FEEDING STRATEGIES OF GREEN FORAGES ASSOCIATED WITH LOCAL SUPPLEMENT RESOURCES INCREASING INCOME FOR RABBIT PRODUCERS AND BENEFITS FOR ENVIRONMENT IN RURAL AREAS IN VIETNAM

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

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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 2008[b])

Intake (g/rabbit/day)	Treatment					SEM/P
	PS0	PS20	PS40	PS60	PS80	
Para grass	77.70[a]	64.90[b]	51.50[c]	39.00[d]	28.70[e]	1.52/0.01
Psophocarpus scandens (PS)	0.00[a]	12.20[b]	25.30[c]	30.20[d]	39.90[e]	0.71/0.01
DM	93.50[a]	93.00[ac]	92.70[ab]	85.00[bc]	84.50[b]	1.82/0.01
OM	84.00[a]	83.60[ab]	83.50[ab]	76.70[ab]	76.30[b]	1.63/0.01
CP	10.90[a]	12.40[b]	14.00[cd]	13.80[c]	15.00[d]	0.32/0.01
NDF	51.60[a]	48.80[ab]	46.10[b]	40.40[c]	38.10[c]	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)	1,860[a]	1,955[ab]	2,075[b]	1,943[ab]	2,027[ab]	42.1/0.04
Daily weight gain (g/rabbit)	15.10[a]	17.30[ab]	18.20[b]	16.30[ab]	17.50[ab]	0.62/0.04
Feed conversion ratio	6.20[a]	5.40[ab]	5.10[b]	5.27[b]	4.83[b]	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 W0.75, 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.

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Feeding strategies of green forages associated with local supplement resources increasing income for rabbit producers and benefits for environment in rural areas in Vietnam

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INTRODUCTION

☞ The world is faced with a global triple crisis including food, energy and climate change, interrelated and interactive.

- 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 are that world cereal grain availability for livestock will be highly restricted, while the GHG emissions increased if more ruminants raised.

INTRODUCTION

- Climate change, sea level rise, serious outbreak & environmental pollution from animal production industry also cause some changes of sustainable livestock systems.
- Rabbit meat produced basically from forages available with better efficient use of plant protein, while producing less methane compared to the ruminants (Crutzen *et al.* (1986), and Belenguer *et al.* (2008). The most capable of supporting themselves through small-scale farmers practices that integrate food and fuel production from renewable energy systems.

INTRODUCTION

- Rabbit industries use mainly concentrate pellets with high price, while not available in the rural areas. In there where the small holder farmers rely on green forages available with the low cost production and better profits.

- Thus, this also allows the small producers could produce the organic meat and reach the International markets. However, the limitation of the green forage feeding is low performance and poor quality products.

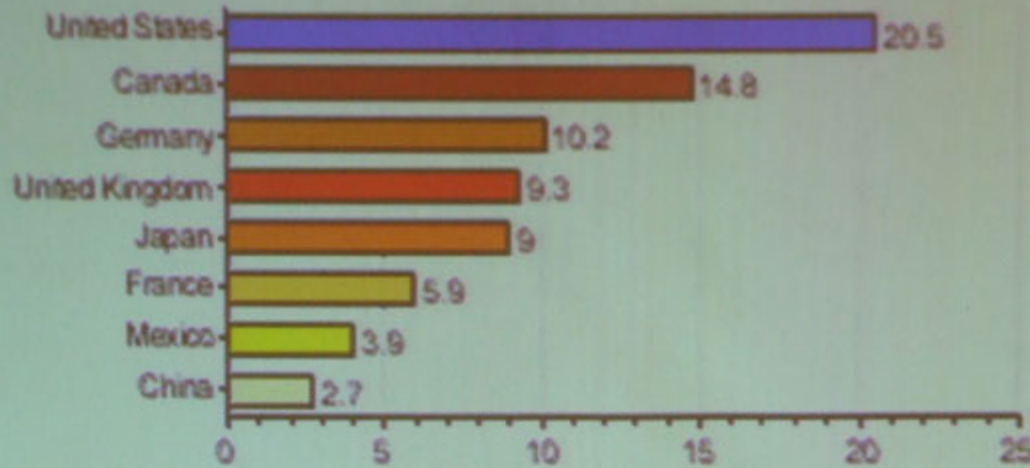
- To improve rabbit performance and better quality products the well balanced-nutrient diets should be considered, particularly on the rabbit nutrition of dietary protein, energy and fiber and vitamin minerals.

INTRODUCTION

- Thus the development of the rabbit feeding systems based on available green forages could be useful for farmers
- This paper aims to introduce the overall research results of rabbit feeding strategies in Vietnam, adapting to climate changes, food and energy crisis with some alternatives, which are relevant for the existing resources of the tropical developing countries.

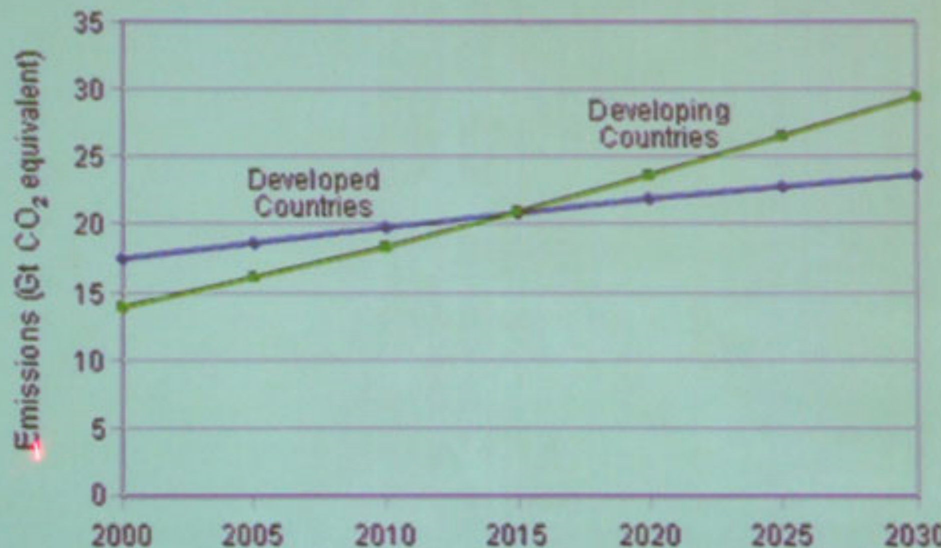
International Carbon Dioxide Emissions

Per capita emissions of carbon dioxide in metric tons, 1995



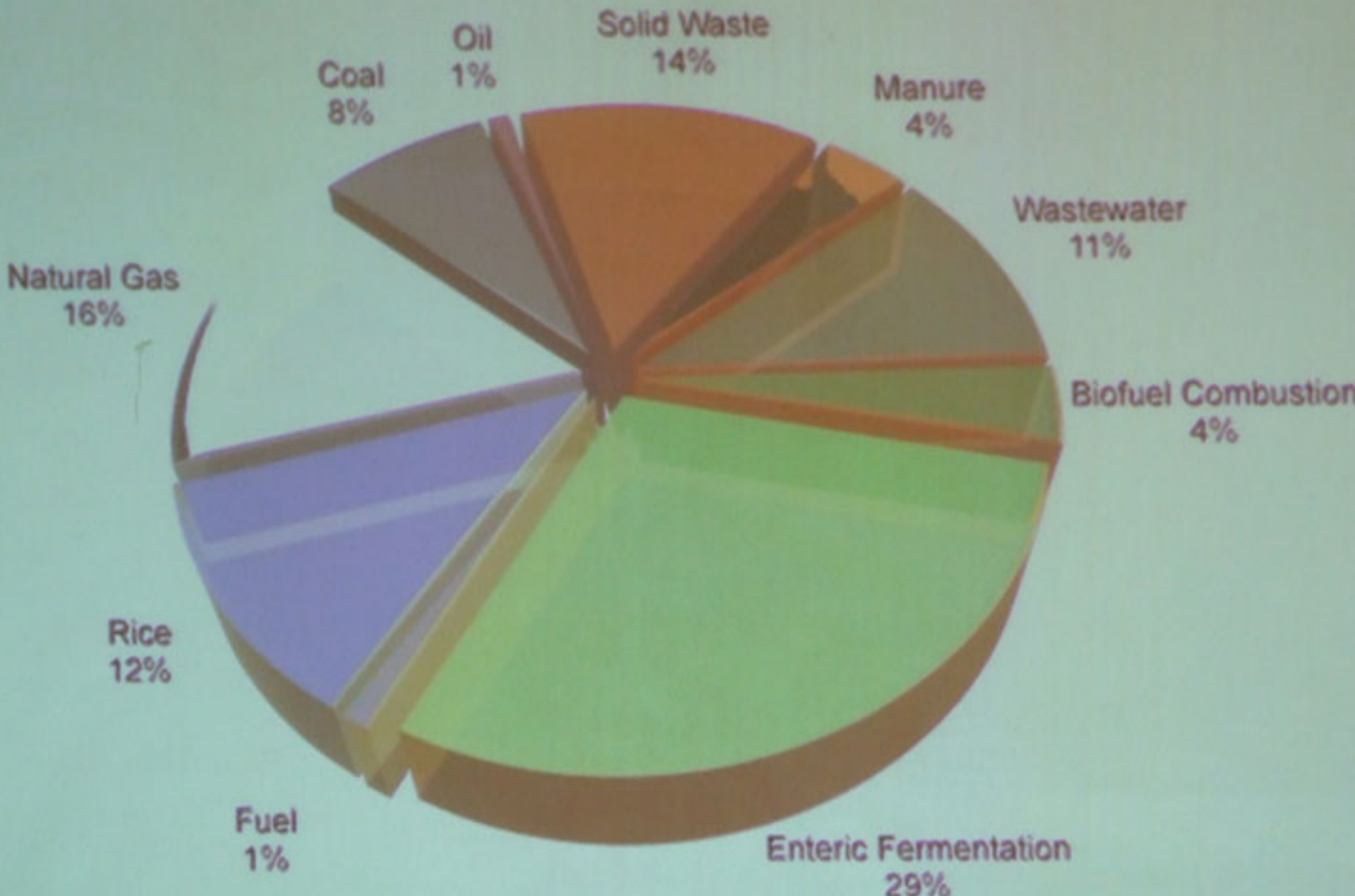
Note: Carbon dioxide is considered a greenhouse gas

Source: "World Resources 1998-99," 1998, World Resources Institute



1 Gt = 10^9 metric tons = 1 billion metric tons = 1 petagram (Pg)

Methane emissions

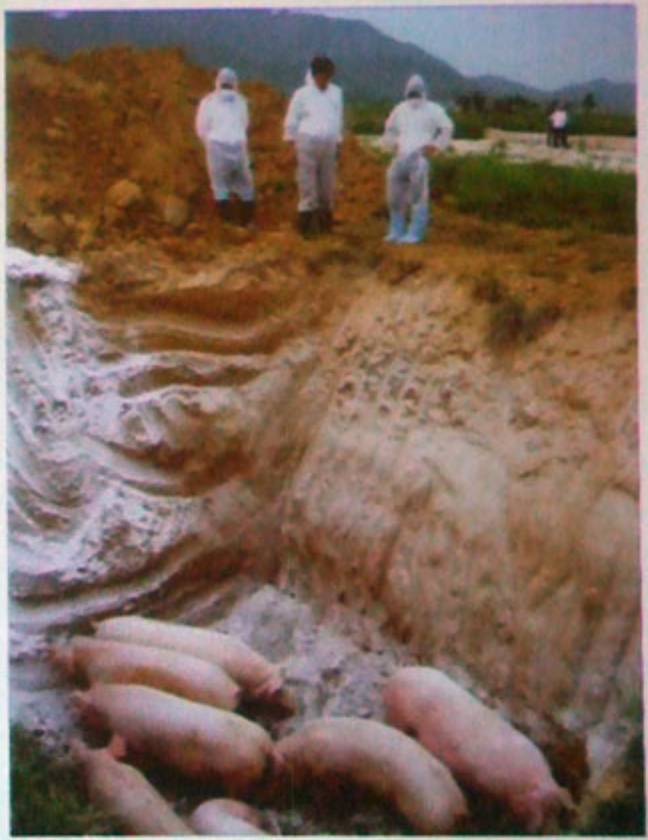


Global Methane Emissions from Human Activities (2006)

(Source: M2M 2006)

Disease outbreak

i.e. Porcine Reproductive & Respiratory Syndrome (PRRS)



Climate change & animal production

- Climate change and sea level rise by GHG emissions effect is now accepted as occurring and cannot be ignored in any discussion on agriculture.
- The crop and animal production systems are changed adapting to the drought, flooding and saline water effects in number of areas in many countries. i.e. local breeds stand the brackish areas
- We must now enter a stage in the world where grain-based animal production will become increasingly <u>expensive</u>.

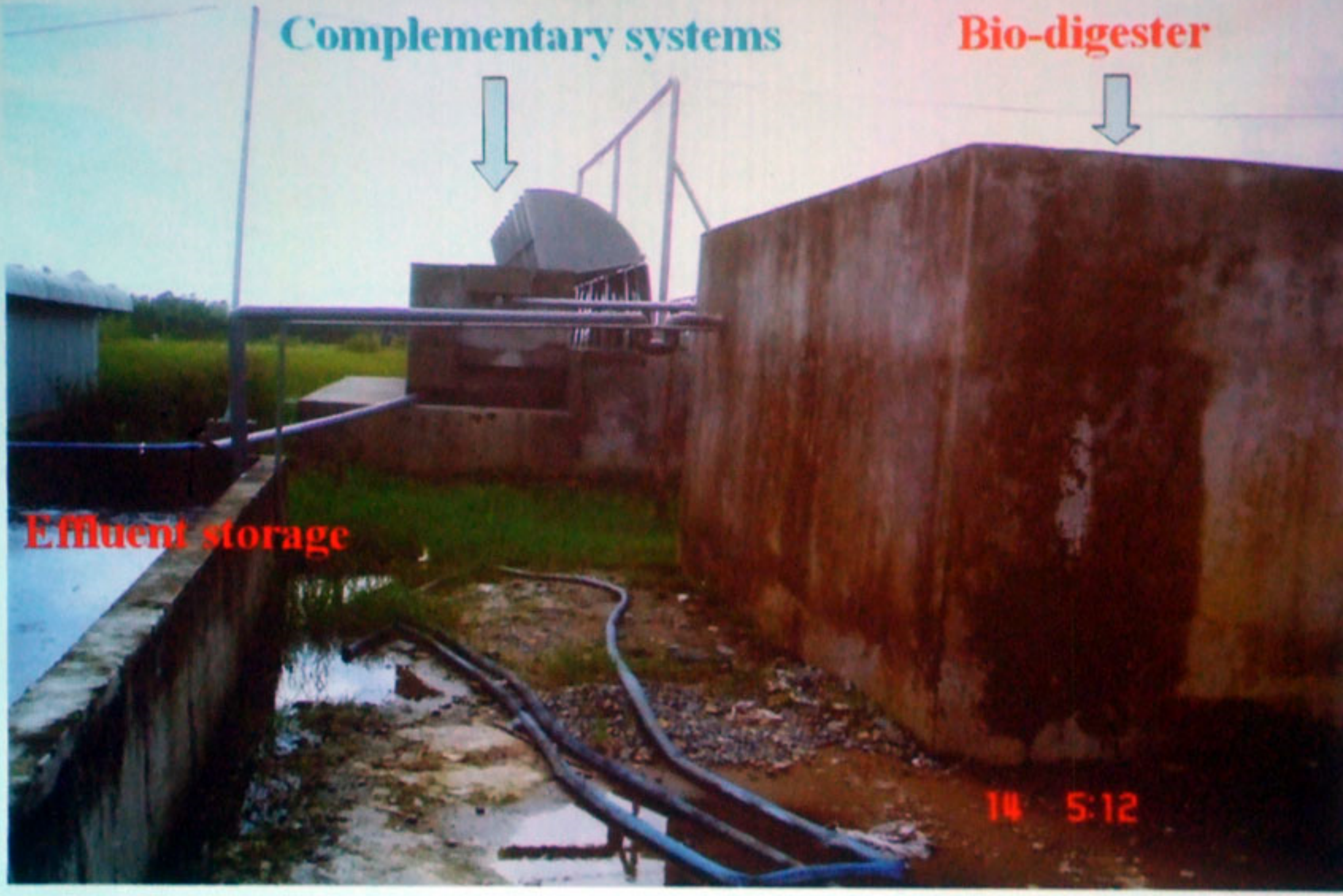
Bird flu outbreak

Environmental polution
By pig wastes

Planting grass for carbon sequestration and animal feeds

[1 hectare (2.47 Acres) of tropical grass can capture as much as 60,000 kgs (133,000 lbs) of CO_2 per year (DORSUS, 2011)]

Water hyacinth in the water ways of Mekong delta, Vietnam



Modified bio-digester for using plant materials

Guinea pig

Horse

Good animal species for future ?

Rabbit

Feeding strategies of green forages supplements

Availability of local green forages

- Give more chances for the producers to utilize the locally available feed resources without payment
- Rabbits seem to prefer the fresh feeds.
- Green forage feeding would generate more profits and environmental benefits and could also encourage the producers to utilize lands for growing more grasses and other plants.
- In tropical developing countries forages are unlimited resources.
- **Some problems:** high moisture and wide-range variation of nutrient composition. Therefore it is necessary to adjust dry matter intake and the dietary components

Chemical composition and metabolizable energy of forages

Table 1. Chemical composition (%DM) of forages as rabbit feeds (Nguyen Van Thu & Danh Mo, 2008).

Forages	DM	OM	CP	EE	CF	NDF	ME, MJ/kgDM
Brachiaria multica	18.5	89.9	9.50	3.70	25.7	67.1	8.23
Paspalum atratum	20.1	92.4	9.50	3.80	32.8	69.5	6.58
B. Ruziziensis	19.6	89.7	9.90	4.10	29.5	67.5	7.44
Pannicum maximum	18.3	89.2	10.2	2.70	31.2	69.3	6.78
Mucana pruriens	17.8	88.1	20.9	7.10	27.6	48.5	9.13
O turpethum	11.9	87.9	15.5	6.50	21.2	38.8	10.2
Phyllanthus niruri	20.2	92.4	11.9	8.70	24.9	42.3	9.55
Wedilia trilobata	10.4	83.9	12.7	8.90	15.5	38.2	11.8
Brassica oleracea 1	7.60	84.5	14.8	5.30	15.3	21.6	11.3
Brassica oleracea 2	8.80	82.1	17.0	6.10	13.4	24.3	12.0
Impomoea quatica	10.9	86.9	28.9	8.30	11.3	25.9	13.7
Amaranthus caudatus	12.9	82.2	24.8	3.00	26.5	42.1	8.80
Ipomoea batatas	9.10	86.2	19.7	9.40	15.0	32.1	12.5
Commelina palidusa	9.80	84.9	16.6	5.50	18.8	45.3	10.6

Green forages as a basal diet

Water hyacinth (*Eichhornia crassipes*)

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. Chemical composition of Water hyacinth

Feeds	DM	OM	CP	NDF	Ash	ME, MJ/kgDM
Water hyacinth	**7.63**	82.5	**11.7**	57.3	17.5	8.29
Para grass	**16.9**	88.7	**11.0**	**68.0**	11.3	8.23
Cassava chip	87.7	96.9	2.84	15.2	3.15	14.6
Soya waste	9.52	94.5	19.1	42.8	5.50	11.2

Rabbit feeds for the Exp

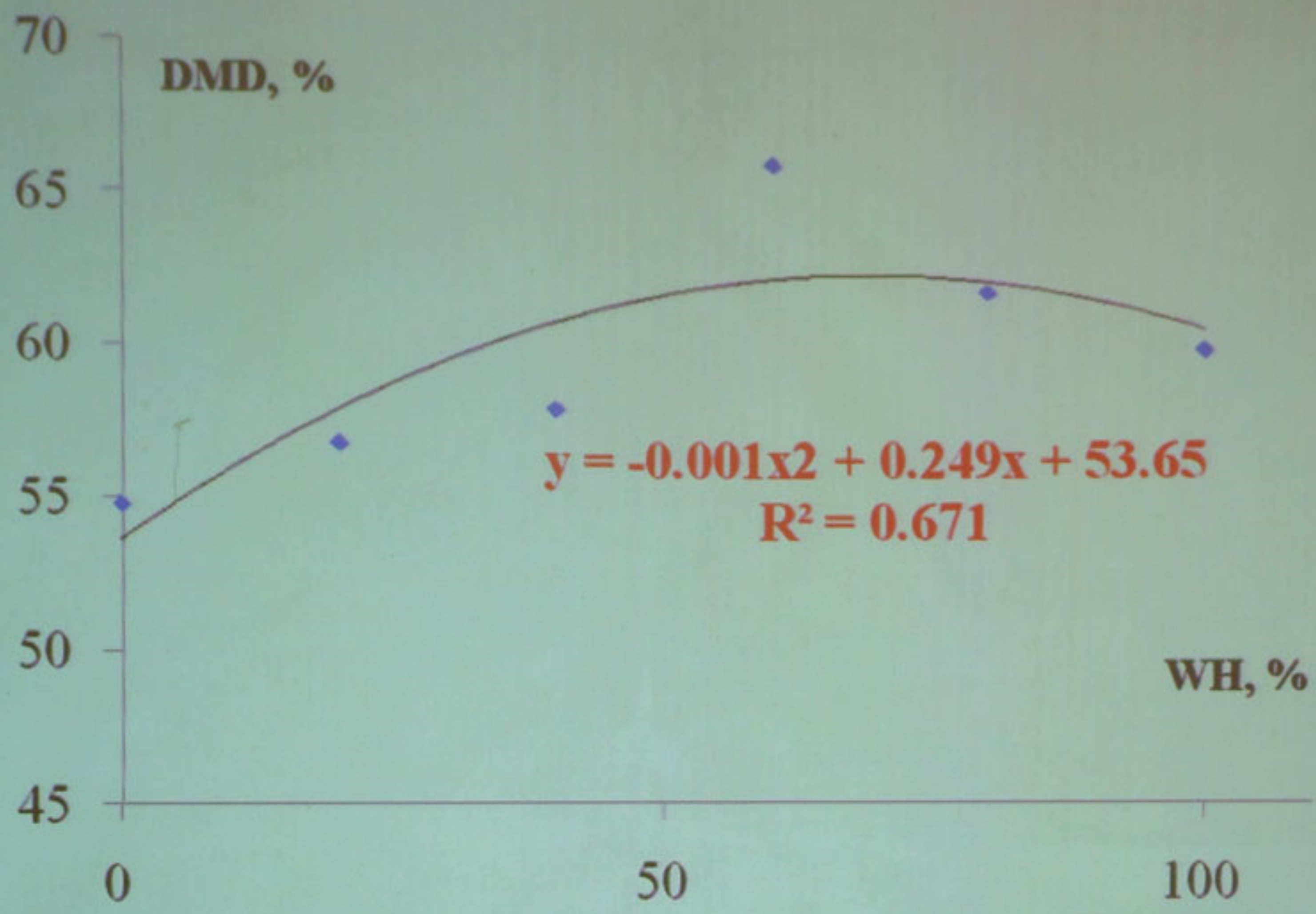


Fig 1. The DMD (%) effected by WH replacement

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

Item	Treatment						SEM/P
	WH0	WH20	WH40	WH60	WH80	WH100	
Final LW, 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	18.9[a]	19.3[a]	19.6[a]	19.0[a]	16.2[c]	14.0[c]	0.955/0.0
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	-
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	-


Wedelia trilobata

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 (Nguyen Thi Vinh Chau and Nguyen Thi Kim Dong, 2010).

	Treatment*						SEM	P
	WT0	WT20	WT40	WT60	WT80	WT100		
Wedelia trilobata	-	12.3[a]	24.7[b]	36.3[c]	45.1[d]	39.0[d]	4.34	0.001
Para grass	59.0[a]	54.0[ab]	41.3[b]	31.9[b]	28.5[b]	0.00[c]	3.10	0.001
Concentrate	61.4	61.4	61.4	61.4	61.4	61.4	-	-
Total DM	120[ab]	128[ab]	127[a]	130[a]	135[a]	100[b]	4.34	0.006
CP	21.9[a]	22.2[a]	22.2[a]	22.5[a]	22.1[a]	17.0[b]	0.452	0.001
NDF	51.3[a]	53.6[a]	50.3[a]	47.5[a]	49.8[a]	28.8[b]	2.83	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

Table 6. The reproductivity of does of litter 3 fed different levels of to replace Para grass (Nguyen Thi Vinh Chau and Nguyen Thi Kim 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	35.4	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	39.5	0.748
Milk production of litter. g/d	76.7	72.2	83.8	87.4	83.4	76.1	5.91	0.474
Daily weight gain of kitten, g	8.20	9.40	9.36	11.4	10.3	11.0	1.26	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	-	-

water spinach
(Ipomoea aquatica)

Paddy rice

Mom grass
(*Hymenachne acutigluma*)

sweet potato vine (*Ipomoea batatas*)

water spinach (*Ipomoea aquatica*)

Mom grass
(*Hymenachne acutigluma*)

Cuc (*Wedelia spp*)

* Thirty six growing male rabbits of 60 days of age allocated in a complete randomized design with 6 treatments and 3 replicates

* Six treatments: water spinach (WS), sweet potato vine (SP), WS and Mom grass (WS+M), WS and Cuc (WS+C), SP and Mom grass (SP+M) and SP and Cuc (SP+C). Rate of the two green feeds in diets was 1:1 (DM basis).

* Paddy rice was added all the diets with the same level of 30g/day/experimental unit

Table 7. Chemical composition (% DM) of feeds used in the Exp

Raw feeds	DM	OM	CP	NDF	ADF	Ash
Water spinach	9.63	89.1	18.1	37.2	25.0	10.9
Sweet potato vine	8.56	87.6	18.8	41.4	29.6	12.4
Mom grass (*H. acutigluma*)	15.7	90.7	12.4	66.3	36.9	9.32
Cuc (*Wedelia spp*)	12.1	84.5	10.0	41.8	34.3	15.5
Paddy rice	87.4	93.6	6.68	29.1	15.8	6.37

DM:dry matter, CP:crude protein, OM: organic matter, NDF: neutral detergent fiber, ADF: acid detergent fiber.

Table 8. feed and nutrient intakes (g/rabbit/day) in Exp (DM)

Intakes (g DM / d)	Treatments						Sig. P value
	WS	SP	WS+M	WS+C	SP+M	SP+C	
Sweet potato vine	-	44.5[a]	-	-	26.4[b]	24.2[b]	0.001
Water spinach	43.9[a]	-	29.5[b]	26.7[b]	-	-	0.001
Mom grass	-	-	18.6	-	20.5	-	0.001
Cuc	-	-	-	19.4	-	21.9	0.001
Overall intakes (g/d)							
Dry matter	60.7	61.4	65.0	63.2	64.0	63.0	0.220
Organic matter	55.0	54.9	58.9	58.1	57.6	55.5	0.200
Crude protein	9.07	9.47	8.77	7.90	8.63	7.83	0.070
NDF	21.2[a]	23.3[a]	30.3[b]	22.9[a]	31.8[b]	24.1[a]	<0.001

WS: Water spinach, SP: Sweet potato vine, M: Mom grass and C: Cuc

Table 9. Daily weight gain (g), feed cost and economic return (VND/rabbit) of rabbits in Exp

Parameters	Treatments						P value
	WS	SP	WS+M	WS+C	SP+M	SP+C	
Ini. Weight	790	780	730	760	730	758	0.836
Final weight	1985[a]	1818[ab]	1780[ab]	1825[ab]	1725[b]	1767[b]	0.030
DWG, g/d	17.7[a]	15.8[ab]	15.0[ab]	15.2[ab]	14.2[b]	14.4[b]	0.032
FCR	3.35[a]	3.91[a]	4.34[b]	4.15[b]	4.50[b]	4.39[b]	0.005
Feed cost	26 385	22 269	20 721	19 897	16 707	16 491	-
Total cost	46 385	42 269	40 721	39 897	36 707	36 491	-
Income	59 550	54 550	53 400	54 750	51 750	53 000	-
Profit	13 165	12 281	12 679	14 853	15 043	16 509	-

WS: Water spinach, SP: Sweet potato vine, M: Mom grass and C: Cuc

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

Crude protein (CP) supplementation

Replacing grass by higher CP forages in diets

Psophocarpus scandens *Para grass*

* 30 growing female rabbits (New Zealand x local breed) at 60 days of age, a complete randomized design with 5 treatments and 3 replications.

* Treatments: replacements of para grass (*Brachiaria mutica*) by *Psophocarpus scandens* at levels of 0, 15, 30, 45 and 60% (DM basis), while the concentrate supplementation was the same in all treatments of 15g /day/rabbit.

* At 105 days of age, feeds offered,, feces and urine collected frefusalsor nutrient digestibility and nitrogen retention measurement. Exp period was 70 days.

Table 11. Chemical composition of feeds used in Exp

Feed	DM	OM	CP	NDF	Ash
Para grass	19.1	89.6	9.92	61.6	10.4
P. scanden	14.0	90.4	23.1	41.8	9.60
Concentrate	87.0	91.1	20.0	23.6	8.90

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

Table 12. Feed and nutrient intakes of rabbits in Exp 1

Intake (g/rabbit/day)	Treatment					±SE/P
	PS0	PS15	PS30	PS45	PS60	
Para grass	77.7^{a}	64.9^{b}	51.5^{c}	39.0^{d}	28.7^{e}	1.52 / 0.01
P. scanden (SS)	0.00^{a}	12.2^{b}	25.3^{c}	30.2^{d}	39.9^{e}	0.71 / 0.01
DM	93.5^{a}	93.0^{ac}	92.7^{ab}	85.0^{bc}	84.5^{b}	1.82 / 0.01
OM	84.0^{a}	83.6^{ab}	83.5^{ab}	76.7^{ab}	76.3^{b}	1.63 / 0.01
CP	10.9^{a}	12.4^{b}	14.0^{cd}	13.8^{c}	15.0^{d}	0.32 / 0.01
NDF	51.6^{a}	48.8^{ab}	46.1^{b}	40.4^{c}	38.1^{c}	1.04 / 0.01

SS0: no Psophocarpus scanden (SS), SS15: SS replace 15% PG, SS30: SS replace 30% PG, SS45: SS eplace 45% PG, SS60: SS replace60% PG

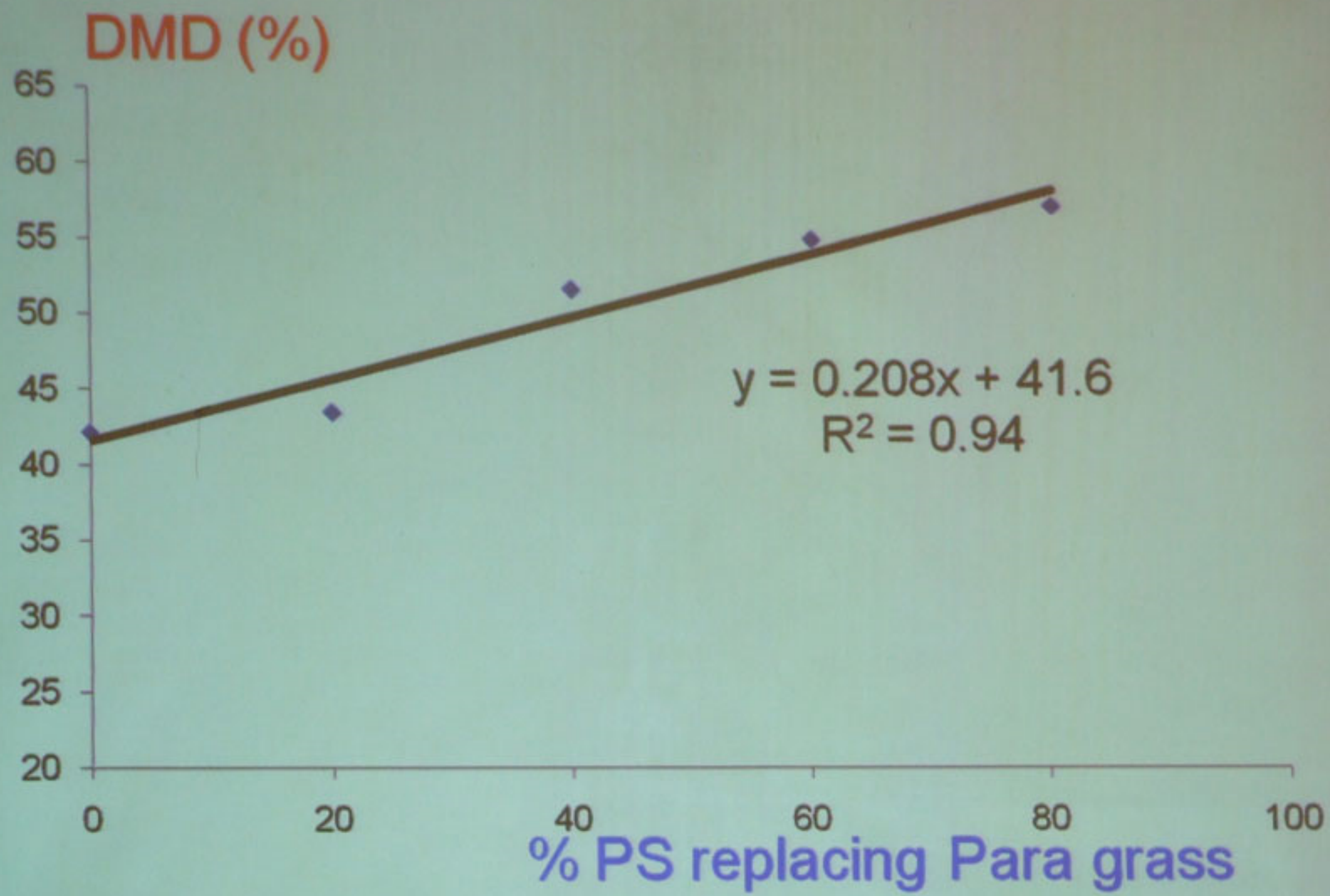


Fig 2. Relationship of PS replacement to Para grass and DM

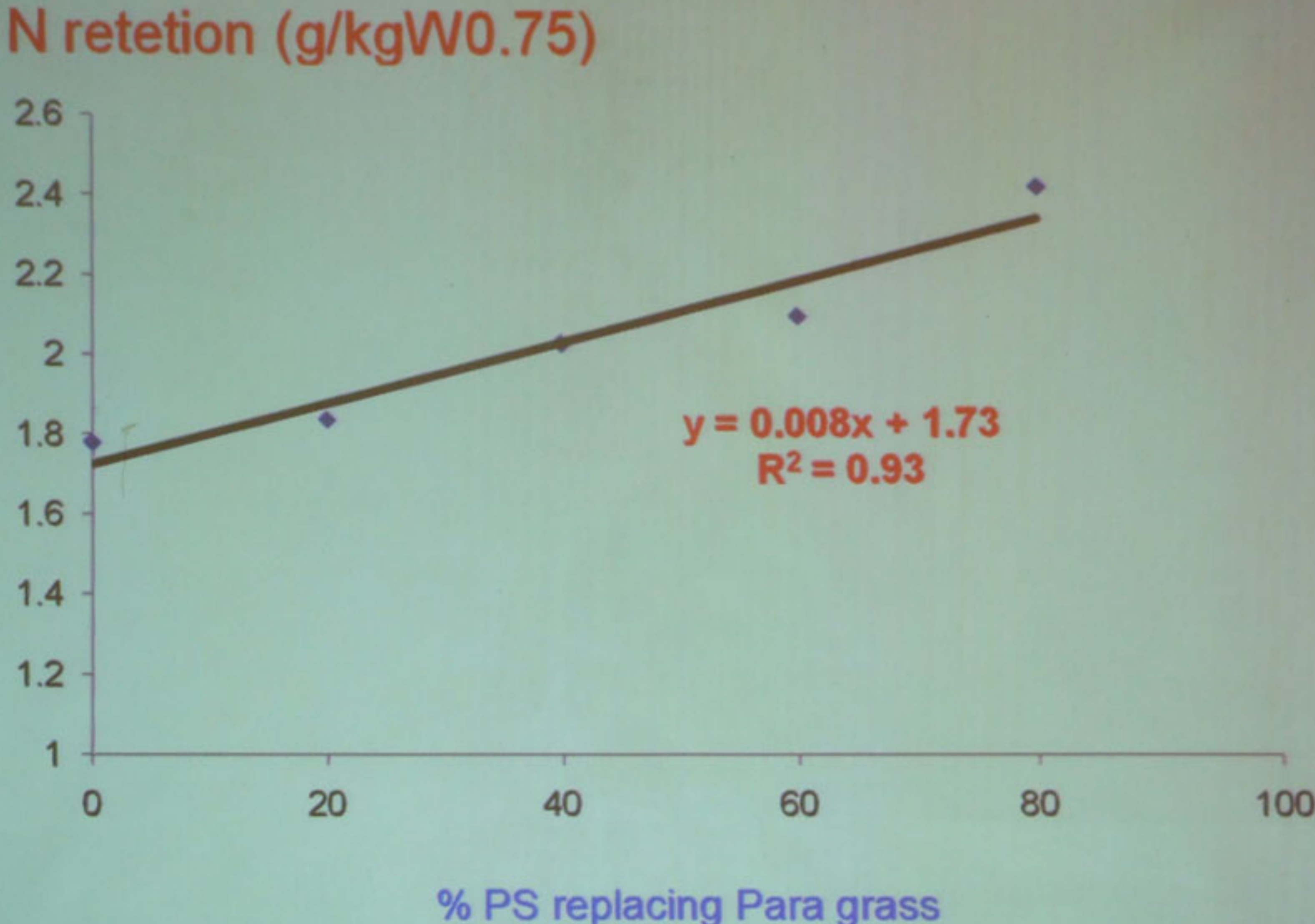


Fig 5. Relationship of PS replacement to para grass and N retentio

Table 13. Daily weight gain, feed conversion ratio and economic return of the rabbits fed different diets in the Exp

Criteria	Treatments					±SE/P
	SP0	SP15	SP30	SP45	SS60	
LW at initial (g)	807	784	798	803	805	6.44/0.16
LW at finishing (g)	1860[a]	1955[ab]	2075[b]	1943[ab]	2027[ab]	42.1/0.04
DWG (g/rabbit)	15.1[a]	17.3[ab]	18.2[b]	16.3[ab]	17.5[ab]	0.62/0.04
FCR	6.20[a]	5.4[ab]	5.10[b]	5.27[b]	4.83[b]	0.62/0.04
Total cost, VND/rab.	40,948	41,810	42,747	42,537	43,209	-
Income, VND/rab,	55,800	59,850	62,250	58,290	60,810	-
Profit, VND/rab.	14,852	18,040	19,503	15,753	17,601	-

LW; live weigh, SS0: no Spophocarpus scandén (SS), SS15: SS replace 15% PG, SS30: SS replace 30% PG, SS45: SS replace 45% PG, SS60: SS replace 60% PG

Conclusion

- ***Spophocarpus scanden*** **to replace para grass in the growing rabbit diets improved crude protein intake, dietary digestibility, daily weight gain and profit.**
- **A replacement of para grass by *Spophocarpus scanden* at a level of 30% should be practiced by farmers for a better income.**

*** Water spinach and sweet potato vine associated Mom grass or Cuc in the diet at the ratio of 1:1 (DM) would be economically fed and increase economic return.**

Water spinach leaves (waste) as protein source

In the Mekong Delta of Vietnam stems are used for making pickles for human consumption, while the leaves (WSL) are normally discarded

Nguyen Thi Kim Dong *et al.* (2008) confirmed by high protein content and the improved apparent digestibility of most nutrients in the diets including water spinach leaves.

Table 14. Chemical composition (% in DM) of Para grass, WSL and paddy rice (Nguyen Thi Kim Dong et al., 2008).

Ingredient	DM	OM	CP	EE	NFE	NDF	Ash	ME, MJ/kg*
Para grass	16.6	87.6	12.9	6.00	76.7	36.9	12.4	9.23
Water spinach leaves	10.8	90.6	32.3	7.60	40.2	24.2	9.40	10.2
Paddy rice	87.1	95.6	6.74	1.40	25.1	13.8	4.40	11.8

Table 15. Effect of level of offer of water spinach leaves (WSL) on feed and nutrient intakes (DM basis) of growing rabbits (Nguyen Thi Kim Dong et al., 2008).

Item	WSL0	WSL25	WSL50	WSL75	SEM/P
Daily intake, g / rabbit					
Para grass (PG)	73.8^{a}	37.3^{b}	28.9^{bc}	19.6^{c}	2.41/0.001
Water spinach leaves	0.00	11.2^{a}	19.2^{b}	30.3^{c}	1.29/0.001
Paddy rice	26.1	26.1	26.1	26.1	
Dry matter	99.9^{a}	74.6^{b}	80.8^{b}	76.0^{b}	1.58/0.001
Organic matter	89.6^{a}	67.8^{b}	73.5^{b}	69.6^{b}	1.39/0.001
Crude protein	11.3^{a}	10.6^{a}	13.9^{b}	15.3^{c}	0.24/0.001
NDF	63.2^{a}	39.6^{b}	40.5^{b}	33.8^{c}	1.17/0.001
ADF	30.8^{a}	20.1^{b}	21.0^{b}	18.2^{b}	0.56/0.001

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 the 5% level.

Table 16. Effect of level of offer of water spinach leaves (WSL) on live weight 1and daily gains of growing rabbits (Nguyen Thi Kim Dong et al., 2008).

Item	WSL0	WSL25	WSL50	WSL75	SEM/P
Final weight, g	1,508[ab]	1,432[a]	1,738[ab]	1,820[b]	77.4/0.03
Daily gain, g/day	13.0[a]	12.9[a]	17.3[b]	19.0[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	
Income, VND/rabbit)	45,255	42,945	52,125	54,600	
Difference, VND/rabbit	24,429	25,349	34,973	36,267	

- Apparent DM digestibility coefficients were significantly highe (P<0.05) in the diets with inclusion of WSL than that of control die
- Both the nitrogen intake and nitrogen retention increase corresponding with increasing levels of WSL in the diet, bu differences were significant only for the nitrogen intake (P<0.001).

Brewery and soya wastes

- It was concluded 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 (Nguyen Thi Kim Dong and Nguyen Van Thu, 2009[a]).

Table 17. Chemical composition of Para grass, brewery waste, soya waste and concentrate pellet (Nguyen Thi Kim Dong and Nguyen Van Thu, 2009[a]).

Item	DM	OM	CP	NDF	Ash
Para grass (PG)	20.2	88.2	10.8	70.0	11.8
Brew . Waste (BW)	27.6	94.8	25.3	48.9	5.20
Soya waste (SW)	10.4	93.9	20.7	44.5	6.12
Concentrate pellet	88.0	91.2	19.9	29.1	8.80

Growing rabbits

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.*

- 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.

- The economic analysis showed that the cost for feeds was lower with increasing the level of SW included in the diet. The close linear relationship ($R^2= 0.91$) between the daily weight gain and CP intakes of rabbit was also found (Nguyen Thi Kim Dong and Nguyen Van Thu, 2009)

Soluble carbohydrate supplements

Within these feeding strategies, green forages are used as the main protein sources and fiber, while for the improved 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 (Nguyen Thi Kim Dong and Nguyen Van Thu, 2009[b]).

Fresh sweet potato tuber (SPT) and dry cassava chips

Table 19. Chemical composition (%DM) of feed used in the experiment (Nguyen Van Thu and Nguyen Thi Kim Dong, 2013).

Feed	DM	OM	CP	EE	CF	NDF	ADF	NFE	Ash	ME* MJ/kg
SPT	26,2	96,9	3,96	1,86	3,24	8,59	5,48	87,9	3,06	15,6
Para grass	17,3	88,5	12,1	3,33	26,6	66,4	33,8	46,5	11,5	8,32
WSL	12,2	90,0	25,6	6,74	12,9	33,3	20,2	44,9	9,99	12,0
Tofu waste	11,1	96,0	22,5	9,23	17,5	32,4	27,8	46,8	3,99	11,0
Soybean cake	87,6	90,0	42,5	2,22	5,80	27,2	18,5	39,5	10,0	11,7

Table 20. Growth rate, feed conversion ratio and economic return of rabbits supplemented SPT (Nguyen Van Thu and Nguyen Thi Kim Dong, 2013).

Item	Treatment					SEM / P
	SPT0	SPT10	SPT20	SPT30	SPT40	
- Final live weight, g/rabbit	1951[a]	2093[ab]	2255[bc]	2282[c]	2271[c]	37.3/0.001
- Daily weight gain, g	17.8[a]	19.5[ab]	21.6[bc]	21.9[c]	21.9[c]	0.46/0.001
- Feed conversion ratio	3.23	3.42	3.46	3.55	3.89	0.19/0.248
- Cost of feed, VND/kg WG	7,971	8,524	9,082	9,975	10,845	
- T. 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

SPT = Fresh Sweet Potato tuber (3.96% CP, 8.6%NDF)

Table 21. Chemical composition of feeds (% in DM except for DM which is on fresh basis, and ME in the feeding trial (Nguyen Thi Kim Dong and Nguyen Van Thu, 2010).

Feed	DM	OM	CP	EE	CF	NDF	Ash	ME MJ/kg
Para grass	17.4	89.6	12.3	5.09	28.9	67.1	11.2	8.72
Dried cassava chips	94.3	97.1	2.70	1.59	3.39	15.6	3.09	13.4
Soya waste	12.0	95.3	21.3	15.4	3.50	35.0	4.96	13.1
Extracted soybean	87.9	90.1	42.8	3.22	3.70	27.4	11.3	12.4

ME: calculated according to Maertens et al.(2002)

Table 22 Mean values for changes in live weight, feed conversion and economic return (Nguyen Thi Kim Dong and Nguyen Van Thu, 2010)

Item	Treatment					SEM/P
	DC0	DC10	DC20	DC30	DC40	
Final weight, g	1755[a]	1848[ab]	2047[abc]	2083[bc]	2255[c]	67.5/0.003
Weight gain, g/d	16.2[a]	17.7[ab]	20.8[abc]	21.5[bc]	24.1[c]	1.09/0.002
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	
Profit, VND	17,707	19,981	24,566	24,357	28,766	

Table 22 Mean values for changes in live weight, feed conversion and economic return (Nguyen Thi Kim Dong and Nguyen Van Thu, 2010)

Item	Treatment					SEM/P
	DC0	DC10	DC20	DC30	DC40	
Final weight, g	1755[a]	1848[ab]	2047[abc]	2083[bc]	2255[c]	67.5/0.003
Weight gain, g/d	16.2[a]	17.7[ab]	20.8[abc]	21.5[bc]	24.1[c]	1.09/0.002
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	
Profit, VND	17,707	19,981	24,566	24,357	28,766	

DC = Dry Cassava chips (2.7% CP - 15.6% NDF)

Paddy rice and sweet potato tuber

Table 23. Chemical composition of feed ingredients (% in DM, except for DM which is on fresh basis) (Nguyen Thi Kim Dong et al., 2010).

Feed	DM	OM	CP	EE	NDF	ADF	Ash	ME*, MJ/kgDM
Sweet Potato vines (SP)	11.8	90.0	22.1	7.44	42.1	29.8	10.0	9.48
Paddy rice (PR)	87.7	95.9	7.37	3.25	25.5	13.8	4.10	10.8
Sweet Potato Tuber (SPT)	31.2	96.9	2.80	1.05	31.2	5.00	3.11	12.2

*: Calculated by Maertens et al.(2002)

Molasses

Sweet potato

Soya waste

Table 25. **Chemical composition of feed ingredients in feeding Exp. (% DM basis)**

Feed	DM	OM	CP	EE	NDF	ADF	Ash	ME MJ/kg
Molasses	69,1	93,0	3,51	-	-	-	6,99	15,4*
Soya waste	11,9	96,2	21,4	9,87	36,6	27,2	3,76	11,2**
Sweet potato	9,72	90,2	19,1	8,40	43,0	33,8	9,78	9,55**

*: *Value calculated (NRC, 1998),* **: *values calculated (Maertens et al.,2002)*

Molasses and sugarcane stalk residue

Table 26: Daily intakes of feeds and nutrients of rabbits in feeding experiment (g DM/rabbit)

Item	Treatment					±SE / P
	ML0	ML10	ML20	ML30	ML40	
SP	29.4	30.1	27.4	26.8	26.0	1.78/0.479
Soya waste	21.7	21.9	21.8	21.5	21.4	0.10/0.514
Molasses	-	6.35[a]	12.7[b]	19.1[c]	25.3[d]	0.29/0.001
Total DM	51.1[a]	58.3[ab]	61.9[bc]	67.4[cd]	72.7[d]	1.65/0.001
CP	10.8	11.2	11.1	11.1	11.2	0.23/0.672
EE	4.24	4.33	4.24	4.02	4.00	0.18/0.656
NDF	20.7	21.1	20.1	19.5	19.3	0.73/0.413
ADF	16.9	16.7	15.9	15.6	15.4	0.51/0.239
ME (MJ/day/rabbit)	0.50[a]	0.61[b]	0.68[b]	0.77[c]	0.86[d]	0.02/0.001

ML10 ML20 or ML30 = rabbits received 10, 20 or 30 g Molasses per day

Fig. 6. Daily intakes of feeds and nutrients of growing rabbits (g DM/rabbit)

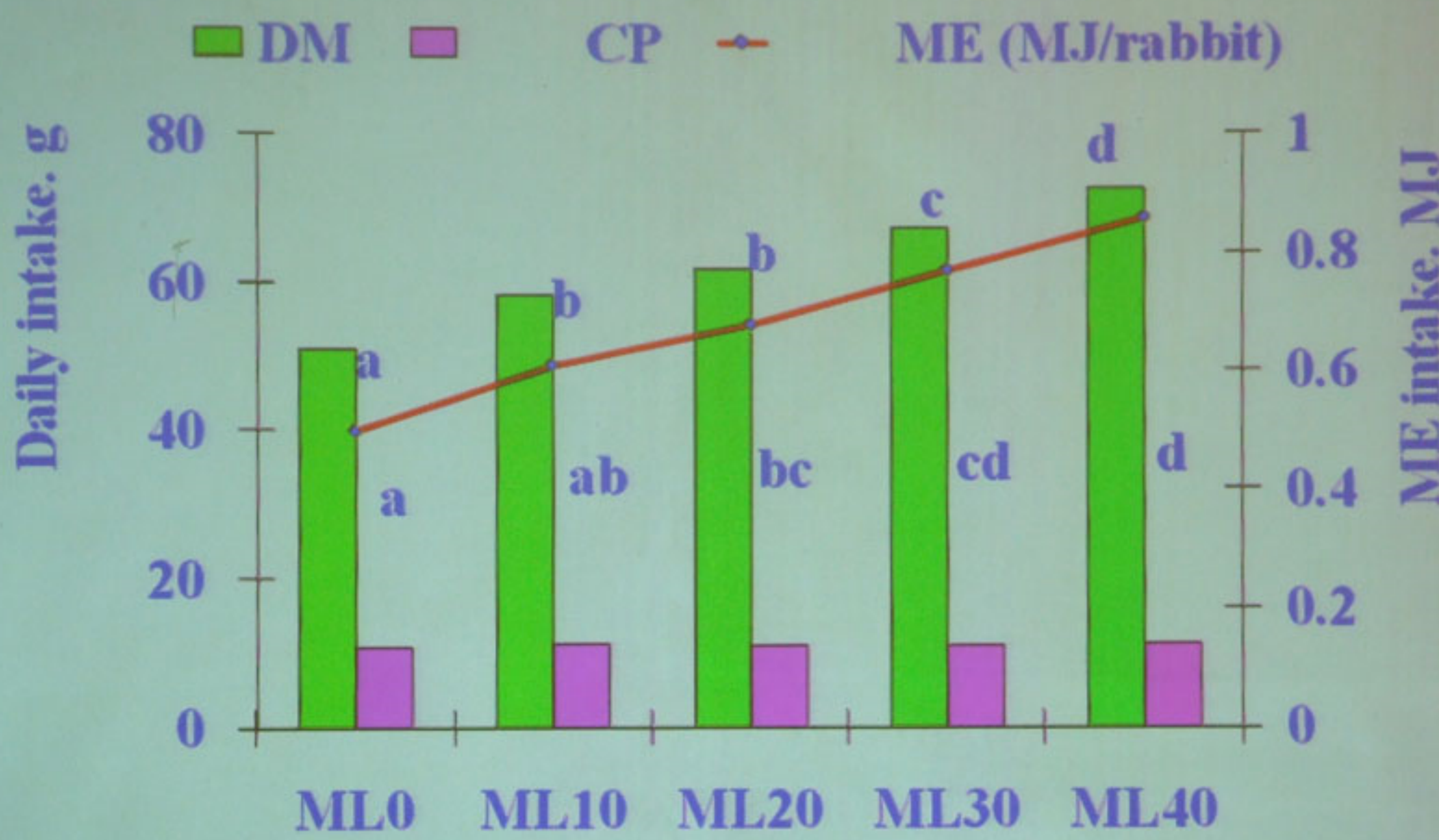


Fig. 7. **Final live weight and daily weight gain (g/rabbit) of rabbits and Relationship between ME intake and DWG**

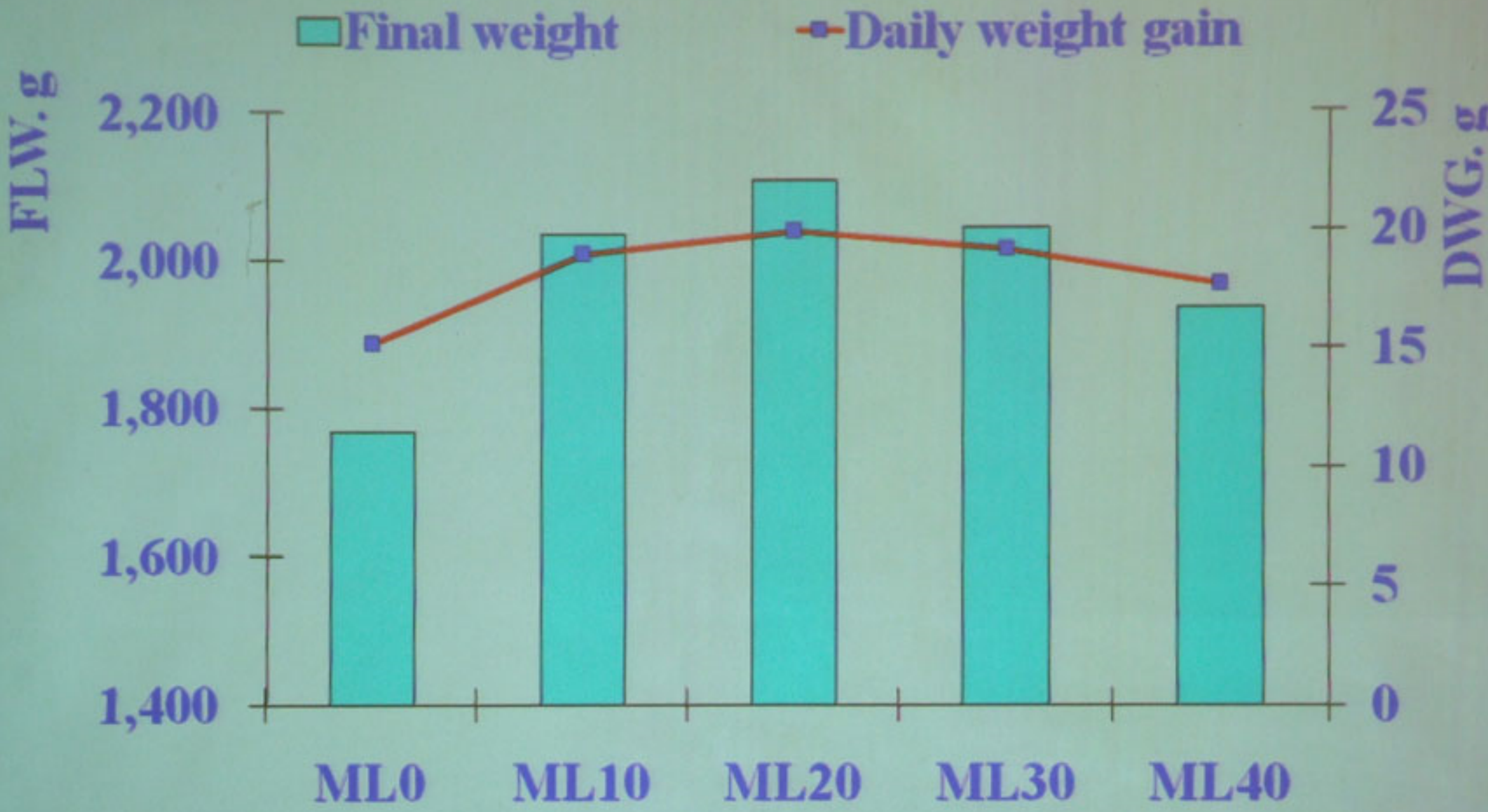


Fig.8. Final live weight and daily weight gain (g/rabbit) of rabbits and Relationship between ME intake and DWG

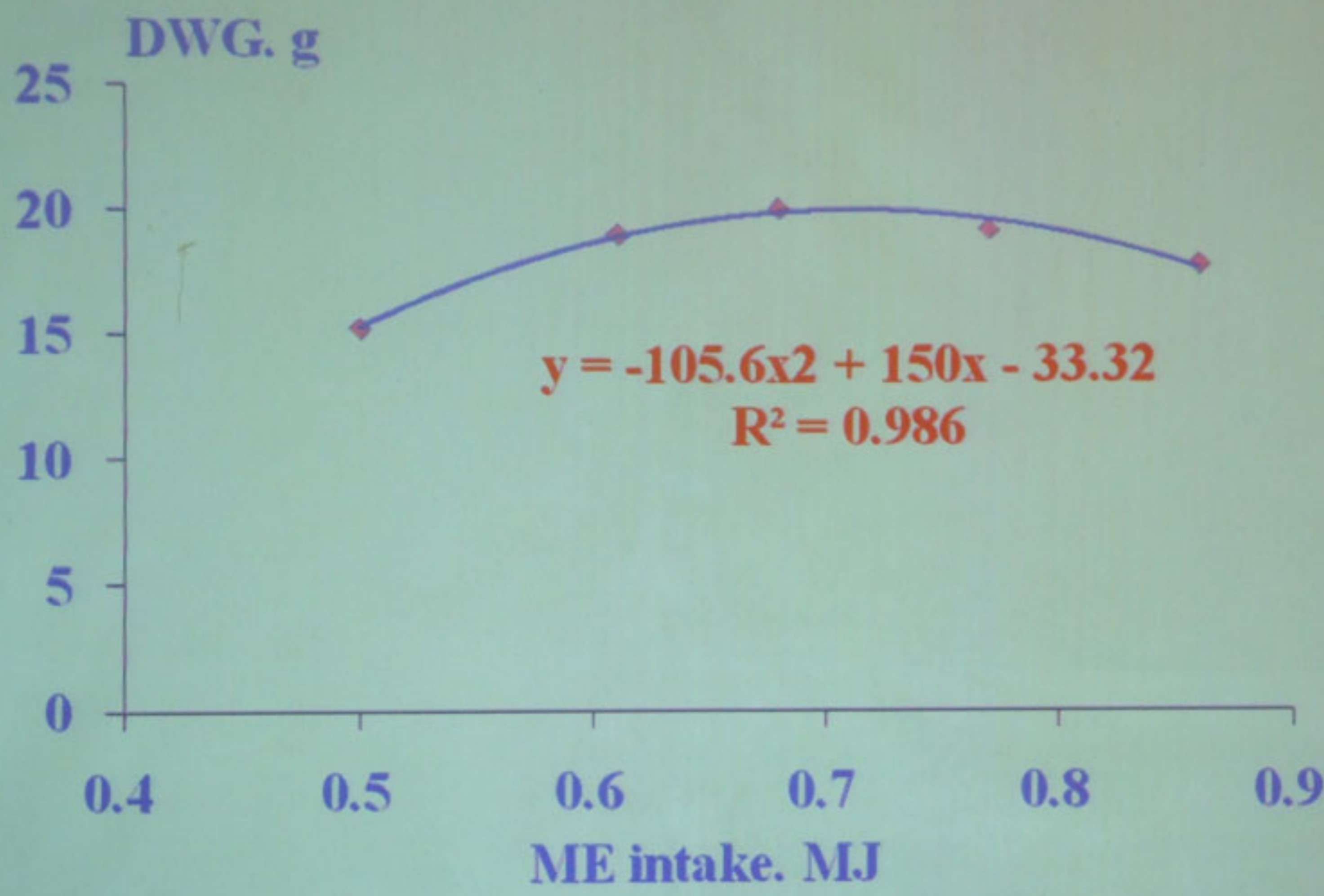


Fig. 9. Mean values of carcass, lean meat weights and economic returns of crossbred rabbits

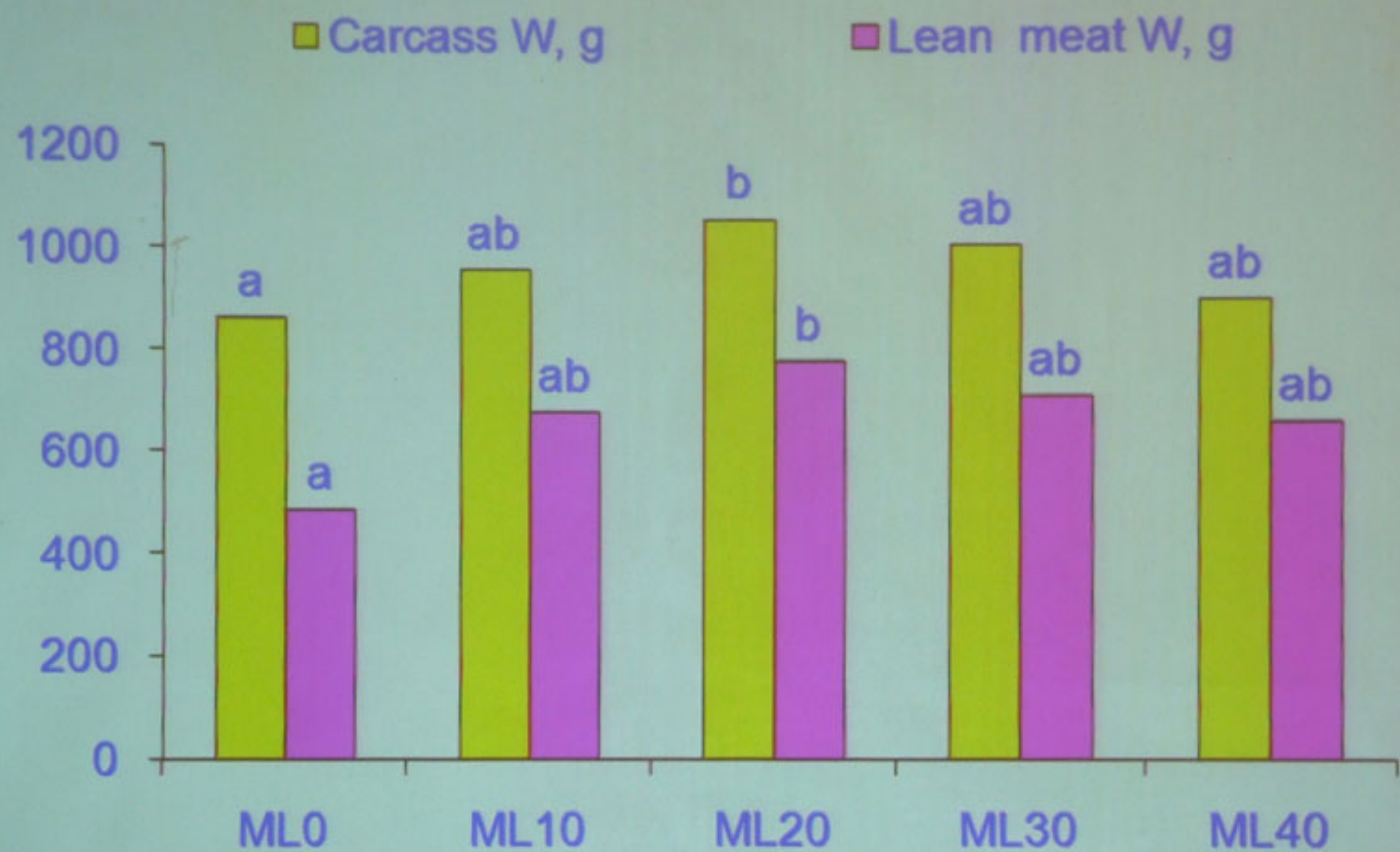
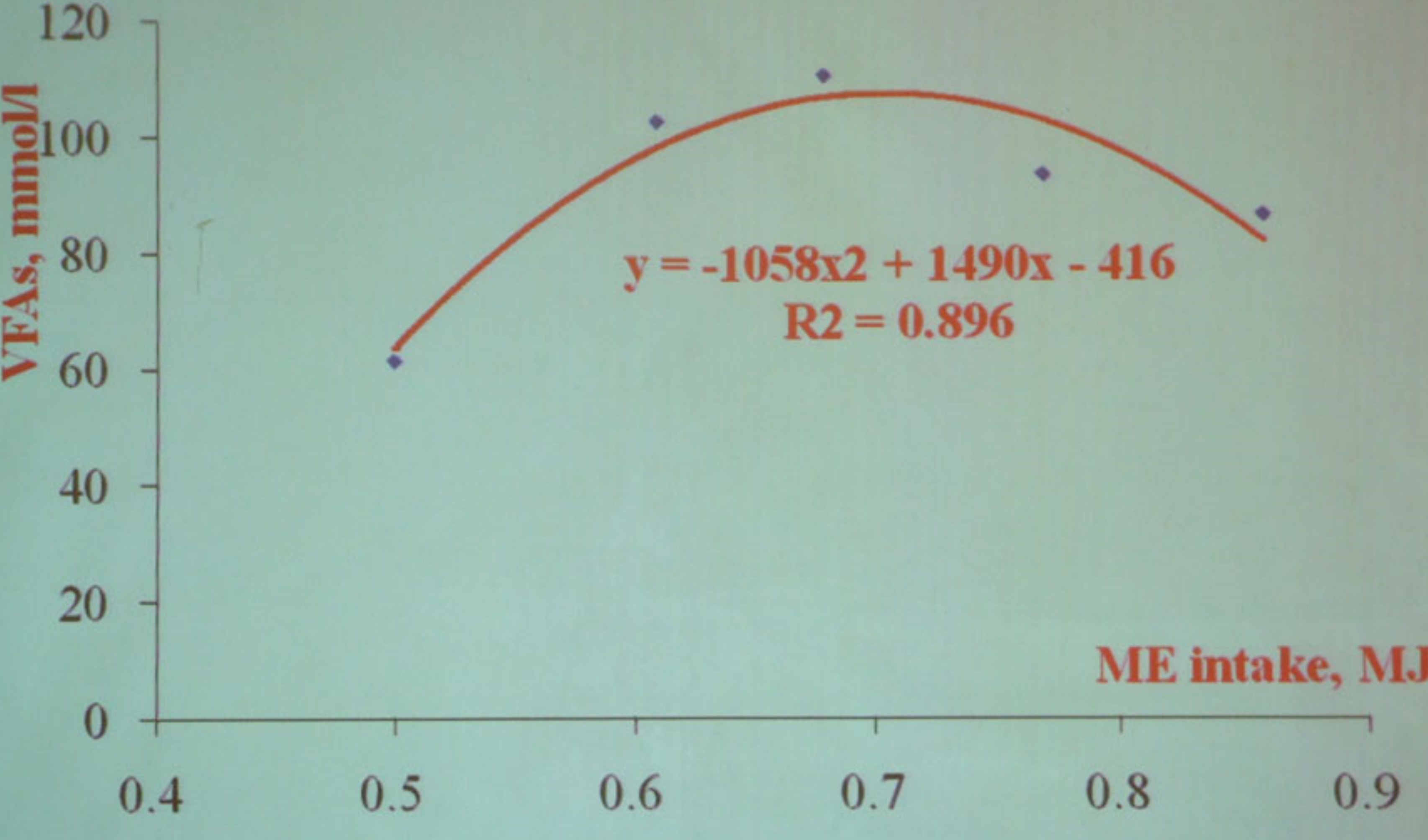


Table 11. **Nutrient composition and N-NH3, VFAs concentration of caecum content**

Item	Treatment					SE/P
	ML0	ML10	ML20	ML30	ML40	
DM, %	19.3	19.9	20.6	18.7	18.6	1.48/0.853
OM, %	87.3	87.4	86.9	86.8	86.5	0.31/0.331
CP, %	33.6	33.3	30.3	29.7	32.8	2.44/0.712
VFA, mmol/l	61.6[a]	103[ab]	111[b]	93.7[ab]	86.4[ab]	9.57/0.047
$N\text{-}NH_3$, mmol/l	8.84	9.79	11.6	11.3	9.10	1.69/0.705
pH level	6.60[a]	5.70[b]	5.65[b]	5.70[b]	5.76[b]	0.11/0.001

Fig 12 . Relationship between ME intake and concentration of Volatile fatty acids of rabbits



CONCLUSION

- Molasses could be supplemented as a energy source for growing rabbits
- At level of 20g/rabbit/day had better meat performance and profit
- **in vivo** nutrient digestibility and ceacal VFAs were improved with ML supplementation in diets.

Sugarcane stalk residue and *Operculina turpethum* used in Exp.

Sugarcane stalk residue

Chopped sugarcane stalk residue

Operculina turpethum

METHODOLOGY

Feeding EXP

- **96 rabbits at 6 weeks**
- **2*4 factorial design with 3 replicates**
- **1st Factor: Sugarcane residue length: 3 cm or 10 cm**
- **2nd Factor : *Operculina turpethum* supplement levels (0, 100,200 and 300g/day**

Digestibility EXP

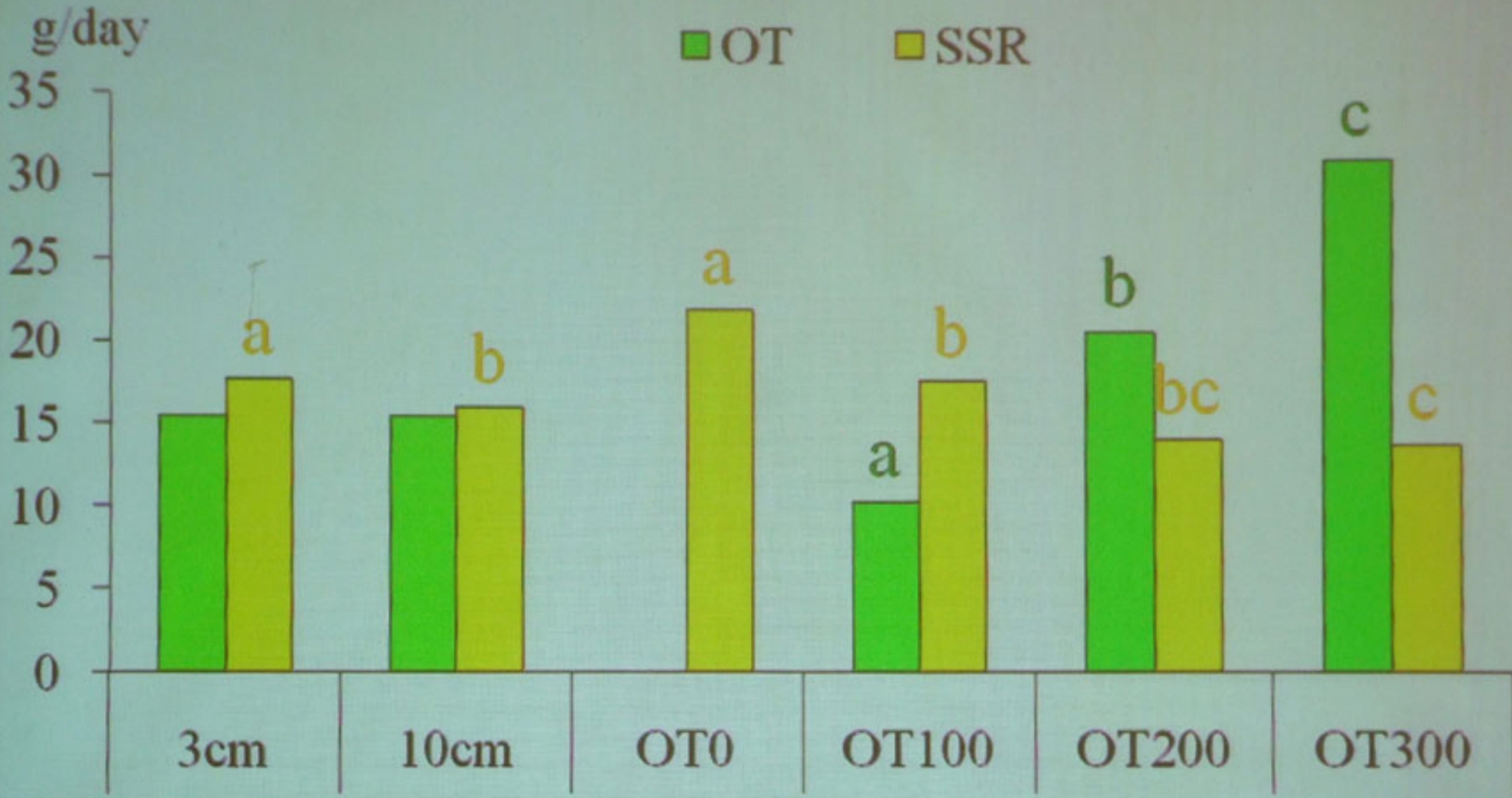
- **48 rabbits at 12 weeks**
- **2*4 factorial design with 3 replicates**
- **Experimental time: 1 week for collection: feeds, urine and feces**

Rabbits eating sugarcane stalk residue

Table 28. Chemical composition of feed ingredients in feeding Exp. (% DM basis)

Feed	DM	OM	CP	EE	NDF	Ash	ME MJ/kg DM
Operculina tur.	10.3	98.2	15.4	6.50	35.2	1.80	10.7
Sugar Cane Residue	25.9	97.5	3.60	4.44	22.0	2.58	9.20
Para grass	18.7	89.3	12.9	3.46	57.6	10.7	9.21
Soya waste	13,6	97.3	20.0	10.0	35.3	2.70	11.3
Dry sweet potato	77.8	97.1	5.06	1.05	24.7	2.90	13.5
Extracted soybean	90.2	91.0	43.2	2.50	27.5	9.00	11.4

Fig. 13. Daily intakes of feeds and nutrients of growing rabbits (g DM/rabbit)



OT = *Opercunlina turpethum* 0 - 100 - 200 or 300 g/d - SSR = Chopped Sugarcane residue 3 or 10 cm long

Fig. 14. Daily intakes of feeds and nutrients of growing rabbits (g DM/rabbit)

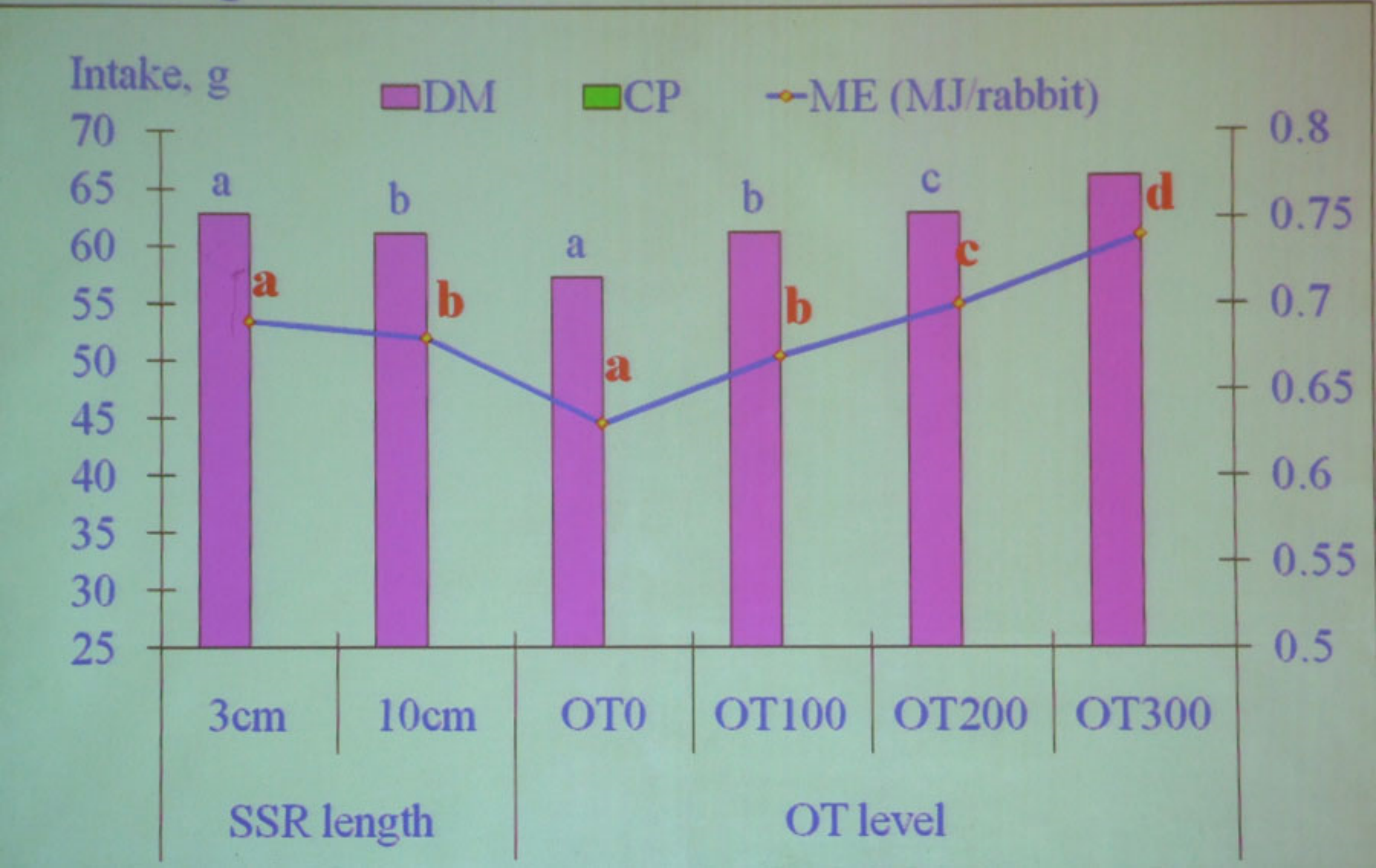


Fig. 15. Final live weight and daily weight gain (g/rabbit) of rabbits in feeding EXP.

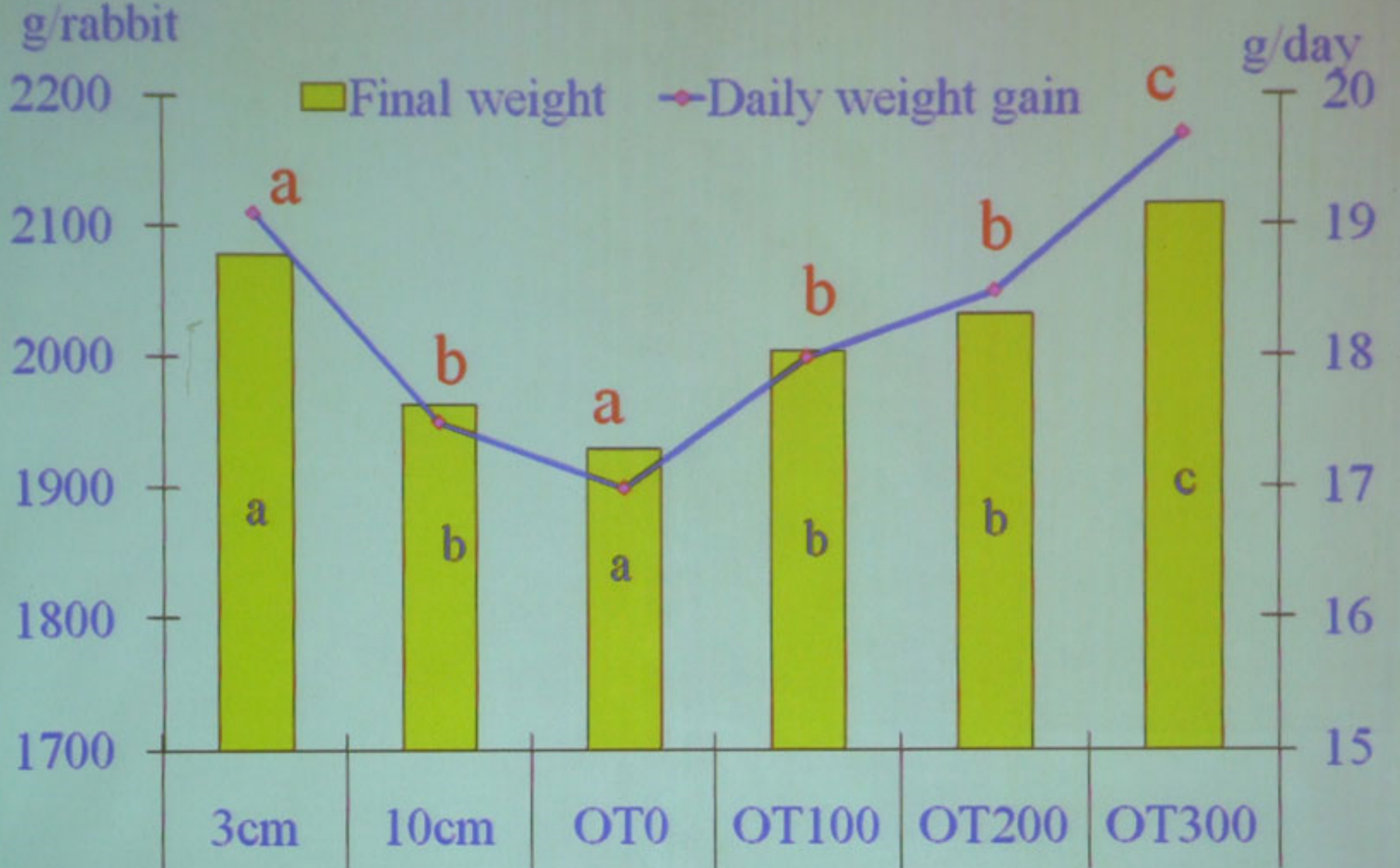
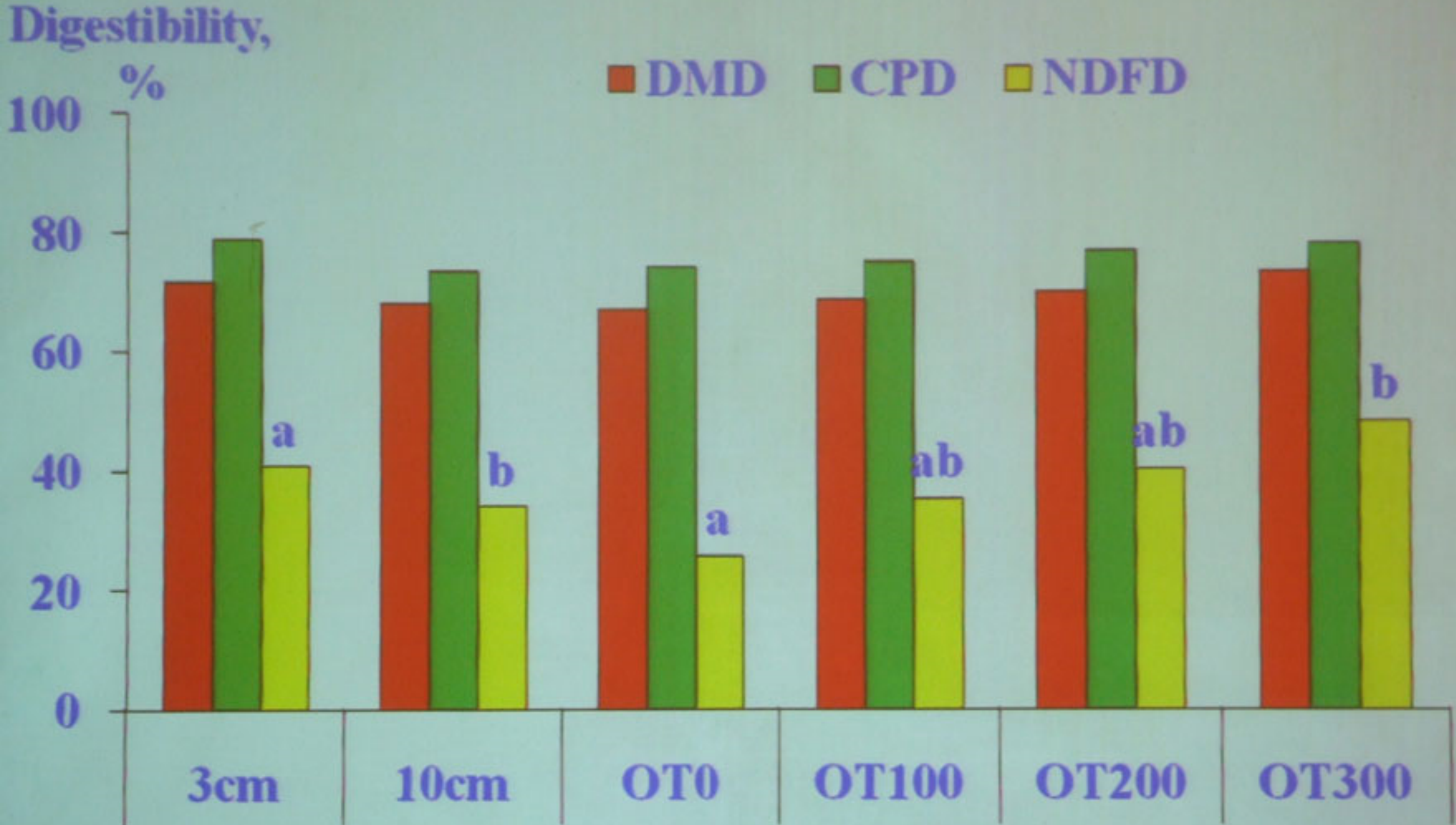


Fig. 16. Nutrient digestibility of rabbits in digestibility trial



CONCLUSION

- Sugarcane stalk residue could be used for feeding rabbits
- At 3cm sugarcane stalk residue had higher nutrient intake, gave higher performance and profits
- At level of 300g *Operculina turpethum* supplement gave better growth performance and profits

CONCLUSION and RECOMMENDATIONS

* 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.