non-governmental society to rabbit industry in a trial to overcome the unemployment of youth in the society required more efforts from scientific institutes to help in development of such industry. Epidemiological studies are of outmost importance to highlight disease nature and to help in meantime implement of successful preventive and control measures. The aim of this paper is to review the situation of rabbit diseases of economic impact in Egypt (1952 to 2013) in the light of available national literature. The most breeds that are reared in Egyptian rabbit farms are floundering, Belgian, French, Erks, Hi-plus, Native, New Zealand, Chinchilla, Gabali and Moshtohor. The system of housing of rabbits was battery and ground breeding systems. Enteritis in rabbits has many causes parasitic and bacterial causes are the commonly recorded in Egypt. Clostridium species, *Escherichia coli, Staphylococcus aureus*, and Salmonella species and all they usually were isolated from young rabbits. Rabbit industry is promising in Egypt to be developed. A national committee consisting of representatives of agencies with legislative responsibility for assessing and improving rabbit industry should be established.

Key Words: Rabbit, Disease, Egypt, Breed

Full text of paper published in Indonesian Bulletin of Animal and Veterinary Science "Wartazoa" 2013, Volume 23 Number 4

Selection of A Precocious Line of *Eimeria Magna* and Evaluation of It as A Vaccine Component

Fang S[1,2], Cui P[2], Gu X[2], Liu X[1], Suo X[1]

[1]*National Animal Protozoa Laboratory & College of Veterinary Medicine*
China Agricultural University, Beijing, 100193, China
[2]*Colloge of Animal Science and Technology, Hebei North University, Zhangjiakou, 075000, Hebei, China*

ABSTRACT

Coccidiosis is an important parasitic disease in rabbits. Bunnies are usually infected with several coccidia species in the genus of *Eimeria,* resulting in diarrhea, weight loss, and death. Although chemotherapy has been widely used for the controlling of coccidiosis, alternative approaches have to be developed as more and more resistant strains have appeared and concerns of meat safety because of drug residue is growing. In this study, coccidia species infecting rabbits and the infection rate were investigated in Zhang Jiakou city, Hebei province. Strains of *Eimeria magna* were isolated in coccidian-free rabbits using the single oocyst isolation technique, a precocious line was selected, and the feasibility using the precocious line as a vaccine component was evaluated. The research results were as follows: 1) Single oocyst isolation: six strains of *E. magna* were isolated from Zhang Jiakou of Hebei province, Wuji of Hebei province, Leshan of Sichuan province, Zhoushan of Zhejiang province, Kunming of Yunnan province, Nanjing of Jiangsu province. Among 18 coccidia-free rabbits inoculated with a single oocyst of *E. magna,* 16 rabbits shed oocysts, isolation rate of the species was 88.9%; no difference in oocyst production was found among different geographical strains. 2) Pathogenicity of the parent strain: The patent period and peak of oocyst excretion were consistent but oocyst outputs varied with different inoculation doses, rabbits inoculated with 5×10^3 oocysts produced the highest number of offspring oocysts. Compared with the control group, infection groups presented clinic syndrome and lesions to different degree, affected rabbits were anorexia, weight loss, diarrhea, decreased appetite and drinking, as well as excreting soft faeces and loose stool, these changes were rather obvious in the 1×10^4 and 1×10^5 groups, whose tissue sections showed that villi were damaged to different degrees and microvilli destroyed. 3) Selection of a precocious line: 45 days coccidian-free rabbits were inoculated with oocysts of 6 original strains of *E. magna* and the first newly developed oocysts recovered from the intestine and stomach were used for infection of other rabbits. The prepatent period was shortened after 20 passages from 156 to 132 hours, shortened by about 20 h and remained stable after 5 passages without selection pressure. Morphologic features of precocious line oocysts differed from those of original strains but difference is not significance in size; sporulation time of the precocious line was shorter than that of original strains, by 2~4 hours. The oocyst production of original strains is about 536 times higher than that of the precocious line, which was less pathogenic and had reduced reproductive capacity. The pathogenicity and immunogenicity study showed the precocious line was attenuated and remained the immune-protective potent of its parent strain. 4) Phylogenetic analysis: 18S rDNA of the precocious line of *E.magna* was respectively aligned with that of the parent strain of *E. magna* and those *E.magna* in the Genbank, identity was 99.8%; the ITS-1 region1 gene of the precocious line of *E.magna* was also aligned with that of the parent strain of *E.magna* and those in the Genbank, identity is 94.7% and 93.1%, respectively. The phylogenetic tree showed that 18S rDNA and ITS-1 region of the precocious line, parent strain of *E.magna* and *E.magna* strains in the Genbank formed a monophyletic cluster. 5) Endogenous development of the precocious line: The endogenous stages mainly parasitized the jejunum and ileum, including three asexual generations and one sexual generation. Two types of meronts were observed in each asexual generation. The first asexual generation of meronts occurred 48h post inoculation (p.i.), the second was 72 h p.i. and the third was 96 h p.i. The macrogamonts and microgamonts took place in 96~108h p.i. The mature oocysts were found 120 h p.i. This is the first report of precocious line selection of rabbit coccidia in China and the selected precocious line was attenuated and its immunogenicity was maintained, indicating its feasibility as a vaccine component.

Key Words: Rabbit, Eimeria Magna, Anti-coccidial Vaccine, Precocious Selection

The Antifungal Activity of *Phellodendron chinense* Schneid Ethanol Extract Against Trichophyton Mentagrophytes in Rabbits

Xiao Chenwen, Ji Quanan, Bao Guolian, Liu Yan, Wei Qiang

Institute of Animal Husbandry and Veterinary Science, Zhejiang Academy of Agricultural Sciences, Hangzhou, Zhejiang 310021, PR China, Phone: +86-571-86400373; Fax: +86-571-86400836
Correspondence e-mail: xiaochenwen.1979@yahoo.com.cn

ABSTRACT

Trichophyton mentagrophytes disease in rabbits could induce hair removal, scab, dandruff and itching, the disease spreads quickly and damage rabbit industry seriously. The bark from the Phellodendron tree has been used as traditional Chinese medicine for curing gastroenteritis, abdominal pain or diarrhea and various inflammatory diseases including arthritis and dermatophytosis. The present study was undertaken to evaluate the antifungal effects of ethanol extract of *Phellodendron chinense* (PAEE) against *Trichophyton mentagrophytes in vivo* and *in vitro*. The milled dried bark was extracted with 75% ethanol at 80°C three times under reflux for 2 h. The combined solution was concentrated with a rotary evaporator at 45° to a concentration of PAEE (2 g/ml). Minimum inhibitory concentration (MIC) was measured using agar-diffusion method with little modification. In brief, serial volume of PAEE or clotrimazole (as the positive control) (0, 0.5, 1, 1.5, 2, 2.5 or 3 mg dissolved in 0.2 ml DMSO) were gently mixed with 100 ml of Tryptic soy agar (TSA), poured into sterile petri dishes and incubated at 45 °C for 15 min. The final concentration of the PAEE in TSA was 0.00, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06 g/ml. Then, 1.0×10^6 CFU/ml eumycete suspension was inoculated and incubated for 72 h. The MIC was taken as the lowest concentration of PAEE or clotrimazole to inhibit growth of the fungus. Each experiment was carried out in duplicate. *In vivo* antifungal assay, 30 New Zealand white rabbits, 31 days old, weighing 400-450 g were divided into five groups consisting of six rabbits in each by simple random method, a suspension (1 ml, 1.0×10^6 cells) of *T. mentagrophytes* was applied to the marked area using a sterile pipette-tip and rubbed thoroughly for 3 consecutive days (1, 2, 3 d). Various concentration of PAEE (group PA1, PA2, PA3) formulations or clotrimazole (group PC) or distilled water (group NC) were applied topically on day 4 and continued up to day 7 (4, 5, 6, 7 d). The lesions were evaluated from the day of post-infection to 10th day continuously. The clinical evaluation was consisted of a semi-quantitative score. During quantitative analysis, the total alkaloids in PAEE was found 7.58±0.46 mg/ml. *In vitro* studies, the MIC values for PAEE and clotrimazole were 1.5% (0.03g/ml and 0.02 mg/ml, respectively). The influence of different doses of PAEE on the growth of *T. mentagrophytes* was also detected by dry weight determination. In addition, transmission electronic microscopy was performed to observe the effect of PAEE on cell ultrastructure and it showed that PAEE destroyed the cell membrane of *T. mentagrophytes*. Furthermore, dermatophytosis infection model in rabbit with *T. mentagrophytes* was established for investigating the effect of PAEE (PA1, PA2, PA3) *in vivo*. The efficacy of each group was PA1 (81.9%), PA2 (87.5%), PA3 (86.1%), PC (83.3%), NC (0.00), respectively. All treatment groups showed the inhibitory effects of PAEE against *T. mentagrophytes*. It can be concluded that PAEE has significant of antifungal activity and could be used as a treatment to *T. mentagrophytes* in rabbits.

Key Words: Phellodendron Chinense, Trichophyton Mentagrophytes, Antifungal, Rabbit

Production Performance of Weaned Rabbit in Household Farming at Different Weaning Age

Yurmiati H, Dwi Cipto B, Nurul N

Faculty of Animal Husbandry, Padjadjaran University
Jl. Raya Bandung-Sumedang km 21, West Java, Indonesia
Corresponding e-mail: husmyyurmiati@gmail.com

ABSTRACT

In any production system, rabbit productivity will be uniquely influenced by complex interaction of environmental, biological and socio economic variables. Many New Zealand White crossbred rabbits are raised by many farmers in Indonesia with the main purpose as a meat producer, so that it needs a good management. One of them is an appropriate weaning age. The purpose of this research was to obtain the production performance of kids in different weaning age which are breeding in household farming. The research was conducted in Desa Kertawangi, Kecamatan Cisarua, Lembang toward 120 kids of New Zealand White breed from 18 rabbit parents, parity two and three. The kids production trait evaluated are litter size, mortality, weaning weight, growth rate, and slaughter weight till weaning 8 week. The result shows that the best production performance of kids was obtained when weaned at 7 weeks with mortality before weaning (15.00%) and after weaning (23.37%), litter size 6-8 kids, weaning weight 850.90 g, growth rate 181.17 g, and slaughter weight 1.02 kg.

Key Words: Production Performance, Rabbits, Weaning Age

Weight Gain and Dressing Percentage of Rabbits Feeding Different Levels of Nacedero (*Trichanthera gigantea*)

Andrea Brenes-Soto

Alternative Livestock and Zoo Animals Program, Animal Nutrition Research Center, Animal Science Department, University of Costa Rica, San José, Costa Rica
Corresponding e-mail: brenes.andrea14@gmail.com

ABSTRACT

Production performance, including weight gain and dressing percentage, of rabbits fed with different levels of Nacedero (*Trichanthera gigantea)* were evaluated. The experiment was conducted in a commercial farm located in San Ramon, Alajuela. Thirty weanling animals (California breed) were used, randomly distributed among three treatments: T1: Control: 100% commercial extruded diet, T2: 85% concentrate and 15% Nacedero fresh leaves, T3: 70% concentrate and 30% Nacedero fresh leaves. Animals were individually weighed weekly for 8 weeks, then slaughtered at 88 days of age and dressing percentage calculated. Significant differences ($p<0.05$) were found between animals from treatments 1 and 2 compared to treatment 3 (Tukey test). Treatment 3 showed the lowest final weight ($p = 0.003$), weight gain ($p = 0.008$) and dressing percentage ($p = 0.002$). Animals initial weights had an important effect in all parameter responses ($p = 0.02$). Average initial weights were 441, 403 and 418 g; weight gain was 19, 19 and 17 g/animal/day and dressing percentage was 55, 54 and 51% for animals from treatments 1, 2 and 3, respectively. Food intake was significantly less in animals from treatments 1 and 2 compared to control ($p<0.05$). It is suggested that a 15% of inclusion of fresh Nacedero foliage in diets for fattening rabbits did not affect productive performance; inclusion of up to 30% decreased productivity. Responses using dry and ground Nacedero must be evaluated further.

Key Words: Food Intake, Nutrition, Weight Gain, *Orytolagus cuniculus*, *Trichanthera gigantea*

Rabbit and the Hadith of Holy Prophet Muhammad SAW

Zainuddin MZ

Faculty of Islamic Theology IAIN Sunan Ampel Surabaya
Corresponding e-mail: zainhadis@gmail.com

ABSTRACT

Rabbits are prolific animal, able to grow and reproduce rapidly from forage or concentrate, does not require a large place, fairly simple enclosure. In addition, rabbits are also easy to be arise, both on the small scale as household scale to large scale as industry. Because of this, rabbits are suitable to be developed as an asset in the economic empowerment of rural communities. In Indonesia, despite the potential interest of breeders and the demand of rabbit is quite high, the demand for meat and other processed products of animal rabbits have not increased significantly. People are still accustomed to eating chicken and beef. In fact, the price of chicken and beef is much more expensive than rabbit meat. In term of nutrition, rabbit meat is also not inferior to beef and chicken. Rabbit meat can also be made other processed products such as nuggets, sausages, meatballs, shredded, dried meat, and so on. Minimal demand for rabbit meat is affected by the uncertainty in the Muslim community about meat rabbit is allowed to be eaten (halal) or not (haram). Among ‘Ulama’ (term of address for Islam teacher) rabbit meat is forbidden to be eaten (haram). In most history of mentioned that rabbits are including animals that have undergone maskh (changed from one form into another form). Therefore, eating rabbit meat is haram. Prophet said: monkeys, pigs, dogs, elephants, wolves, rats, rabbits, lizards and other animals that are experiencing maskh and are not allowed to be consumed. Another argument said that prohibition of eating rabbits because rabbit has claws like a cat. In another history, Ridha said: Blood rabbits have similar to woman, therefore meat rabbit is haram. Contrary to the decision of the committee of Indonesian Ulama (MUI) about eating rabbit meat. MUI in its meeting in Jakarta on March 12, 1983, established a law that consuming rabbit meat is halal. It is based on the hadiths of the Holy Prophet. Anas narrated, he said: Crossing in front of us a rabbit in Marri Zahran, then people chased and caught it, and I found it, then I give to Abu Thalhah and slaughtered it. And he sent its thighs to the Prophet and he accepted it, in another narration He eats the meat. (Narrated by Bukhari and Muslim). Accuracy haram and halal rabbit meat can certainly be explained on the credibility and accuracy of the transmission of the hadiths, in addition to other secondary means such as on the benefits and loses, not the generality caused by clawed. Based on the claws, even chicken has claws, but all Ulama decide that chicken meat is halal. The same is obtained for other animals that experienced maskh (changed from one form into another form). According to Sri Martini, expert of rabbit who is also a lecturer at the Veterinary of Padjadjaran University, Bandung, rabbit meat contains high protein and directly absorbed by the body, giving rise to energy. Because it produce energy, emerging myth that rabbit meat can make a man more strong virility. Actually, meat rabbits do not differ much with goat meat, but meat rabbits have higher content of protein and very little fat than goat meat. The explanation scientific above and the other opinion, simply by writer, the authenticity of the hadiths that explain rabbit meat is halal sharpen, as patterned by the Prophet ever. Beside of the uncertainty issue of halal-haram, still many people are reluctant to consume meat rabbits. It caused by rabbit characteristics that cute and fun pet. In this case, the author proposed two things. First, the naming of "rabbit" is replaced with "arnab", so the placard "rabbit satay" was changed to "arnab satay", which means word of ‘arnab’ as same as rabbit. The second suggestion is more on the management in the rabbit farm which clearly requires the existence of institutions so that management of rabbit farm can be more professional.

Key Words: Rabbit, Halal, Haram, Hadith

Effects of Dietary α-Linolenic Acid on Growth Performance, Meat Quality, Fatty Acid Composition and Liver Relative Enzyme mRNA Expression of Growing Meat Rabbits

HT Du, Wang CY, Wang XP, Ma MW, Li FC

College of Animal Science and Technology, Shandong Agricultural University, Tai'an, Shandong, 271018, P.R. China
Corresponding e-mail: *chlf@sdau.edu.cn*

ABSTRACT

One hundred and fifty crossbred rabbits of New Zealand white rabbits × local white rabbits (9 weeks old) were allocated to five groups and to evaluate the effects of five levels of α-linolenic acid (ALA) addition (0, 1, 2, 3 and 4 g/kg diet, as-fed basis) in the diets on growth performance, meat quality, fatty acids composition of muscle and liver, acetyl-CoA carboxylase (ACC) and carnitine palmitoyl transferase 1 (CPT1) mRNA expression in the liver of growing meat rabbits were studied. The quadratic effect of ALA addition on average daily intake (ADI) was obtained ($P<0.0001$). ALA addition had significant influence on muscle color of longissimus lumborum (LL) included L^*, a^* and b^*($P < 0.0001$, $P = 0.0007$ and $P = 0.0120$, respectively). The monounsaturated fatty acids (MUFAs) content of LL decreased with dietary ALA increase ($P = 0.0001$) and the polyunsaturated fatty acids (PUFAs) and C18:3 (n-3) contents in the LL and liver increased with dietary ALA increase ($P = 0.0006$, $P<0.0001$, $P<0.0001$, and $P<0.0001$, respectively). The acetyl-CoA carboxylase (ACC) mRNA expression in the liver decreased ($P<0.0001$) and carnitine palmitoyl transferase 1 (CPT 1) mRNA expression in the liver increased ($P<0.0001$) with dietary ALA increase.

Key Words: Rabbit, α-Linolenic Acid, Growth Performance, Meat Quality, Fatty Acid, mRNA Expression

LIST OF PARTICIPANTS

Name	Institution	Country
AANB Kamandalu	Bali Assessment Institute for Agricultural Technology	Indonesia
A Razak Alimon	Faculty of Agriculture Universiti Putra Malaysia	Malaysia
Adelia Maria	Indonesian Research Institute for Animal Production	Indonesia
Amed Hasan Daader	President Secretary of ERSA - Egyptian Rabbit Science Association, Faculty of Agriculture, Zagazig University	Egypt
Andrea Brenes Soto	Alternative Livestock and Zoo Animals Program, Animal Nutrition Research Center, Animal Science Department, University of Costa Rica, San José	Costa Rica
Armadani	Samarinda Fishery and Livestock Service	Indonesia
Arnold Sinurat	Indonesia Research Institute of Animal Production	Indonesia
Asep Kurnia Saputra	Indonesian Research Institute for Animal Production	Indonesia
Atien Priyanti	Indonesian Center for Animal Research and Development	Indonesia
Attawit Kovitvadhi	Faculty of Veterinary Medicine, Kasetsart University, Thailand	Thailand
Avita Sheikadena	Indonesian Research Institute for Animal Production	Indonesia
Bambang Ngaji Utomo	Indonesian Research Center for Veterinary Science	Indonesia
Bao Guolian	Institute of Animal Husbandry and Veterinary Sciences, Zhejiang Academy of Agricultural Sciences, Hangzhou	China
Bess Tiesnamurti	Indonesian Center for Animal Research and Development	Indonesia
Bram Brahmantyo	Indonesian Research Institute for Animal Production	Indonesia
Cisilva	Directorate of Livestock Breeding, Ministry of Agriculture	Indonesia
Dadang Sudarman	Indonesian Research Institute for Animal Production	Indonesia
Dinh Van Binh	Vietnamese Rabbit Production Association	Vietnam
Do Trong Phat	Ho Chi Minh University of Techonology	Vietnam

Name	Institution	Country
Dwi Retno Lukiwati	Diponegoro University	Indonesia
Dwistha Satya Pradika	Pradika Rabbit	Indonesia
Dyarta W	General Directorate of Livestock and Animal Health, Ministry of Agriculture	Indonesia
Elizabeth Wina	Indonesian Research Institute for Animal Production	Indonesia
Enih Sukaenih	Indonesian Research Institute for Animal Production	Indonesia
Engkus	Bali, Assessment Institute for Agricultural Technology	Indonesia
Fauzi Luthan	General Directorate of Livestock and Animal Health, Ministry of Agriculture	Indonesia
Fawzan Sigma Aurum	Bali, Assessment Institute for Agricultural Technology	Indonesia
Francois Lebas	Cuniculture Association	France
Franki Polii	Minahasa Agricultural, Livestock and Plantation Service	Indonesia
Gao Yanxu	President of ARPA, CEO, Kangda Food	China
Gerolamo Xicatto	Dpartment of Animal Science, University of Padova, Agripolis, 35020, LEGNARO	Italy
Ha Thi Hoa		Vietnam
Hamed A Mohamed	Department of Animal Medicine, Faculty of Veterinary Medicine, Zagazig University	Egypt
Haryono	Indonesian Agency for Agricultural Research and Development	Indonesia
Hastho Yulianto	Directorate General of Processing and Marketing for Agricultural Products	Indonesia
Helene Lebas	-	France
Henny Nuraini	Department of Animal Production and Technology, Faculty of Animal Science. Halal Science Center, Bogor Agricultural University	Indonesia
Himas Ayu Pertiwi	Pradika Rabbit	Indonesia
Husmy Yurmiati	Faculty of Animal Husbandry, Padjadjaran University	Indonesia
I Ketut Kariada	Bali, Assessment Institute for Agricultural Technology	Indonesia
I Ketut Mahaputra	Bali, Assessment Institute for Agricultural Technology	Indonesia

Name	Institution	Country
I Made Londra	Bali, Assessment Institute for Agricultural Technology	Indonesia
I Made Mangku Pastika	Governor of Bali	Indonesia
I Made Rai Yasa	Bali, Assessment Institute for Agricultural Technology	Indonesia
I Made Wiska Antara	East Kalimantan, Assessment Institute for Agricultural Technology	Indonesia
I Nyoman Adhijaya	Bali, Assessment Institute for Agricultural Technology	Indonesia
I Putu Sumantra	Disnak Keswan Bali	Indonesia
I Putu Suratmini	Bali, Assessment Institute for Agricultural Technology	Indonesia
IA Parwati	Bali, Assessment Institute for Agricultural Technology	Indonesia
IGN Badi Wangsa	Klungkung Livestock Service	Indonesia
Jemmi Rinaldi	Bali, Assessment Institute for Agricultural Technology	Indonesia
Jernih Rosida	Indonesian Research Institute for Animal Production	Indonesia
Komarudin	Indonesian Research Institute for Animal Production	Indonesia
Kumbawan	Samarinda Fishery and Livestock Service	Indonesia
Kusmayadi Suradi	Faculty of Animal Husbandry, Padjadjaran University	Indonesia
L Hardi Prasetyo	Indonesian Research Institute for Animal Production	Indonesia
Laping Wu	College of Economics and Management, China Agricultural University, Qinghua	China
Lai Songjia	Institute of Animal Genetics and Breeding, Si Chuan Agricultural University	China
Li Fu Chang	College of Animal Science and Technology, Shandong Agricultural University	China
Lin Jin Yun		China
Liu Yan	Institute of Animal Husbandry and Veterinary Sciences, Zhejiang Academy of Agricultural Sciences, Hangzhou	China
Lounarto Pilipus	Private sector	Indonesia
Luc Maertens	Ministry of the Flemish Community, Institute for Agricultural and Fisheries Research (ILVO), Animal Sciences, Melle	Belgium

Name	Institution	Country
M Baihaqi	Department of Animal Production and Technology, Faculty of Animal Science, Bogor Agricultural University	Indonesia
M Mastika	University of Udayana, Bali	Indonesia
M Zainuddin	Agency for Food Security and Agricultural and Livestock Extension Services, Bantaeng	Indonesia
Made Ngurah Arsana	Bali Plantation Service	Indonesia
Maijon Purba	Indonesian Research Institute for Animal Production	Indonesia
Margaretha P	Private sector	Indonesia
Marini Kuhon	Minahasa Agricultural, Livestock and Plantation Service	Indonesia
Mark Grobner	Department of Biological Sciences, California State University, Stanislaus	USA
Mukti Ali	East Kalimantan, Assessment Institute for Agricultural Technology	Indonesia
Nasrullah	Indonesian Research Institute for Animal Production	Indonesia
Nguyen Ngoc nam	Vietnam Rabbit Association, Hanoi	Vietnam
Nguyen Thi Hoa	Hue University of Agriculture and Forestry	Vietnam
Nguyen Thi Kim Dong	Faculty of Agriculture and Applied Biology, Can Tho University, Vietnam	Vietnam
Nguyen Van Thu	Faculty of Agriculture and Applied Biology, Can Tho University, Vietnam	Vietnam
Nguyen Xuan Trach	Hanoi University of Agriculture	Vietnam
Noldy Nayoan	Minahasa Agricultural, Livestock and Plantation Service	Indonesia
Pande Gede Arya Saputra	District of Karangasem Livestock Service	Indonesia
Pham Thi Nga	Information Centre for Agriculture and Rural Development	Vietnam
Phan Ngoc Minh		Vietnam
Pierre Dermawan	Private sector	Indonesia
Qin Yinghe	College of Animal Science and Technology, China Agricultural University	China
R Suryadi	Himakindo IB-WRSA	Indonesia
Rita S Pasha	Bantaeng Agricultural and Livestock Service	Indonesia
Rossuartini	Indonesian Research Institute for Animal Production	Indonesia

Name	Institution	Country
SA Abd. EL-Latif	Department of Animal Production, Faculty of Agriculture, Minia University	Egypt
Saiful Muhtadin	Denpasar Agricultural Quarantine Agency	Indonesia
Samantha	-	China
Setyo Adhie	Directorate General of Processing and Marketing for Agricultural Products	Indonesia
Sofyadi	Directorate General of Processing and Marketing for Agricultural Products	Indonesia
Soni Sopiyana	Indonesian Research Institute for Animal Production	Indonesia
Subandryo	Indonesian Research Institute for Animal Production	Indonesia
Sugianto	Samarinda Resilience Agency for Food and Implementation Guidance	Indonesia
Sulastri	Samarinda Fishery and Livestock Service	Indonesia
Suriansyah	Samarinda Resilience Agency for Food and Implementation Guidance	Indonesia
Susana IWR	Indonesian Research Institute for Animal Production	Indonesia
Syamsu Alam	Bantaeng Agricultural and Livestock Service	Indonesia
Syarifuddin	Indonesian Research Institute for Animal Production	Indonesia
Tati Herawati	Indonesian Research Institute for Animal Production	Indonesia
Thang Thanh Hoa		Vietnam
Thierry Gidenne	INRA	France
Triana Susanti	Indonesian Research Institute for Animal Production	Indonesia
Tuti Haryati	Indonesian Research Institute for Animal Production	Indonesia
Veeram Muralidhara Reddy	Rabbit Development Center, Matha socio educational society,Veeram Muralidharareddy Foundation	India
Vu Dinh Tho		Vietnam
Wu Laping	College of Economics and Management, China Agricultural University, Qinghua	China
Wu Zhonghong	College of Animal Science & Technology,China Agricultural University	China
Xiao Chenwen	Institute of Animal Husbandry and Veterinary Science, Zhejiang Academy of	China

Name	Institution	Country
	Agricultural Sciences	
Xun Suo	National Animal Protozoa Laboratory & College of Veterinary Medicine China Agricultural University, Beijing	China
Yono C Raharjo	Indonesian Research Institute for Animal Production	Indonesia
Yuliana	Samarinda Fishery and Livestock Service	Indonesia
Yuliesynoor	General Directorate of Livestock and Animal Health, Ministry of Agriculture	Indonesia
Yulvian Sani	Indonesian Research Center for Veterinary Science	Indonesia
Yusra	Directorate of Livestock Breeding, Ministry of Agriculture	Indonesia
Zainuddin	Faculty of Islamic Theology IAIN Sunan Ampel Surabaya	Indonesia
Zhang Xiangyu	Research Institute of Rabbit, Sichuan Animal Science Academy	China
Zhang Zongcai	National Engineering Laboratory for Clean Technology of Leather Manufacture Sichuan University, Chengdu	China
Zhao-Hui-ling	Institute of Animal Husbandry and Veterinary Medicine, Anhui Academy of Agricultural Sciences	China

AUTHOR INDEX