THE DOMESTIC RABBIT: ITS NUTRITIONAL REQUIREMENTS AND ITS ROLE IN WORLD FOOD PRODUCTION

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SUMMARY

The domestic rabbit has great potential as a meat producing animal. Rabbits can produce more meat from forage-based diets than can any other type of livestock. Feed conversion ratios' of 3-4: 1 can be obtained with high roughage diets. Rabbits are adaptable to both small and large scale production, and may be especially useful in tropical developing countries. Profitability of commercial rabbit production is currently limited by labor intensive management techniques, severe disease problems, and inadequate knowledge of nutritional requirements and nutritional effects on the development of enteric diseases. If these problems can be overcome, and if grains become less available and more expensive for animal feeding, the rabbit may become a major livestock species.

INTRODUCTION

At present, rabbit production, is a minor agricultural enterprise throughout the world. It is developed to its highest degree in Western European countries such as France, Italy and Spain, which have a long tradition of consuming rabbit meat,. Rabbits are raised in comparatively large numbers in China, which is the main exporter of rabbit meat, and in Hungary, which has the world's largest rabbitries. Even in these countries, however, rabbit production is minor compared with that of cattle, swine and poultry.

Rabbits have a number of attributes which may lead to their increasing in importance in the years ahead. They have the potential to become a major livestock species. The intention of this article is to outline and discuss these attributes, to discuss the problems which presently prevent this potential from being realized', and to review the current state of rabbit research.

Rabbits have a number of attributes which lead to a very high biological potential for meat production (Cheeke, 1980):

1. Rabbits can be fed high forage, low grain diets that are largely non-competitive with human food requirements.
2. Rabbits can utilize forage protein more efficiently than can other livestock.
3. Rabbits exhibit a high feed conversion efficiency, even on high roughage diets.
4. Rabbits have the potential of being in a constant state of reproduction.
5. Rabbits have a rapid growth rate, similar to that of broiler chickens,
6. There is a high degree of genetic diversity, both within and between breeds.
7. Rabbits are suited to both small scale production (backyard, self-sufficiency) and to large scale intensive commercial production.

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8. Rabbit meat is a high quality, nutritious product.

UTILIZATION OF FORAGES BY RABBITS

It is widely predicted that in the future, grains will be increasingly used for human consumption and be less available and more expensive for animal feeding. Animals which efficiently use roughages would be non-competitive with human food needs, and might be more suitable livestock species than those which require high energy grain-based diets.

In recent studies at the Rabbit Research Center, the effect of replacing grain with lucerne meal on the performance of weanling rabbits ha's been investigated (Pote et al, 1980). The results are summarized in Table 1. Even when corn was completely replaced by lucerne meal, there was'no reduction in average daily gain. As the lucerne level increased, caloric density of the diet decreased, but the animals increased their feed intake to maintain the samecaloric intake. This demonstrates that the rabbit, like other species, eats sufficient feed to meet its energy requirements. The group fed the high energy corn-soy diet with no lucerne had the poorest growth rate, confirming earlier studies (Cheeke and Patton,, 1978) showing a growth response to the addition of lucerne to a low fibre diet. Enteritis caused mortality in all treatments except the one in which lucerne completely replaced corn, which supports the carbohydrate overload theory of enteritis (Cheeke and Patton, 1980). This theory will be discussed in more detail later. This experiment demonstrated that it may be possible to effectively produce rabbits on diets that are low in grain. Even with total replacement of grain by lucerne', the feed conversion of 3.9 (Table 1) is much better th-an would be observed with ruminants fed a 74% lucerne diet. In another experiment (Harris et al, 1981) even higher lucerne levels were used with no decrease in growth rate (Table 2)

TABLE 1 Performance of weanling rabbits fed high lucerne diets (Pote et al, 1980),3

% dietary lucerne	% corn replaced by lucerne	Av. daily gain (g)	Av. daily intake (g)	Feed/ gain	Daily DE intake (MJ)
0	0	31.4[a]	84.2[a]	2.7	1.30
10	10.1	44.0[b]	107.5[b]	2.4	1.57
20	21.7	36.6[ab]	105.3[b]	2.9	1.47
30	36.2	40.1	110.4[b]	2.8	1.46
40	50.7	36.4[ab]	115.8[b]	3.2	1.44
50	65.2	41.1[b]	130.9[c]	3.2	1.53
60	79.7	37.3[ab]	134.3[cd]	3.6	1.46
74	100	38.2[ab]	147.6[d]	3.9	1.45

Means followed by different superscripts are different (P<.05)

TABLE 2 Performance of weanling rabbits fed various levels of lucerne meal

% lucerne	Av. daily gain (g)	Av. daily feed intake (g)	Feed/ gain
20	39.1	99^{a}	2.57^{a}
70	39.0	132^{bc}	3.40^{b}
74	36.3	124^{b}	3.64^{b}
78	36.7	128^{b}	3.39^{b}
82	40.8	144^{c}	3.55^{b}
86	38.8	142^{c}	3.75^{b}
90	35.9	135^{bc}	3.78^{b}

Means followed by different superscripts are different ($P<0.05$)

Rabbits have considerable potential in tropical countries. Some of their attributes under these conditions have been discussed by Owen (1976) and McNitt (1980). They can efficiently convert tropical forages into meat, and can be raised on a backyard scale by villagers. They can be regarded as "biological refrigerators," because the meat can be stored alive until needed, and then the entire carcass consumed by a family in one or two meals. This eliminates the refrigeration problems that are associated with the meat of larger animals. Several tropical forages have been evaluated at the Rabbit Research Center with the intent of increasing the productivity of tropical rabbit production (Harris et al, 1981). They were used at a dietary level of 408, and compared with lucerne at the same level. Growth performance and feed conversions with several of the tropical forages were excellent (Table 3). Digestibility of the protein and fibre fractions also compared favorably with lucerne (Table 4). These data, and numerous other studies previously reviewed (Cheeke, 1977), show that rabbits digest the protein in forages quite efficiently but do not use the fibre fraction efficiently. While the low digestibility of the fibre may at first seem to limit forage utilization, it may not. As Hintz et al (1978) suggest, the low digestibility of fibre in herbivorous monogastrics may be advantageous. They make efficient use of the 75-80% of a forage that is non-fibre, and rapidly excrete the fibre fraction. In ruminants, the passage of ingesta from the rumen is dependent on particle size, so that forage fibre must be degraded before it can leave the rumen. Thus on a high roughage diet, nutrient intake is limited by the rate at which fibre is excreted rapidly, 'so relative feed intake can be higher,. and a greater quantity of non-fibre components is available to the animal.

The digestibility of forage protein by rabbits (Table 4) compares favorably with that in ruminants. The digested protein is probably used more efficiently in rabbits. In ruminants, some of the amino acids in forage are degraded and used to synthesize bacterial protein, which has a fairly low biological value. In rabbits, the amino acids liberated in digestion are absorbed directly, while in ruminants, some of the protein is converted to ammonia in the rumen, which may be absorbed and excreted, representing a nitrogen loss.

TABLE 3 Growth performance of weanling rabbits fed lucerne meal and tropical forages (Harris et al, 1981)

Forage	Av. daily gain (g)	Feed/ gain	Mortality (%)	Incidence of diarrhea (%)
Lucerne	39.9[a]	2.94[a]	0	20
Desmodium distortum	45.1[a]	2.62[b]	0	0
Macroptilium lathyroides	40.6[a]	2.98[a]	10	20
Cassava	31.5[b]	3.16[ac]	0	0
Stylosanthes guinensis	33.5[b]	3.13[ac]	30	50
Winged bean	34.5[b]	3.24[c]	0	20
Clitoria ternata	32.3[b]	2.34[d]	0	40
Cassia tora	30.1[b]	3.02[a]	10	40
Guinea grass	26.7[b]	3.65[e]	0	40

Means followed by different superscripts are different (P<0.05)

TABLE 4 Digestibility of lucerne and tropical forages by weaning rabbits.

	Digestibility (%)*		
Forage	Crude protein	Acid detergent fiber	Cell wall constituents
Lucerne	79.9	29.0	22.6
Desmodium distortum	76.6	20.8	24.3
Macroptilium lathyroides	71.0	21.5	13.5
Cassava	59.5	6.0	16.1
Stylosanthes guinensis	64.0	8.8	6.8
Winged bean	67.5	24.7	20.8
Clitoria ternata	71.1	24.5	29.5
Cassia tora	68.7	25.5	22.9
Guinea grass	73.8	1.5	5.0

*These values are for the complete diet, in which the forage constitutes 40% of the complete diet. The remainder of the diet was primarily corn and soybean meal.

The conversion of feed to gain by weanling rabbits fed high roughage diets is excellent. Even with complete replacement of grain with 74% lucerne, the feed/gain ratio was less than 4 (Table 1). With the diets containing 40% tropical forages, the feed/gain ratio was about 3. This value compares favorably with feed conversions observed with swine fed a corn-soy diet, and is better than conversions achieved with ruminants on any diet. The reasons for the high feed conversions obtained with rabbits are not entirely clear, since they do not utilize the fibre portion of roughages effectively. Apparently an increased gut size produced on a high fibre diet, which might contribute to increased total gain, is not a factor. In the studies of Pote et al (1980) the dressing percentages of rabbits fed the 0 and 74% lucerne diets were virtually identical (48.4 and 49.2% respectively). Since rabbit meat 'is low in fat (Pote et al, 1980; Rao et al, 1979), the energy costs per unit of weight gain may be low. This could at least partially explain the high feed conversions observed.

REPRODUCTION AND BREEDING ATTRIBUTES

Another attribute of rabbits is their potential for a constant state of reproduction. Does can be rebred on the day that they kindle (give birth) and the young can be weaned at 28 days. Since the gestation period is 31 days, a doe can have a litter three days after weaning. Thus. it is theoretically possible to have a doe with three litters simultaneously: one weaned litter (4-8 weeks), one litter in the nest box, and one in utero. This *system of intensive breeding (post-partum breeding) is being evaluated in Europe and at the OSU Rabbit Research Center. Intensive breeding is still experimental, and is not recommended until further evaluation is completed. Nevertheless, the capacity for post-partum breeding is indicative of the high rate of productivity potentially attainable in rabbit production.

The high degree of genetic diversity in rabbits offers the potential for advances in productivity through selection and cross-breeding. Various breed differences exist for traits of productive performance. Breed differences in conception rate, birth'weight, % young born alive, weaning weight, rate of gain, and'disease resistance have been reported (Lukefahr et al, 1980a, 1980b, 1980c). Through the- application of selection techniques and crossbreeding, increases in productivity similar to those experienced in other livestock are 'likely.' Lukefahr et al (1980a) have examined the potential of producing a terminal cross, using Flemish Giant sires on small crossbred does. The offspring have the same growth rate as New Zealand White fryers,' while the small does have lower feed requirements because of their small size. The use of small does may offer increased feed efficiency and reduced cage space requirements. As the rabbit industry develops, production of hybrid strains with increased productivity will likely occur.

SCALE OF RABBIT PRODUCTION

Another attribute of rabbits is that they are suited to both small and large scale production. Rabbits are the only livestock that can be raised on a backyard scale in a city or suburban setting. They are noiseless, and relatively free of odor. They can be fed various greens such as weeds, vegetable tops, lawn clippings, etc. as a substantial part of their diet. With increasing emphasis on home food production and self sufficiency, rabbit production on a backyard scale is increasing in the USA. . In developing countries, rabbit production can make a major contribution to food supplies (Owen, 1976). Large scale commercial production has reached its highest development in Hungary, where 10,000-doe rabbitries exist. These large farms are able to use technological advances such as artificial insemination, synchronized breeding, automatic cleaning systems, hybrid breeding stock, etc. (Cheeke and Patton, 1981).

FACTORS LIMITING RABBIT PRODUCTION

In spite of these various attributes of the rabbit in terms of its high biological productivity, rabbit production is a minor industry. Several factors account for this. They include high labor intensity, disease problems, and nutritional problems.

Labor intensity

Compared to the raising of other livestock, rabbit production is labor intensive and requires a high degree of management skill. Rabbit does are caged individually, are hand-mated, and the fryers are handled individually at weaning and marketing.

If rabbit production is to be competitive with other types of animal production, production systems to increase the efficiency of labor utilization are needed. In Europe, harem breeding systems have been used. Does are kept individually in cages. A long narrow buck cage is constructed behind a bank of doe cages. The bucks may enter the doe cages through an opening whereas. each doe wears a collar to prevent her from leaving her cage. In this way, the does can be bred without any human labor required. Artificial insemination may be another way of increasing breeding efficiency, especially in large rabbitries. Automated feeding and cleaning systems could reduce labor costs as well. It is possible that new methods of production need to be developed to make this a viable industry. For example, Lukefahr et al (1980d) are investigating the possibility of using feedlot cages, in which hundreds of weanling rabbits are kept. In this system, it may be possible to raise weanling rabbits to market weight in feedlot cages on wheels with automatic feeders and waterers. When the fryers reach market weight, the cage could be wheeled onto a truck, and taken to the processing plant, with very little labor in-put.

Diseases

A major factor limiting commercial rabbit production at present is a number of devastating diseases. These include enteritis, pasteurella infections, and "young doe syndrome."

Enteritis is responsible for the death of at least 20% of all fryers born. It is characterized by profuse diarrhea, dehydration and death. While the cause(s) and prevention of enteritis are not fully understood, progress is being made. It has been widely believed that enteritis is diet-related. Cheeke and Patton (1978) demonstrated that dietary fibre has a protective effect against enteritis, and proposed that fibre may exert a physical effect on the gut lining, helping to maintain its'integrity. Recently, it has been hypothesized that dietary fibre may aid in preventing carbohydrate overload of the hindgut (Cheeke and Patton, 1980). Briefly, we hypothesize that enteritis may be caused by bacterial toxins, produced by bacteria that proliferate in the cecum and colon when conditions permit their rapid growth. These bacterial toxins are absorbed, and are lethal. Patton et al (1978) have identified Clostridium perfringens Type E as one of the causative organisms. Prescott (1978) has implicated E. coli. Cheeke and Patton (1980) suggested that these organisms proliferate in the hindgut when dietary starch. or other readily available carbohydrate passes undigested through the small intestine., and reaches the hindgut. This allows the pathogens to proliferate. Increasing the fibre level of the diet results in reducing the amount of gain. According to the carbohydrate overload theory, the reduction in grain, rather than the fibre per se, exerts the enteritis-preventing effect. In a study of replacement of grain with lucerne, enteritis was completely prevented with a high lucerne low grain diet (Pote et al,. 1980).

Pasteurella infection is another major cause of economic loss. Patton et al (1980) demonstrated that colonization of the nasal passages of the rabbit with Pasteurella multocida is dependent on the presence of ammonia in the environment. Adequate ventilation to control ammonia and humidity levels is vital in controlling pasteurella infections. This disease is manifested in various ways, including metritis, orchitis, mastitis, conjunctivitis, sinusitis, and subcutaneous abscesses. Sinusitis (snuffles) is the most severe problem.

New systems of management

The. rabbit industry could probably become more competitive if new improved management techniques were developed. These should emphasize utilization of inherent biological advantages of the rabbit, such'as the short interval between litters, controlling light for year-round production, early weaning, and new caging systems. A major area of emphasis in future rabbit research should be the development of management procedures to increase productivity and lower labor costs.

NUTRITIONAL REQUIREMENTS

Information on specific nutrient requirements of rabbits can be obtained from the National Research Council publication on rabbit nutrition (NRC, 1977). Briefly, for major nutrients, the requirements for growth and lactation as a % of the diet are: crude protein, 17%; digestible energy, 10.5 MJ; crude fiber, 10-12%; calcium, 0.75% and phosphorous, 0.5%. On a practical basis, the nutritional requirements of the rabbit are met with quite simple diets. Because rabbits engage in coprophagy, their B vitamin requirements are satisfied by intestinal synthesis. Rabbit diets are traditionally high in lucerne, which is an excellent source of fat soluble vitamins and trace minerals. Thus a simple mixture of grain or grain by-products, lucerne, a protein supplement, and a mineral supplement is satisfactory.

Recently there has been much interest in the role of fibre in rabbit nutrition. Fibre has an interesting role, in that while it is largely indigestible in the rabbit, it seems to be necessary for normal growth and prevention of enteritis. Cheeke and Patton (1978) and Pote et al (1980) found that the growth rate of weanling rabbit was significantly poorer on a high energy, low fibre diet, than when higher fibre levels were used. The incidence of enteritis was higher with low fibre diets..

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