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RABBIT NUTRITION AND FEEDING: RECENT ADVANCES AND FUTURE PERSPECTIVES.

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Interest in commercial rabbit production is increasing rapidly in many parts of the world. In North America, rabbit production for meat is expanding, because of interest in rabbit meat as a low cholesterol, low sodium high quality product. Development of a fur industry based upon the Rex breed is proceeding in the United States, and in some other countries such as New Zealand (Cheeke, 1981). Raising Angora rabbits for wool is increasingly important in China (Milne, 1982) and in Hungary. Rabbit production is also viewed as having considerable potential in developing countries (Owen, 1976; Lebas, 1983; Cheeke, 1980a, 1983). Expansion and development of the rabbit industry in these varied aspects will require refinements in knowledge of rabbit feeding and nutrition.

The potential of rabbits as meat and fur producing animals is related in large part to their ability to utilize fibrous feedstuffs that can't be effectively consumed by humans. This is particularly true in developing countries, where rabbits can be raised to convert tropical forages and feed by-products into high quality human food. An advantage of rabbits over several other types of livestock is that their nutritional needs can be met by the use of simple mixtures of feedstuffs, and that high quality supplements are not required for a moderate level of productivity. For example, the vitamin requirements can be provided entirely by the forage component of the diet and from coprophagy (cecotropy). The major nutritional problems encountered in rabbit production are probably not due to nutrient deficiencies per se, but rather are diet-related problems such as enteric diseases, fur chewing, pregnancy toxemia, and feed spillage.

At the Second World Rabbit Congress, Lebas (1980) reviewed recent research on rabbit nutrition, and provided a comprehensive table of nutrient requirements. Lang (1981 a, b) provided an excellent review of the digestive physiology, nutrient requirements, and general aspects of feeding of commercial rabbits. It would not be useful to duplicate in the present paper the same information as has previously been reviewed by these authors. Therefore, the objectives of this paper will be to discuss particular aspects of rabbit nutrition not emphasized in those reviews, and to provide a perspective on productive areas of rabbit nutrition research for the future. A consideration of each of the major nutrient categories will be given.

ENERGY METABOLISM AND REQUIREMENTS

Major energy sources include lipids and carbohydrates. Fats are well utilized by rabbits; a dietary fat level as high as 25% has been fed with no adverse effects (Arrington et al, 11974). Pote et al (1980) used 20% added fat in a high-alfalfa diet, and found a significant improvement in feed conversion efficiency. The use of high levels of fat may be a feasible way of increasing the energy content of high-fiber diets while avoiding carbohydrate overload of the hindgut. Feed ingredients high in fat, such as full-fat extruded soybeans, should be examined.

Carbohydrates can be broadly classified into the readily-available carbohydrates (RAC) and those associated with the fiber component of feeds. Diets high in RAC when fed to fryers result in a high incidence of enteritis (enterotoxemia), related to carbohydrate overload of the hindgut (Cheeke and Patton, 1980). When diets containing high energy grains such as corn (maize) are fed, starch may pass undigested through the small intestine, and serve as a substrate for growth of bacteria in the cecum. The transit time of ingesta through the small intestine is rapid in the rabbit (Lang, 1981a), especially when the diet is composed of finely ground ingredients (Laplace and Lebas, 1977), allowing undigested starch to reach the hindgut. Patton et al (1978) identified iota toxin produced by Clostridium perfringens Type E as the causative agent of enterotoxemia. Other workers (Baskerville et al, 11980); Eaton and Fernie, 1980) confirmed the role of iota toxin in etiology of enterotoxemia. None of these investigators were successful in isolating Clostridium perfringens Type E from rabbits with enteritis. Borriello and Carman (1983) clarified the situation by demonstrating that the source of the iota toxin is another organism, Clostridium spiroforme. They demonstrated that this bacterium produced toxin only when grown on a glucose-containing medium, supporting the concept that a diet high in starch induces enterotoxemia. Sanchez et al (1981) found that oats and barley, which are low starch grains, were less implicated in enterotoxemia than high starch grains such as maize. The dietary involvement in enterotoxemia can be summarized as follows. Diets high in cereal grains result in the presence of starch in the hindgut, allowing the proliferation of Clostridium spiroforme, which produces iota toxin. The iota toxin is lethal to the affected rabbit. It causes hemorrhage of the cecal wall, and dehydration, as well as being acutely toxic to the nervous system. Dietary crude fiber levels of 12-15% minimize the occurrence of enteritis (Colin et al, 1976; Grobner, 1982; Pote et al, 1980; Spreadbury and Davidson, 1978). It is not clear if this is an effect of fiber per se, or is simply a consequence of the low starch level of a high fiber diet.

Harris et al (1982b) investigated the effect of dietary buffers on enteritis and growth, when used in a high RAC diet. The results (Table 1) show little beneficial effect. It was hypothesized that buffers might increase the digestibility of starch in the small intestine, and reduce carbohydrate overload of the hindgut. Similarly, Grobner et al (1982a) found only slight beneficial effects from the feeding of zeolite, a type of clay with buffering properties.

Table 1. Effect of dietary buffers on growth and incidence of enteritis of weanling rabbits (From Harris et al, 1982b)

Treatment	Avg. daily gain (g)	Feed/ gain	% mortality
Control	42.9	2.77	13.4
1% magnesium oxide	35.3	2.55	6.7
5% sodium bicarbonate	34.6	2.91	26.7
3% limestone	37.3	2.60	26.7
3% limestone + 3% sodium bicarbonate	35.1	4.33	40.0

Table 2. Response of weanling rabbits to diets high in alfalfa meal (from Pote et al, 1980a).

% dietary alfalfa	Avg. daily gain (g)	Daily feed intake (g)	Feed/ gain
0	31.4[a]	84.2	2.7
10	44.0[b]	107.5	2.4
20	36.6[a,b]	105.3	2.9
30	40.1[a,b]	110.4	2.8
40	36.4[a,b]	115.8	3.2
50	41.1[b]	130.9	3.2
60	37.3[a,b]	134.3	3.6
74	38.2[a,b]	147.6	3.9

a different than b ($p<.05$).

Indigestible dietary fiber is important in rabbit nutrition, not only for prevention of enteritis, but also for maximum growth and to prevent fur chewing. Pote et al (1980a) found that the growth rate of fryers was lower on a high energy corn-soybean meal diet than when a fiber source (alfalfa meal) was added (Table 2). Similarly, Cheeke and Patton (1978) and Champe and Maurice (1983) reported that gains were reduced on a low fiber, high energy diet. Thus it appears that there is a requirement for dietary fiber for minimum growth rate. On low fiber diets, fur chewing may be pronounced. An increase in the fiber level, or provision of loose hay, will generally stop an outbreak of this problem.

Although rabbits are herbivorous animals, the digestibility of fiber in the species is low. This is a consequence of the separation of large and small particles in the hindgut, resulting in the retention of small particles and solubles in the cecum, and rapid excretion of the larger fiber particles. This process has been excellently reviewed by Lang (1981a). Antiperistaltic waves in the proximal colon in conjunction with the normal peristaltic action and the continual contractions of the cecum are responsible for the separation and selective excretion of fiber particles. The digestive strategy of the rabbit is to concentrate on digestion of the non-fiber components of feed, with the rapid elimination of the fiber fraction. Thus rabbits can consume large quantities of low-energy fibrous feeds, and derive their nutritional needs from digestion of the components other than lignocellulose. The low digestibility of cellulose, due to its selective excretion, suggest that processing methods such as alkali treatment which improve the digestibility of lignocellulose in ruminants might not be effective in rabbits.

An additional effect of fiber in rabbit nutrition is that it may be involved in cecal impaction, a disorder often observed in U.S. rabbitries. Patton and Cheeke (1981) suggested a possible involvement of high (over 22%) dietary fiber levels. Grobner et al (1983a) examined the effect of a high dietary level (5%) of sodium bentonite, a commonly used pellet binder, on the incidence of impaction. Because of the clay-like nature of cecal impaction contents, it was hypothesized that selective retention of fine particles in the cecum could result in accumulation of bentonite, causing an impaction. However, high dietary bentonite did not induce an increased incidence of the disorder.

Rabbits are well adapted to the use of low energy diets. Specific energy requirements have not been well studied, but a dietary level of 2500 kcal D.E.per kg of feed (10.5 MJ) provides for adequate growth and reproductive performance. Butcher et al (1983) reported that an energy level of 2390 kcal/kg (10 MJ/kg) ME supported a greater preweaning growth rate than did a diet with 1900 kcal/kg (8 MJ/kg). Milk yield of the does was not different on the two diets. Partridge et al (1983) studied energy requirements of lactating rabbits. Their results indicate that a doe yielding 300 g of milk daily at peak lactation would have a daily ME requirement of 8150 kcal (3.41 MJ). The total daily energy requirement of a 4 kg doe would be about 10,920 kcal (4.57 MJ). On typical commercial diets, feed intake of more than 500 g per day would be required to meet this requirement. Such levels of intake are not feasible. Thus it may be desirable to employ high energy lactation diets. Energy requirements are greater for lactation than for other productive functions in rabbits (Lang, 1981), because milk production relative to body weight is high, and rabbit milk has a high energy content (8.4 - 12.6 MJ/kg). Evans (1982) has provided prediction equations for maintenance and growth requirements for DE.

The performance of does and litters fed diets high in alfalfa meal has been studied by Harris et al (1982a) and Lukefahr (1983a,b,c). The high alfalfa diets (54% and 74%) were compared with a commercial diet (Carnation Albers Family Ration). The 54%, 74% and commercial diets had protein (%) and DE (kcal/kg) values of: 21.7, 2815; 22.1, 2527; 18.8, 2605. The results (Table 3) show that production of fryers was similar

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with the three diets. Neither the 54% or 74% alfalfa contained cereal grain, indicating that satisfactory production can be achieved with high forage diets. Milk production of does on the 74% and commercial diets was measured (Lukefahr, 1983b); total milk production for 1-21 days was 3940 g and 3420 g per doe for the 74% alfalfa and commercial diets respectively.

Table 3. Performance of does and litters fed a commercial diet or high alfalfa diets.

Treatment	% born alive	Litter weight at 28 days (g)	Litter weight at 56 days (g)	% mortality 1-28d	% mortality 28-56d
Commercial diet*	72.6	3546	9224	23.3	16.7
54% alfalfa diet*	83.3	3854	9216	18.2	22.4
Commercial diet**	75.0	2890	8150	29.1	8.8
74% alfalfa diet**	92.7	3630	9170	14.5	15.5

*Harris et al (1982).
**Lukefahr et al (1983a,b,c).

An important metabolic problem in does is pregnancy toxemia (ketosis). Classic signs are a fatty liver, an enlarged gall bladder and ketones in the urine. Does are susceptible to this condition at the time of parturition. Patton et al (1983) have found a high association between the occurrence of pregnancy toxemia and the presence of hairballs in the stomach. The hairballs result in a lack of feed intake inducing a ketotic condition. When does pull fur to prepare the nest, they may consume some of it, causing a mass of hair to accumulate in the stomach. It appears that young does that are over-fat are those most likely to develop a hair ball condition, leading to pregnancy toxemia. The hair ball can be broken down by administering a source of proteolytic enzyme, such as raw pineapple juice, to the affected animals. Feeding loose hay following this treatment will aid in passing the hair through the digestive tract.

PROTEIN METABOLISM AND REQUIREMENTS.

Rabbits require dietary essential amino acids; estimates of requirements for growth and lactation were provided by Lebas (1980). The protein and amino acid requirements are higher for lactation than for growth. Protein requirements (assuming high quality proteins) are 15-16% for growth, and 18-20% for lactation (Lebas, 1980; Lang, 1981; Omole, 1982; Harris et al, 1982). Microbial synthesis of protein in the cecum makes a minor contribution to the amino acid needs of growing rabbits, but there is some evidence that microbial protein synthesis could be important in adults (Lang, 1981a). The lower protein requirement for growth than for lactation suggests that the common practice of using one diet for both fryers and does is inefficient. It would be desirable to use a minimum of two diets in rabbit production. For weaned fryers, a diet low in fermentable carbohydrate (to minimize enterotoxemia) and a protein level of about 16% should be used, whereas for lactating does, a higher protein level (18-20%) and a higher energy content would increase efficiency. The crude fiber level should be about 15% in both cases.

VITAMIN REQUIREMENTS

Because of the nature of common rabbit diets and of the digestive tract, the vitamin needs of rabbits are generally quite easily met. Rabbit diets usually contain 30-60% of dried forage, such as alfalfa meal. If this is of good quality, the requirements for the fat soluble vitamins will be met. The B vitamins are provided both by the diet and from consumption of cecotropes (Lang, 1981a). The major function of coprophagy in the rabbit appears to be the provision of B vitamins synthesized by bacteria in the cecum. Harris et al (1982) tested a diet with 54% alfalfa meal, with no vitamin supplementation, and found superior doe production than with a commercial diet containing a vitamin supplement. With fryers, Harris et al (1983b) found no response to the addition of vitamin mixtures to the 54% alfalfa diet. As Lang (1981a) suggests, vitamin supplementation is relatively cheap and generous levels are usually added to rabbit diets, although it is usually unnecessary.

MINERAL REQUIREMENTS

As with vitamins, the mineral requirements of rabbits can be satisfied readily. The provision of 0.5% trace mineralized salt in the diet will provide adequate quantities of these nutrients. Alfalfa meal, a major constituent of most commercial feds, is an excellent source of most trace elements as well as being a good source of calcium and potassium. Grain by-products, such as wheat bran, are excellent sources of phosphorus, so a combination of alfalfa meal and grain by-product as major diet ingredients can satisfy the calcium and phosphorus requirements. Phytate phosphorus is available to rabbits; Swick et al (1981) found no effect of a high level (28%) of soybean meal on the availability of phosphorus, copper or zinc. Most rabbit diets contain excess calcium as evidenced by the excretion of calcium carbonate in the urine (Cheeke and Amberg, 1973). Probably the major consideration regarding mineral nutrition is the provision of optimal calcium: phosphorus ratios. Further studies are required to determine the optimal balance between these elements. This may be involved in prevention of the broken back syndrome, which is quite common in many rabbitries. Recent studies (Evans et al, 1983) suggest that the magnesium requirement of 0.03% (Lebas, 1980) should be further evaluated. Evans et al, (1983) found significantly greater growth rates with 0.35% magnesium than with 0.17%. They also reported growth depressing effects of 1% potassium.

FUTURE PERSPECTIVES IN RABBIT NUTRITION RESEARCH

Lebas (1980) suggested that a good direction for research in rabbit nutrition would be the study of the ability of rabbits to utilize forages. Rabbit production, based on the conversion of forages and grain by-products to meat, has considerable potential in developing countries (Owen, 1976; McNitt, 1980; Cheeke, 1980, 1983; Lebas, 1983). The feeding of green feeds, although labor intensive, can support reasonable growth of rabbits. For example, Pote et al (1980b) fed greens ad libitum as a supplement to varying amounts of a pelleted diet. With free choice greens, the amount of pellets fed could be reduced by about 50% with no adverse effect on growth rate (Table 4).

Table 4. Response of rabbits fed greens as a supplement to a pelleted diet (from Pote *et al*, 1980b)

Treatment	Avg. daily gain (g)	Daily pellet intake (g)	% mortality
1. Pellets *ad lib*	36.8[a]	127.0	10
2. Pellets and greens *ad lib*	35.4[a]	79.7	10
3. 75 g pellets + greens	37.2[a]	66.6	20
4. 50 g pellets + greens	31.4[a,b]	46.8	10
5. 25 g pellets + greens	26.0[b,c]	24.9	20
6. Greens *ad lib*	25.2[c]	0	10

a,b,c, differ ($p<.05$).

Table 5. Digestibility of crude protein and acid detergent fiber (ADF) of diets containing tropical forages (from Harris *et al*, 1981a).

	% digestibility	
Forage Source	Crude protein	ADF
Alfalfa	79.9	29.0
Stylosanthes guianensis	64.0	8.8
Clitoria ternata	71.1	24.5
Cassia tora	68.7	25.5
Guinea grass	73.8	1.5
Desmodium distortum	76.6	20.8
Macroptilium lathyroides	71.0	21.5
Cassava leaves	59.5	6.0
Winged bean	67.5	24.7

Research is needed on the nutritional value of tropical forages, to optimize efficiency of rabbit produccion in developing countries. The optimal supplementation of forages with concentrates such as rice bran should be determined. Harris *et al* (1981a) evaluated a number of topical legumes and grasses as rabbit feeds. Tropical forage legumes and cassava leaf meal gave acceptable performance. The digestibility of crude protein was low in cassava leaves (Table 5), probably because of the tannin content. Digestibility of acid detergent fiber (ADF) in guinea grass was very low (1.5%) whereas it was about 20% for the other tropical feeds. Leucaena leucocephala is a high protein tropical legume, containing the toxic amino acid mimosine. When fed as the sole forage, it causes reproductive problems, poor growth and hair loss in rabbits. The digestibility of crude protein and ADF in Leucaena compares favorably with that in alfalfa meal (Harris et al, 1981d). There is a wide variety of tropical legumes and other forages which show potential as rabbit feed, and should be evaluated. For example, in Indonesia, where rabbit production is expanding rapidly, potential feeds include Gliricidia, Sesbania and Calliandra species, cassava leaves, sweet potato vines and a variety of vegetable leaves and tops (Cheeke, 1983). Other forages which have been examined include amaranthus species and sunflower leaves (Harris et al, 1981b). Bermuda grass, which might be a potential replacement for alfalfa meal in warm climate areas, is reportedly toxic to rabbits (Champe and Maurice, 1983). Further research with forages should involve assessment of their nutrient content, digestibility, toxicological effects, and long term effects on production. Optimal feeding systems for tropical forages, including appropriate supplementation with other feeds, is an area of research need. On a more fundamental level, the reason for the efficient digestion of forage proteins, in conjunction with the low digestibility of the fiber fraction, is of interest. It is probably related to the selective separation and excretion of fiber particles, and the practice of coprophagy.

In North America and Europe, where intensive rabbit production has been developed, a promising area for future research is the development of optimal diets for various production phases. The protein and energy requirements for lactation are higher than for growth. If only one diet is used for the entire herd, as is common in North America, neither the fryers nor the does are receiving optimal nutrition. If the protein and energy requirements for lactation are used, than the fryers receive excess protein, and the high energy level induces diarrhea. If a diet adequate for fryers is fed, then doe productivity is reduced. Grobner et al (1983b) suggested that at least two diets could be advantageously used for fryers: a high fiber weaning diet, and a higher energy finishing diet. Lukefahr et al (1980) and Harris et al (1981c) suggested a "feedlot" system for rabbit production. This system is now being used commercially in the US. Feedlot operators purchase 3-4 week old rabbits from rabbit raisers, and feed them until slaughter weight. This system permits the rabbit raiser with the doe herd to feed an optimal lactation diet, while the feedlot operator can feed a series of grower and finisher diets, with adjustments in protein and energy content to compensate for changes in requirements with age. A great deal of research is needed to improve the efficiency of diet formulation to optimize the system.

Further research is needed on the evaluation of many common feedstuffs. Grain by-products, such as wheat bran and rice bran, are excellent sources of protein and energy for rabbits. Cottonseed meal can be used effectively at higher levels than previously recommended; gossypol does not appear to have adverse effects on male rabbit fertility (McNitt et al, 1982). Canola meal (low glucosinolate rapeseed meal) appears to be an effective replacement for soybean meal (Throckmorton et al, 1980). Because alfalfa meal is very widely used in rabbit feeding, a complete evaluation of the effects of quality (protein and fiber levels), processing method, etc. is needed. For example, Harris et al (1983a) observed that sun-cured alfalfa meal gave better performance than dehydrated alfalfa in fryer studies, and was more palatable.

There has been little research on nutritional requirements for Rex fur and Angora wool production. Wehr et al (1982) discussed some of the nutritional factors affecting fur color and growth. Research on the effect of nutrition on fur priming of Rex rabbits is needed.

Summary

Rabbit production for meat, fur and wool is becoming of increasing importance in many countries. Expansion of the rabbit industry to its full potential will require expanded knowledge in rabbit nutrition and feeding.

The digestive tract of the rabbit is capable of selective rapid excretion of dietary fiber, with prolonged retention of solubles and small particles in the cecum. This digestive strategy facilitates the utilization of low energy, high forage diets. While the digestibility of fiber is low, the non-fiber constitutents of forages are used efficiently.

Diets high in fermentable carbohydrate provoke enteritis (enterotoxemia) by promoting growth of pathogens (eg. Clostridium spiroforme) in the cecum. Dietary modifications to minimize enteritis are described.

The energy requirements for lactation are high, suggesting that high energy diets for lactating does might be useful. The protein requirement for growth is 15-16% of the diet, whereas for lactation it is 18-20%. Therefore, efficiency of rabbit production could be improved by the use of separate diets for growing animals and lactating does.

Vitamin requirements of rabbits are readily met by using a forage meal (eg. alfalfa) in the diet, and by coprophagy. Similarly, the mineral requirements are met by the use of trace mineralized salt, and a calcium-phosphorus supplement. Further work is needed to define the optimal calcium-phosphorus ratio for growth and lactation.

A promising area for further research is the assessment of nutritive value of tropical forges and by-products, to be used in rabbit feeding in developing countries. Rabbit production could play an important role in meeting human protein needs in developing countries. The success of rabbit production programs in these countries will be influenced to a considerable extent by progress in developing inexpensive feeding programs based on forages.

It is suggested that in intensive commercial rabbit production, future progress in improving efficiency will be achieved by formulating diets for specific productive functions, so that starter, growth, finisher and lactation diets might be used. The development of rabbit "feedlots" could enhance the feasibility of this approach.

Further studies are needed to better evaluate numerous common feedstuffs, and also to investigate the effect of feed processing on rabbit performance. For example, sun-cured alfalfa meal appears to be superior to dehydrated alfalfa for rabbit feeding.

Finally, nutritional requirements and feeding programs for production of Rex fur and Angora wool should be promising areas for further research.

References

Arrington, L.R., J.K. Platt and D.E. Franke. 1974. Fat utilization by rabbits. J. Anim. Sci. 38:76-80.

Baskerville, M., M. Wood, and J.H. Seamer. 1980. Clostridium perfringens Type E enterotoxemia in rabbits. Vet. Rec. 107:18-19.

Borriello, S.P. and R. J. Carman. 1983. Association of iota-like toxin and Clostridium spriroforme with both spontaneous and antibiotic-associated diarrhea and colitis in rabbits. J. Clin. Microbiol. 17:414-418.

Butcher, C., M.J. Bryant and E. Owen. 1983. The effect of dietary metabolizable energy concentration upon the pre-and post-weaning performance of growing rabbits. Anim. Prod. 36:229-236.

Champe, K.A. and D.V. Maurice. 1983. Response of early weaned rabbits to source and level of dietary fiber. J. Anim. Sci. 56:1105-1114.

Cheeke, P.R. and J.W. Amberg. 1973. Comparative calcium excretion by rats and rabbits. J. Anim. Sci. 37:450-454.

Cheeke, P.R. and N.M. Patton. 1978. Effect of alfalfa and dietary fiber on the growth performance of weanling rabbits. Lab. Anim. Sci. 28:167-172.

Cheeke, P.R. 1980. The potential role of the rabbit in meeting world food needs. J. Appl. Rabbit Res. 3(3):3-5.

Cheeke, P.R. and N.M. Patton. 1980. Carbohydrate overload of the hindgut - a probable cause of enteritis. J. Appl. Rabbit Res. 3(3):20-23.

Cheeke, P.R. 1981. Rabbit production in Australia and New Zealand. J. Appl. Rabbit Res. 4:119-120.

Cheeke, P.R. 1983. Rabbit production in Indonesia. J. Appl. Rabbit Res. 6:80-86.

Colin, M., C. Maire, J. Vaissaire and L. Renault. 1976. (Trial of replacing cellulose in rabbit diets by mineral ballasts: sand and vermiculite. (Fr.) Rec. Med. Vet. 152:457-465.

Eaton, P. and D.S. Fernie. 1980. Enterotoxemia involving Clostridium perfringens iota toxin in a hysterectomy-derived rabbit colony. Lab. Anim. 14:347-351.

Evans, E. 1982. An analysis of digestible energy utilization by growing rabbits. J. Appl. Rabbit Res. 5:89-91.

Evans, E., V. Jebelian and W.C. Rycquart. 1983. Effects of potassium and magnesium levels upon performance by fryer rabbits. J. Appl. Rabbit Res. 6:49-51.

Grobner, M.A., W.K. Sanchez, P.R. Cheeke and N.M. Patton. 1982a. Effect of dietary zeolite on mortality and growth of weanling rabbits. J. Appl. Rabbit Res. 5:51-53.

Grobner, M.A. 1982b. Diarrhea in the rabbit. A review. J. Appl. Rabbit Res. 5:115-127.

Grobner, M.a., P.R. Cheeke and N.M. Patton. 1983a. The effect of sodium bentonite on performance and feed preference of weanling rabbits. J. Appl. Rabbit Res. 6:9-14.

Grobner, M.A., P.R. Cheeke and N.M. Patton. 1983b. Diet switching and enteritis. J. Appl. Rabbit Res. 6:25-28.

Harris, D.J., P.R. Cheeke, L. Telek and N.M. Patton. 1981a. Utilization of alfalfa meal and tropical forages by weanling rabbits. J. Appl. Rabbit Res. 4(4):4-9.

Harris, D.J., P.R. Cheeke and N.M. Patton. 1981b. Effect of feeding amaranthus, sunflower leaves, Kentucky bluegrass and alfalfa to rabbits. J. Appl. Rabbit Res. 4:48-50.

Harris, D.J., P.R. Cheeke, N.M. Patton and J.L. Brewbaker. 1981d. A note on the digestibility of leucaena leaf meal in rabbits. J. Appl. Rabbit Res. 4:99.

Harris, D.J. S.D. Lukefahr, P.R. Cheeke and N.M. Patton. 1981c. A note on growing weanling rabbits in feedlot cages. J. Appl. Rabbit Res. 4:73-74.

Harris, D.J. P.R. Cheeke and N.M. Patton. 1982a. Effect of diet, light and breeding schedule on rabbit performance. J. Appl. Rabbit Res. 5:33-37.

Harris, D.J., P.R. Cheeke and N.M. Patton. 1982b. The effect of dietary buffers on growth of weanling rabbits and incidence of enteritis. J. Appl. Rabbit Res. 5:12-13.

Harris, D.J., P.R. Cheeke and N.M. Patton. 1983b. Effect of supplemental vitamins on fryer rabbit performance. J. Appl. Rabbit Res. 6:29-31.

Lang, J. 1981a. The nutrition of the commercial rabbit. 1. Physiology, digestibility and nutrient requirements. Nutr. Abst. & Rev. 51:197-225.

Lang, J. 1981b. The nutrition of the commercial rabbit. 2. Feeding and general aspects of nutrition. Nutr. Abst. & Rev. 51:287-302.

Laplace, J.P. and F. Lebas. 1977. (Digestive transit in the rabbit. 7. Effect of fineness of grind of ingredients before pelleting.) (Fr.). Ann. Zootech. 26:413-420.

Lebas, F. 1980. Les recherches sur l'alimentation du lapin: Evolution au cours des 20 dernieres anners et perspectives d'avenir. Proc. 2nd World Rabbit Congress, p. 1-17.

Lebas, F. 1983. Small-scale rabbit production. Feeding and management systems. World Anim Rev. 46:11-17.

Lukefahr, S.D., D.D. Caveny, P.R. Cheeke and N.M. Patton. 1980. Rearing weanling rabbits in large cages. J. Appl. Rabbit Res. 3(1):20-21.

Lukefahr, S., W.D. Hohenboken, P.R. Cheeke and N.M. Patton. 1983a. Doe reproduction and preweaning litter performance of straightbred and crossbred rabbits. J. Anim. Sci. 57:1090-1099.

Lukefahr, S., W.D. Hohenboken, P.R. Cheeke and N.M. Patton. 1983b. Characterization of straightbred and crossbred rabbits for milk production and associative traits. J. Anim. Sci. 57:1100-1107.

Lukefahr, S.D., W.D. Hohenboken, P.R. Cheeke and N.M. Patton. 1983c. Breed, heterotic and diet effects on postweaning litter growth and mortality in rabbits. J. Anim. Sci. 57:1108-1116.

McNitt, J.I. 1980. The rabbit as a domestic meat source in Malawi. J. Appl. Rabbit Res. 3(3):5-11.

McNitt, J.I., P.R. Cheeke and N.M. Patton. 1982. Feeding trials with cottonseed meal as a protein supplement in rabbit rations. J. Appl. Rabbit Res. 5:1-5.

Milne, G. 1982. A first-hand look at Chinese rabbit production. J. Appl. Rabbit Res. 5:54-60.

Omole, T.A. 1982. The effect of level of dietary protein on growth and reproductive performance in rabbits. J. Appl. Rabbit Res. 5:83-88.

Owen, J.E. 1976. Rabbit production in tropical developing countries. Trop. Sci. 187:203-210.

Partridge, G.G., M.F. fuller and J.D. Pullar. 1983. Energy and nitrogen metabolism of lactating rabbits. Brit. J. Nutr. 49:507-516.

Patton, N.M., H.T. Holmes, R.J. Riggs and P.R. Cheeke. 1978. Enterotoxemia in rabbits. Lab. Anim. Sci. 28:536-540.

Patton, N.M. and P.R. Cheeke. 1980. A precautionary note on high fiber levels and mucoid enteritis. J. Appl. Rabbit Res. 4:56.

Patton, N.M., H.T. Holmes and P.R. Cheeke. 1983. Hairballs and pregnancy toxemia. J. Appl. Rabbit Res. 6:99.

Pote, L.M., P.R. Cheeke and N.M. Patton. 1980a. Utilization of diets high in alfalfa meal by weanling rabbits. J. Appl. Rabbit Res. 3(4):5-10.

Pote, L.M., P.R. Cheeke and N.M. Patton. 1980b. Use of greens as a supplement to a pelleted diet for growing rabbits. J. Appl. Rabbit Res. 3(4):15-20.

Sanchez, W.K., D.J. Harris, P.r. Cheeke and N.M. Patton. 1981. Free choice feeding of rolled grains, alfalfa pellets and mixed grass-red clover hay to weanling New Zealand White rabbits. J. Appl. Rabbit Res. 4:75-76.

Spreadbury, D. and J. Davidson. 1978. A study of the need for fibre by the growing New Zealand White rabbit. J. Sci. Fd. Agr. 298:640-648.

Swick, R.A., P.R. Cheeke and N.M. Patton. 1981. The effect of soybean meal and supplementary zinc and copper on mineral balance in rabbits. J. Appl. Rabbit Res. 4:57-65.

Throckmorton, J.C., P.R. Cheeke and N.M. Patton. 1980. Tower rapeseed meal as a protein source for weanling rabbits. Can. J. Anim. Sci. 60:1027-1028.

Wehr, N.B., J.E. Oldfield and J. Adair. 1982. Fur growth and development: nutritional implications. J. Appl. Rabbit Res. 5:38-44.

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