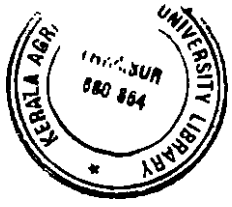
EVOLVING LOW COST RATION FOR COMMERCIAL BROILER RABBIT PRODUCTION

BIYA ANN JOSEPH



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DECLARATION

I hereby declare that the thesis, entitled **"EVOLVING LOW COST RATION FOR COMMERCIAL BROILER RABBIT PRODUCTION"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Introduction

1. INTRODUCTION

Rabbits *(Oryctolagus cuniculus)* are herbivorous animals, which belong to the order *Lagomorpha*. Rabbit farming is a rapidly growing enterprise in India. It has been realized that the domestic rabbit is an important livestock species that has immense potential to improve the socio-economic status of the rural poor as well as to contribute substantially to the country's Gross Domestic Product. Broiler rabbits are reared for meat and fur and Angora rabbits for wool production.

India has about 3,00,000 breedable female rabbits (Gulyani *et al.*, 2000) and according to a 2004 census, Kerala has the highest number (1,48,233) of rabbits followed by Nagaland (38,408), Bihar (29,380), Rajasthan (22,929) and Uttar Pradesh (22,191). Rapid growth rate, early maturity and high rate of reproduction are some of the assets with this species (Risam *et al.*, 2005). Rabbit meat is a good source of high quality protein, low in fat and is accepted by the non-vegetarians of all religions. Rabbits can turn 20 per cent of the protein they eat into edible meat (Gulyani *et al.*, 2000).

Broiler rabbit farming has also been accepted as a source of income among educated people in Kerala. Rabbit farming has the potential to serve all sections of the society by providing employment for women, children, aged or handicapped people. Since rabbits are amenable to backyard farming, semi intensive and intensive system of management, rabbit rearing can be a profitable operation for both landed and landless farmers. Success of rabbit farming at all levels depends on the identification and control of diseases and effective management practices. Since the basic environmental and management factors are widely different in our country as compared to western countries, to optimize the production performance, it is necessary that extensive feeding trials be carried out under controlled conditions.

One of the advantages of production in tropical countries is that rabbits can be fed forages and agricultural byproducts not suitable for human consumption. When these feeds make up the bulk of the diet for rabbits, the use of a small quantity of concentrate feed to improve performance can be justified. When rabbits are fed with lower quantity of pellets, the nutritional value must be replaced without increasing the calories, which is done by increasing the vegetables. As efficient converters of vegetable protein into high quality animal protein, broiler rabbit has gained much popularity among people and their rearing has become a common occupation.

Higher percentage of good quality roughage can be a part of rabbit diet provided it is supplemented with small percentage of concentrate to meet the nutrient requirement (Gupta *et al.,* 2001). This emphasizes the importance of a balanced diet for rabbits. But rabbit rearing based on a commercial rabbit diet with conventional feed ingredients is not profitable considering the present market values of the feed ingredients, as feed cost is the most critical aspect that determines the profit of a rabbitry enterprise. The need for formulating low cost rabbit ration without compromising on the performance of the rabbits deserves top priority for enhancing rabbit husbandry in Kerala. Recommendation of an optimum feed composition will improve the economic return of the farmer and the overall productivity of the rabbit production system. With this in mind, the present study was envisaged to evolve a low cost feeding system for efficient rabbit production. The different objectives of the study are:

1. Documentation of rabbit husbandry systems in the field conditions
2. Evaluation of different low cost feeding systems on broiler rabbit production
3. To recommend an optimum low cost feeding system for better productivity of rabbits.

Review of Literature

2. REVIEW OF LITERATURE

2.1 RABBIT PRODUCTION SYSTEM

Owen (1976) observed an apparent trend of lower disease incidence and/or higher productivity levels in rabbit operations managed as small-scale family units as opposed to intensive, commercial units where the management quality per animal may be less.

Suitable shelter for rabbits might be a veranda or empty room of the family compound, or a complete hutch (cage with roof and siding) or outdoor shed with narrow width (less than 6 m) with open sides to facilitate natural ventilation (Lukefahr and Cheeke, 1990).

Hoffmann *et al.* (1992) reported that the main limiting factor for rabbit meat consumption in Bobo-Dioulasso was its price, which was not affordable by commoners, and low cost carcass cuts were not offered.

Hassan and Owolabi (1996) revealed that rabbits were used as a cheap meat source in Nigeria which were mainly fed on Amaranthus along with garden trimmings and leftovers, kitchen waste, grains, lettuce, carrot leaves and other leafy vegetables. The herd size ranged from 3-10 with 60 per cent farmers keeping less than 10 rabbits and sanitation was mainly done by sweeping.

Kustos and Szendrö (1996) estimated that 31 per cent of rabbit breeders in Hungary kept a herd size of 6 to 10 does but only 17.2 per cent have over 20 does, most of which were kept in wire cages.

Suc *et al.* (1996) observed that the does reared in underground shelters were 8 per cent heavier after 2 months; they gave birth to 39 per cent more offspring and weaned 60 per cent more than those in cages. Survival rate from

birth to weaning was improved by 16 per cent. They concluded that the underground housing system for rabbits were markedly superior to the conventional cage system in North Vietnam.

Lopez *et al.* (1999) conducted a survey in Mexico city and stated that the mean number of rabbits found in the households was 9 and the breeds preferred by the producers were New Zealand, California, Giant and Criollo at 28, 21, 19 and 19 per cent respectively. Household consumption was the most common though 68 per cent reported selling the animals, which contributed to family income. The management of the animals is principally the task of women and children. Fresh Lucerne, commercial feed, tortilla, maize, wheat bran, native grasses and household wastes were utilized for feeding rabbits. Scabies, diarrhoea and catarrh were common which were treated with conventional medicines (54 per cent), home remedies (21 per cent) or not at all (25 per cent). Most producers (80 per cent) reported cleaning cages periodically as a means to prevent illness.

Gulyani *et al.* (2000) estimated that a family raising 5-6 does on locally available grain, forage and household waste can obtain 2 rabbits or 2.5 kg meat every week for domestic consumption or sale. They suggested that small-scale backyard rabbit rearing can be a useful enterprise to improve the health and socio- economic condition of the tribals and rural and urban poor.

Kumar *et al.* (2001) states that under Indian conditions, extensive system of reproduction is preferred without subjecting the animals to unnecessary stress. They inferred that 30-35 weaned young ones could be produced under favourable climatic and strict management conditions.

A survey on rabbit rearing conducted by Prathap and Ponnusamy (2006) revealed that a majority of the respondents were young, had studied up to high school, and possessed favourable attitude towards rabbit rearing. The respondents

belonged to both middle and high-income groups, had both agriculture and other occupations and lived in both nuclear and joint families.

2.2 PERFORMANCE OF RABBITS UNDER DIFFERENT FEEDING SYSTEMS

2.2.1 Body Weight

Sastry and Mahajan (1982) found poor performance of rabbits that were completely fed on roughage diet and recorded a total weight gain of 925±124.72 g from 10 to 20 weeks of age Vs above 1400 g with supplemented groups.

In an experiment conducted on four week old rabbits fed on an unrestricted pellet diet, it was found that rabbits receiving ginseng grew more rapidly than the controls (King, 1983).

Ravindran *et al.* (1986) suggested that cassava leaf meal could be replaced upto the 40 per cent level in growing rabbit diets without any adverse effects on growth performance.

Tangendjaja *et al.* (1990) reported that diets replaced with leucaena in various levels of inclusion had significantly slower growth than the control diet and inferred that Leucaena leaf meal had insignificant effect on growth in intensive rabbit production in the tropics.

Deodhar *et al.* (1991) observed that the rabbits fed with concentrate and *Coprious fimetarius* treated rice straw showed a significantly higher body weight (2.22±0.03 kg) as compared to urea treated straw (2.055±0.11 kg) and untreated straw (1.94±0.10 kg) along with concentrate.

Gangadevi and James (1992) revealed that animals maintained on ensiled subabool exhibited better growth rate when compared to fresh subabool.

Gupta (1992) studied the growth performance of rabbits on different roughages and inferred that green fodder of oat and pea can be safely fed to growing rabbits upto 30 per cent level.

Gupta *et al.* (1992) observed that there was no significant difference between the body weights of rabbits maintained on pellets and green ricebean fodder (2.50±0.05 and 2.35±0.05 kg). They indicated that ricebean could fully meet the maintenance needs of rabbits on sole feeding.

Radhakrishnan (1992) observed that the mean values of body weights at fourth, sixth, eighth, tenth and twelfth weeks were highest in Soviet Chinchilla rabbits compared to Grey Giant and New Zealand White rabbits. The mean values of body weights for New Zealand White rabbits during the same period were 383.3±12.4, 573.1±18.1, 788.6±23.2, 1000.5±24.0 and 1205±29.9 g respectively.

Tiwari *et al.* (1994) observed significantly higher total and average body weight gains in rabbits fed with 0.5 per cent livol in their diet (1132±12.58 g and 21.21±1.16 g) than in control group without livol supplementation (1023±16.54 g and 18.26±0.66 g) though the dry matter intake was slightly less for the livol group (125±2.84 g) than the control (138.0±3.42 g). They inferred that 0.5 per cent livol supplemented group of rabbits showed superior growth rate and better utilization of feed nutrients than those without livol supplementation.

The study done by Gupta *et al.* (1995) revealed that corticated job's tears (*Coix lachryma)* grain can be incorporated upto 30 per cent in grower and 20 per cent in adult rabbit's ration and can be fed to them as pelleted and mash form respectively for satisfactory growth and maintenance.

Sawal *et al.* (1995a) observed that the gain in body weights of Soviet Chinchilla rabbits, which were fed with two brands of commercial pelleted feed, were non- significant upto 8th week but thereafter with every week the animals gained significantly ($P<0.01$) higher body weight upto 12th week.

Sawal *et al.* (1995b) inferred that incorporation of 11.3 per cent apple pomace might be optimum level in the diet of growing rabbits for good growth performance.

Bora *et al.* (1996) inferred that 75 per cent commercial pellet ration along with 25 per cent fresh Paragrass on DM basis can used for optimum performance in New Zealand White and Soviet Chinchilla rabbits in hot humid climatic condition.

Prasad and Singh (1996) observed that rabbits maintained on *ad libitum* green fodder alone and overnight water soaked whole corn alone consistently lost ($P<0.05$) their body weight averaging 0.8 and 0.6 kg respectively while those fed on concentrate and a mixture of overnight water soaked whole corn and green fodder *ad libitum* maintained their body weights.

Sawal *et al.* (1996) inferred that 13.2 per cent tomato pomace might be safe level for satisfactory gain in growing rabbits.

Abu *et al.* (1999) concluded that it was best to combine dehydrated sweet potato tops and sweet potato root meal in the proportion of 80:20 for optimum utilization by growing rabbits.

The results of the study conducted by Igwebuike *et al.* (1999a) using graded levels of *Acacia albida* pods indicated that upto 20 per cent could be incorporated into the diet of growing rabbits without compromising performance.

Sese *et al.* (1999) reported that replacing growers' mash by dry cowpea testa upto 60 per cent level results in better growth performance and digestibility in rabbits.

Uko and Ataja (1999) studied that millet or maize offals are good substitutes for maize grain in diets for rabbits because they were cheaper and produced higher weight gains.

Bhasin *et al.* (2000) recommended that concentrate intake can be reduced to 20-30 per cent by supplementing diets of growing rabbits with high energy and fibre from roughage source such as mulberry leaves.

Bhatt *et al.* (2000) observed that body weight increased with robinia leaves incorporation at 25 per cent level (1591± 49.8 g) and was significantly ($P<0.05$) higher than other treatments with 50 and 75 per cent incorporation and concluded that robinia leaves at 25 per cent level inclusion gave higher growth performance, nutrient utilization and carcass composition than other treatment groups. At 50 per cent level, the performance was comparable with control group.

Kasiviswanathan (2000) recorded the mean body weights of New Zealand White rabbits at weaning (fourth week), sixth, eighth, tenth and twelfth weeks as 236.7±20.6, 461.7±27.4, 678.2±31.0, 934.2±44.1 and 1117±51.5 g respectively.

Kumar and Bhatt (2000a) recommended replacing 40 g mash feed /day in the diet of Angora rabbits with 60 g lucerne hay without any adverse effect.

Kumar and Bhatt (2000b) revealed that by replacing 20 g mash with 50 g partially sun dried robinia leaves, there was a comparable increase in the body weight of rabbits.

Rohilla and Bujarbaruah (2000a) observed that the rabbits under 60 per cent concentrate and *ad libitum Morus alba* leaves weighed heavier than those kept under 100 per cent concentrate and 75 per cent concentrate and *ad libitum Morus alba* leaves and concluded that *Morus alba* leaves can be fed to rabbits advantageously with concentrate diet for better growth rate and feed efficiency.

Rohilla and Bujarbaruah (2000b) observed the live weight change of groups fed with fresh broom grass *(Thysanolaena maxima)*, dried broom grass and concentrate mixed with dried broom grass in the ratio 40:60 as 1025.50±13.61, 1237.33±17.12 and 1650.75±14.36 g respectively. It was concluded that broom grass can be fed to rabbits with advantage only if it is well processed and mixed with concentrate in the ratio 40:60.

De *et al.* (2001) confirmed that cabbage waste can be utilized as rabbit feed to produce as good a performance as on traditional feeding systems with Nevaro and Amsilo leaves when supplemented with 50 per cent concentrate mixture.

Fru and Ekpenyong (2003) observed that incorporating 3 and 5 per cent each of palm kernel oil (PKO) in the standard diet of rabbits did not have any significant effect on live weight gain. However, they recommended the use of PKO at 3 per cent level in commercial farming under tropical conditions, as it is cheap and readily available.

Igwebuike *et al.* (2003) found that the weight gain did not differ significantly in any of the treatments incorporating 0, 5, 10, 15 and 20 per cent of soaked *Acacia albida* pods to the control diet.

Yalcin *et al.* (2003) reported that inclusion of 20 and 30 per cent vetch seed in the diet of New Zealand White rabbits decreased the weight gain by 13.04

and 10.76 per cent respectively compared to that of control group with no vetch seed in their diet.

De *et al.* (2004) concluded that Barhar leaves as a sole diet was unable to meet the requirements of adult crossbred rabbits during the lean season as the body weights of rabbits were observed to have decreased from 2197.5±58.40 to 2010.9±67.49 g within a period of 20 days.

Kumar *et al.* (2004) revealed that the total and average body weight gains from weaning to slaughter were 1300 g and 13.83 g/d, 1425 g and 13.84 g/d and 1483 g and 15.29 g/d respectively for Soviet Chinchilla, New Zealand White and White Giant.

Saikia *et al.* (2004) stated that sole feeding of Paragrass could not meet even the maintenance requirement of rabbits. They observed negative nitrogen balance and loss weight in animals and concluded that the sole feeding of Paragrass cannot be recommended for rabbits.

Bhatt *et al.* (2005) reported that gain in weight was significantly higher in group fed with *ad libitum* concentrate (1543.8±30.4 g) and 80 gm concentrate per day (1547.0±28.3 g) as compared to the rabbits fed 50 gm concentrate per day (1442.6±28.5 g).

2.2.2 Average Daily Gain

Gangadevi and James (1992) observed that rabbits maintained with concentrate and Guinea grass diet exhibited significant growth response than those fed with either fresh or ensiled subabool, which replaced Guinea grass. The average daily gains (ADG) for these groups were 11.6, 8.5 and 10.4 g respectively.

According to Gupta (1992) rabbits fed with oat fodder had the highest daily weight gain (22.71±1.07g) and the lowest was recorded for Nevaro leaves at 15.96±1.23g.

Reddy and Reddy (1993) opined that Subabul meal, Hedge lucerne meal and Red gram forage meal when supplemented at 70 per cent level in the ration could not support the maintenance requirements of rabbits and a loss of weight of 1.33, 7.44 and 5.78 g/head/day respectively was recorded.

Bora *et al.* (1996) observed that total gain and gain per day were significantly higher ($P<0.05$) in 100 per cent concentrate (2016.34±6.61 and 22.40±2.75 g) and 75:25 concentrate – roughage ratio (2017.84±6.07 and 22.42±1.00 g) than in 50:50 (1465.66±4.08 and 16.28±0.34 g) and 25:75 concentrate – roughage ratio (1187.50±3.13 and 13.17±0.45 g).

Abu *et al.* (1999) observed that rabbits placed on diets containing dehydrated sweet potato tops and sweet potato root meal in the ratio 80:20 had the best daily weight gain of 12.70±0.17 g. They also reported that the average daily gain of rabbits fed 100 per cent dehydrated sweet potato tops and 50:50 dehydrated sweet potato tops and sweet potato root meal were similar.

Igwebuike *et al.* (1999a) studied that rabbits fed 20 per cent *Acacia albida* pods had the highest daily gains (11.57 g/rabbit/d), while those fed with 5 per cent recorded the least gain (10.83 g/rabbit/day).

Kumar and Bhatt (1999) reported that the ADG were 8.69 gm (pelleted ration), 8.82 gm (20 g replaced by white clover) and 8.20 gm (40 g replaced by white clover) and the differences were non significant.

Sese *et al.* (1999) revealed that rabbits on 60 per cent Dry Cowpea Testa (DCT) diets recorded the highest average daily live weight gain (19.57 g/d) while those on 80 per cent DCT had the least average daily live weight gain (6.37 g/d).

Uko and Ataja (1999) noticed that maize and millet offals offered superior average daily weight gains (16 and 17g/rabbit) and maize grain and sorghum offals supported poorer weight gains (13 g/rabbit).

Rohilla *et al.* (2000) recorded growth rate as 16.92±0.67, 18.00±1.01, 18.88±1.18 and 15.67±0.49 g/d respectively for the following treatments: 100 per cent concentrate, 20, 40 and 60 per cent concentrate replaced with subabul (*Leucaena leucocephala*) leaves and inferred that leucaena tree leaves up to 40 per cent can be included in rabbit diet without any adverse effect on growth.

Rohilla and Bujarbaruah (2000a) reported that the growth rate differed significantly ($P \leq 0.05$) between the three groups as 17.55±0.28 in 100 per cent concentrate, 22.76±0.70 in 60 per cent concentrate and *ad libitum Morus alba* leaves and 19.32±0.40 g/d in 75 per cent concentrate and *ad libitum Morus alba* leaves.

De *et al.* (2001) observed a live weight gain of 13.16±2.94 g/d in rabbits fed with 50 per cent concentrate and 50 per cent cabbage waste.

Linga *et al.* (2003) confirmed that excluding the control data, the best growth rates of 12.5 and 10.3 g/d were observed in the diets consisting of fresh lablab or lablab hay with molasses blocks.

Bhatt *et al.* (2004) stated that rabbits from 28 to 84 days of age can be reared successfully with 40g concentrate per day instead of 60g concentrate per day if supplemented with *ad libitum* quantity oat fodder. The gains per day for 40 and 60g groups were 23.9 and 24.8 g respectively.

Lei *et al.* (2004) inferred that growth performance of weaner to two month old meat rabbits was the best when dietary crude protein was 18-20 per cent, as the ADG was the highest (34.94±1.5 g) in this group. The average daily gain exhibited by 14 and 22 per cent CP groups were the lowest with 32.3 and 32.1 g/d respectively.

2.2.3 Feed Consumption

Sastry and Mahajan (1982) stated that the dry matter (DM) required to produce 1 kg of edible meat when Bengal gram, barley grain and tree leaves were fed was 5.27, 6.20 and 9.22 kg respectively.

Litters fed with 74 per cent alfalfa diet had higher feed intake as compared to litters fed the commercial diet (Lukefahr *et al.*, 1983).

Alawa *et al.* (1990) reported that increase in fibre levels of diets resulted in increased feed intake to compensate for the reduced energy density of such diets.

Gangadevi and James (1992) reported a concentrate – roughage ratio of 1.04:1, 1.16:1 and 1.15:1 respectively for rabbits fed with Guinea grass, fresh subabool and ensiled subabool each fed along with concentrate indicating a better choice of concentrate when fed with subabool. The average DM consumption per rabbit per day in these groups was 84.9, 82.7 and 84.2 g respectively.

Gupta (1992) stated that the dry matter intake (DMI)/100kg body weight in rabbits fed Nevaro leaves was significantly higher than other groups. DMI in rabbits fed ricebean and kabra leaves were almost similar and significantly more than the rabbits fed pea or oat fodder. DMI quickly increases after weaning till it stabilizes around 5.5 per cent of live weight.

Gupta *et al.* (1992) revealed that the average DMI per rabbit fed solely on ricebean fodder was 136.28±4.82 g/d.

Gupta *et al.* (1993) replaced 25 per cent of the concentrate mixture with one of the following dried and ground grass- Setaria, Guinea grass, Hamil and Broom grass and the results indicated that Hamil and Broom grass were better accepted. DMI for the four feeds were 105.12±12.82, 95.24 ±1.33, 114.60±8.24 and 113.20±2.97 g/d respectively.

Sawal *et al.* (1995a) reported a significant ($P<0.01$) increase in DMI from 8^{th} to 10^{th} week, which declined ($P<0.01$) thereafter in the 12^{th} week indicating decrease in feed utilization. Total DMI of the two groups were 3601±57 and 4165±188 g respectively.

Bora *et al.* (1996) reported that the total DMI for 100 per cent concentrate, 75:25, 50:50 and 25:75 concentrate – roughage ratios were 85.08, 91.11, 91.20 and 85.88 g respectively.

Gowda *et al.* (1996) observed the feed intake (kg) per unit meat production (kg) varied between 10.6±0.66 and 13.1±0.91 when rabbits are fed with various vegetable protein supplements.

Prasad and Singh (1996) noticed that rabbits relished green fodder and the DMI in the fodder only group (99.32 g/d) was comparable with control group (100.74 g/d) and the group fed with a combination of fodder and soaked corn (100.0 g/d).

Bhatt *et al.* (1999) observed that DMI per day was higher on rice-phak incorporated diet (115±1.6 g) as compared to control diet (110±1.6 g).

Igwebuike *et al.* (1999a) observed highest feed intake (61.13 g/rabbit/day) in rabbits fed 15 per cent *Acacia albida* pods and the lowest (54.36 g/rabbit/d) with 5 per cent incorporation.

Sese *et al.* (1999) observed an increase in average daily feed intake by rabbits as dry cowpea testa (DCT) increased in the diet upto 60 per cent and then a significant decrease when DCT was increased upto 80 per cent in the diet of rabbits. Rabbits fed with 60 per cent DCT consumed 13 per cent more feed than animals on growers mash and those on 80 per cent DCT consumed 19 per cent less than the control.

Uko and Ataja (1999) confirmed that the feed intake of the rabbits during the experimental period in which maize grain was replaced by offals of millet, sorghum or maize, ranged from 43 to 58 g/rabbit /day.

Gowda *et al.* (2000) observed that dry matter consumption by rabbits in their study was significantly higher in groups fed processed neem kernel meal.

The average DMI as recorded by Rohilla *et al.* (2000) was 112.77±1.07, 114.97±2.30, 114.56±2.85 and 98.88±0.84 g/d for the following treatments: 100 per cent concentrate, 20, 40 and 60 per cent concentrate replaced with subabul (*Leucaena leucocephala*) leaves respectively. They inferred that leucaena tree leaves up to 40 per cent could be included in rabbit diet without any adverse effect on growth.

Rohilla and Bujarbaruah (2000a) reported that the treatment means for DM consumption differed significantly ($P \leq 0.05$) from each other. Daily DMI averaged as 122.67±0.50 g in 100 per cent concentrate, 108.79±0.82 g in 60 per cent concentrate and *ad libitum Morus alba* leaves and 117.56±0.66 g/d in 75 per cent concentrate and *ad libitum Morus alba* leaves.

Rohilla and Bujarbaruah (2000b) reported that DMI increased by 5.29 per cent resulting in 20.69 per cent more growth in rabbits fed dried and ground broom grass than those fed with fresh broom grass and when processed broom grass was mixed with concentrate in the ratio 40:60, DMI enhanced by 7.55 per cent causing 37.95 per cent more growth in that group.

Fru and Ekpenyong (2003) observed that as the animals got older feed intake in all experimental groups reduced at almost the similar rate indicating that palm kernel oil supplementation had no effect on feed intake.

Igwebuike *et al.* (2003) noticed that rabbits on 20 per cent incorporation of *Acacia albida* pods (AAP) consumed significantly more feed (50.82 g) than those with 0 per cent (41.80 g), 5 per cent (42.30 g) and 10 per cent (44.04 g) incorporation. The feed intakes expressed as live weight were 3.08, 3.08, 3.12, 3.28 and 3.58 per cent for rabbits on diet with 0, 5, 10, 15 and 20 per cent incorporation of AAP respectively.

An increase in feed consumption per kg weight gain in rabbits by 7.12 and 7.40 per cent was reported by Yalcin *et al.* (2003) when vetch seed was included in their diet at the rate of 20 and 30 per cent respectively as compared to rabbits without vetch seed.

The total dry matter intake was 98.7 and 114.9 g per day respectively for rabbits fed with 40 g and 60 g concentrate with *ad libitum* quantity oat fodder (Bhatt *et al.*, 2004).

De *et al.* (2004) observed that DMI of Barhar leaves fed, as a sole diet to crossbred rabbits was 119.1 g/d.

Shanmuganathan *et al.* (2004) observed that diets with enzymes added resulted in highest intake (114 g/d) while yeast and effective micro-organism

culture have increased the feed intake by 4.4 per cent as compared to control (104.8 g/d).

Singh *et al.* (2004) inferred that higher level (70 g/d) of concentrate must be fed to rabbits in their initial stages of growth (42 to 84 days) the positive effect of which can not be compensated in the rabbits fed lower level by feeding higher levels in the later stages.

The total dry matter intake was highest (154±15.4 g) in rabbits fed *ad libitum* concentrate and lowest (80.7±3.6 g) in rabbits fed 50 g concentrate (Bhatt *et al.*, 2005).

2.2.4 Feed Conversion Efficiency

Gangadevi and James (1992) recorded better feed conversion efficiency in rabbits maintained on concentrate and Guinea grass than those fed with either fresh or ensiled subabool which replaced Guinea grass, the values being 7.327, 9.696 and 8.144 respectively.

Gupta (1992) observed that feed conversion ratio (FCR) was significantly higher in rabbits fed ricebean (4.62±0.14) and kabra leaves (4.41±0.09) compared to the groups fed oat (3.69±0.16) and pea fodder (3.56±0.08).

Tiwari *et al.* (1994) reported significantly higher feed: gain ratios in livol group (5.09±0.62) than without (7.57±0.89).

Feed: gain ratio were 4.41±0.16 and 4.96±0.45 for the two brands of pelleted complete feeds respectively (Sawal *et al.*, 1995).

Igwebuike *et al.* (1999a) stated that FCR was highest with 10 per cent incorporation of *Acacia albida* pods (5.48) and lowest in the control group (4.89).

Bhasin *et al.* (2000) observed that FCR was best in individually reared rabbits fed mulberry leaves (3.49±0.50) and poorest in batch reared weaners fed with mixed grass.

Feed:gain ratio deteriorated with the addition of robinia leaves and was highest (4.96±0.4) with 75 per cent robinia leaves addition (Bhatt *et al.*, 2000).

Kasiviswanathan (2000) found that the overall feed efficiency for New Zealand White rabbits from fourth to twelfth week of age was 4.179±0.058.

Rohilla and Bujarbaruah (2000b) calculated the feed efficiency of rabbit groups fed fresh broom grass, dried broom grass and concentrate mixed with dried broom grass in the ratio 40:60 as 0.091, 0.104 and 0.135 respectively.

The FCR computed by Igwebuike *et al.* (2003) was similar in all treatments ranging from 4.48 in 10 per cent incorporation to 5.09 in 20 per cent incorporation of soaked *Acacia albida* pods.

Linga *et al.* (2003) noticed that rabbit fed fresh lablab with molasses blocks had a numerically better conversion rate of 5.9.

Kumar *et al.* (2004) revealed that FCR was superior in White Giant rabbits at 1:3.80 as compared to New Zealand White rabbits at 1:4.43.

Lei *et al.* (2004) stated that feed/gain ratio was highest for 14 per cent crude protein (CP) group (3.10) and lowest for 20 per cent CP group (2.74).

Shanmuganathan *et al.* (2004) observed that enzyme supplementation resulted in significantly ($p<0.05$) lower FCR (5.60) compared to yeast (6.40), effective micro-organism culture (6.43) and control (8.20).

Bhatt *et al.* (2005) revealed that the feed:gain was best at low level concentrate supplementation (3.15) and deteriorated with increase in concentrate level (5.59).

2.3 PROXIMATE ANALYSIS

Sastry and Mahajan (1982) estimated that crude protein of Bengal gram had the highest with 16.30 per cent, followed by white clover hay with 14.40 per cent and least was for biul tree leaves at 7.98 per cent.

Deodhar *et al.* (1991) found that fungal treated rice straw had higher crude protein content (11.73 per cent) as compared to urea treated rice straw (7.37 per cent).

The percentage chemical composition of ensiled *Leucaena leucocephala* (subabool) were 67.10, 18.42, 5.54, 13.55 and 55.47 for moisture, crude protein (CP), ether extract (EE), crude fibre (CF) and nitrogen free extract (NFE) respectively (Gangadevi and James, 1992).

Gupta (1992) evaluated the percentage nutrient composition of different roughages and found that ricebean and pea fodder contained higher CP content (12.90 and 12.92) than others on dry matter (DM) basis, whereas Nevaro leaves contained relatively less CF content (17.32).

Gupta *et al.* (1992) estimated that the ricebean fodder *(Vigna umbellata)* contained 18.36, 21.79, 1.42 and 50.63 per cent CP, CF, EE and NFE respectively, on dry matter basis.

Reddy and Reddy (1993) reported that the chemical composition of subabul meal and red gram forage meal were comparable except for higher CF

(31.43 per cent) and NFE (42.39 per cent) in subabul meal. Hedge lucerne meal had less protein and NFE and more CF (39.55 per cent) compared to others.

Sawal *et al.* (1995b) evaluated the chemical composition of dried apple pomace on percentage dry matter basis and estimated that CP, EE and CF were 7.53, 1.57 and 19.31 respectively.

Prasad and Singh (1996) evaluated the nutritional value of soaked corn and found that it has lesser crude protein content (8.20 per cent) than fodder (21.80 per cent) and concentrate pellets (19.60 per cent) used as control.

Proximate composition of tomato pomace as found by Sawal *et al.* (1996) were 17.41, 5.58, 35.58 and 31.52 per cent of CP, EE, CF and NFE respectively.

Abu *et al.* (1999) found that sweet potato tops contain 19.29, 23.53 and 5.29 per cent of CP, CF and EE respectively.

Bhatt *et al.* (1999) estimated that the nutritive value of diet incorporating rice-phak was lower as compared to control diet. Rice-phak was found to contain 14.1 per cent protein, 27.5 per cent fibre and 5.25 per cent fat.

The proximate composition of *Acacia albida* pods reveals 12.37 per cent CP and 11.18 per cent CF (Igwebuike *et al.*, 1999b).

Sese *et al.* (1999) evaluated dry cowpea testa and found that it was lower in crude protein (13.86 per cent) and higher in crude fibre (29.52 per cent) than growers mash.

Uko and Ataja (1999) estimated the chemical contents of various cereal offals and found that millet had a higher crude protein (12.1 per cent) whereas maize offal was superior in its ether extract (4.6 per cent).

Bhasin *et al.* (2000) evaluated mulberry leaves and found that it had a CP, CF, EE and DM of 20.44, 14.32, 3.06 and 91.67 per cent respectively.

Kumar and Bhatt (2000a) found that lucerne hay contains 19.10, 21.60, 2.80 and 42.10 per cent of CP, CF, EE and NFE respectively.

The chemical composition of robinia leaves on percentage DM as evaluated by Kumar and Bhatt (2000b) revealed crude protein, crude fibre and ether extract as 17.68, 19.24 and 5.10 respectively.

The chemical composition (per cent DM) of cabbage waste was DM- 10.94, CP- 22.75, CF- 6.50, EE- 4.96 and NFE- 55.29 (De *et al.*, 2001).

Farzana *et al.* (2003) evaluated the nutrient composition of the cereals in their raw form and found that though moisture content was highest in rice, protein and fat contents were highest in wheat compared to other cereals.

Igwebuike *et al.* (2003) reported the percentage chemical composition of soaked *Acacia albida* pods as follows: DM - 92.36, CP- 11.90, CF- 11.10, EF- 2.50, Ash- 5.50 and NFE- 69.0.

Yalcin *et al.* (2003) estimated the proximate principles in vetch seed (*Vicia sativa L.*) on percentage DM as follows: CP- 25.3, CF- 5.5, EE- 1.2 and Ash- 3.1.

According to Bhatt *et al.* (2004) the pelleted concentrate mixture and green oats contained 21.8 and 13.7 per cent CP and 10.2 and 17.2 per cent CF respectively on DM basis. The green oats had 22.2 per cent DM.

The proximate composition of Barhar leaves in per cent DM basis was CP: 12.00 and EE: 4.60. (De *et al.*, 2004).

Saikia *et al.* (2004) estimated Paragrass to have only 8.4, 2.8, 8.4 and 57.6 per cent of CP, EE, CF and NFE respectively on DM basis and concluded that the sole feeding of Paragrass cannot be recommended for rabbits.

2.4 OCCURRENCE OF DISEASES

Pascual and Carmona (1980) observed that rabbits fed more than 45 g/d citrus pulp suffered from diarrhoea which even caused mortality in these groups.

Lukefahr *et al.* (1983) observed that mortality from diarrhoea was higher in rabbits fed with 74 per cent alfalfa diet than those maintained on a commercial diet.

Loliger (1987) stated that the risk of feedborne disorders increases by use of self harvested or collected feedstuffs in cases of rotting or contamination with toxic articles. Furthermore, the level of protein and energy in feed may influence the development and course of enteric disorders. He recommended the practice of prophylactic medication using feed or drinking water additives for the prevention of enteric and hepatic coccidiosis especially for high risk groups like recently weaned rabbits.

The study on post weaning rabbit mortality in India by Rai and Singh (1987) revealed that gastrointestinal affections contributed 49.89 per cent of the total mortality and 62.39 per cent of the total morbidity. Enteritis was responsible for the highest number of deaths, especially in weaners with coccidiosis causing 9.12 per cent of the mortality.

Devi *et al.* (1990) confirmed that Pasteurellosis and Intestinal coccidiosis were the major causes of death in rabbits. Highest mortality due to Pasteurellosis was seen during the period from March to June. Season wise mortality revealed that it was highest in dry season and lowest in the rainy season.

Srilatha *et al.* (1993) studied the gastrointestinal disorders encountered in rabbits at the College of Veterinary Science, Tirupati and rabbit mortality due to digestive disorders was recorded at 13.3 per cent and coccidiosis in 2.7 per cent rabbits.

Harikrishnan *et al.* (1996) observed that against rabbit mange a single dose of ivermectin at 800 µg/kg body weight was found to be very effective and rapid compared to that observed with multiple doses at 400 µg/kg and 200 µg/kg body weight.

High mortality in rabbits recorded during fattening period in the experiment conducted by Yalcin *et al.* (2003) suggested that the lower fibre content of the diet was the cause rather than the inclusion of 0, 10, 20 and 30 per cent vetch seed.

Vasanthi *et al.* (2004) reported that tobacco decoction was highly effective in controlling *Sarcoptes scabiei* infestation in rabbits, without any side effects. Severely infested, moderately infested and mildly infested rabbits required 3, 2 and 1 application respectively for complete healing of lesions.

Kapoor *et al.* (2004) estimated 0.39 per cent each of *Pasteurella multocida* and *Pasteurella haemolytica* out of 207 samples studied. They also reported that there was low isolation of *Pasteurella spp.* from rabbitories, which had better management and hygienic conditions, and no previous history of Pasteurellosis.

Shakuntala *et al.* (2005) confirmed the role of *Staphylococcus aureus, Pasteurella multocida* and *Bordetella bronchiseptica* as important etiological agents for respiratory disease of rabbits. *Staphylococcus aureus* showed highest prevalence in both diseased (72.2 per cent) and healthy animals (59 per cent).

2.5 CARCASS CHARACTERISTICS

Gowda *et al.* (1996) while studying the effect of different vegetable protein supplements on rabbits, discovered that none of the carcass traits varied significantly due to dietary variation except a higher ($P<0.05$) percentage yield of carcass with pluck (58.4±1.50) and carcass with pluck and head (65.1±1.01) in rabbits fed 100 per cent urea ammoniated deoiled mustard meal diet. The overall meat: bone ratio varied between 5.0±0.19 and 5.9±0.60.

Abu *et al.* (1999) observed that rabbits fed on 20 and 30 per cent inclusion of sweet potato root meal recorded the best killing out percentage (49.63 and 49.91 per cent respectively) and 30 per cent group also had the highest kidney weight of 0.74 g which was significantly different ($P<0.05$) from other dietary treatments.

Rabbits raised with 20% *Acacia albida* pods (AAP) showed a superior dressing percentage (54.55 per cent) while those on 15 per cent AAP had the least value (Igwebuike *et al.*, 1999a).

Fru and Ekpenyong (2003) noticed that 3 per cent inclusion of palm kernel oil (PKO) in rabbit diet showed better results than 5 per cent level. The carcass yield and liver weight percentage were significantly better in 3 per cent PKO inclusion (49.65±3.68 and 2.79±0.14) than in 5 per cent PKO inclusion (43.10±4.20 and 2.79±0.24).

Igwebuike *et al.* (2003) reported that the dressing percentage and weight of head, skin, liver, kidney and lungs expressed as percentages of slaughter weight did not differ significantly among different treatments having 0, 5, 10, 15 and 20 per cent incorporation of soaked *Acacia albida* pods in the control diet.

Linga *et al.* (2003) reported that control animals had 6.7 per cent higher carcass yield ($P<0.01$) and 6.3 and 2.8 per cent lower non-emptied and emptied gastro intestinal tract (GIT) ($P<0.01$) compared to rabbits fed lablab forage with an energy supplement. In addition, rabbits fed fresh lablab had 4.0 per cent higher dressing percentage and 3.2 per cent lower non emptied GIT than rabbits fed lablab hay ($P<0.01$) and the molasses block group had 3.1 per cent lower dressing percentage and 4.2 per cent higher non-emptied GIT compared to the sugarcane group ($P<0.01$).

Yalcin *et al.* (2003) reported that average carcass yields were 46.66, 47.40, 45.96 and 47.32 per cent respectively in rabbit groups fed with 0, 10, 20, and 30 per cent vetch seed in their diet which indicated that inclusion of vetch seed did not affect carcass weight and carcass yield.

Kumar *et al.* (2004) observed that the overall average weight of edible offals of White Giant (WG), New Zealand White (NZW) and Soviet Chinchilla (SC) breeds were 62.94, 12.94 and 7.44 g for liver, kidney and heart respectively. NZW and SC had similar dressing percentage (46 per cent) but the weight of head and skin were least in NZW (182.25 and 232.80 g respectively).

Shanmuganathan *et al.* (2004) observed that the use of enzymes and yeast in the feed increased the carcass recovery by 24.7 per cent while effective micro-organism culture increased it by 16.7 per cent in spite of heavier giblets.

The carcass and gastrointestinal attributes indicated higher hot carcass per animal in rabbits fed 80 g concentrate (910.2±19.2 g) followed by *ad libitum* concentrate fed group (905.0±24.3 g) and lastly the 50 g concentrate fed group (867.2±21.1 g). The weight of skin increased and the dressing percentage decreased with higher level of concentrate supplementation (Bhatt *et al.*, 2005).

2.6 ECONOMICS OF PRODUCTION

Although the proximate composition of dry leucaena leaf suggested that it could make a useful contribution to intensive rabbit production in the tropics, the results indicate that its use would be uneconomic in most other circumstances (Tangendjaja *et al.*, 1990).

The results of the study conducted by Onwudike (1995) suggested that gliricidia is a better green feed than leucaena for rabbits and will help to reduce the cost of rabbit production in developing countries.

Igwebuike *et al.* (1999b) stated that feed cost per kg decreased as the level of *Acacia albida* pods (AAP) increased. Compared to the control diet, the inclusion of AAP at 5, 10, 15 and 20 per cent levels reduced the feed cost per kg of weight gain by 9.3, 7.2, 4.9 and 12.9 per cent respectively.

The study conducted by Kumar and Bhatt (1999) revealed that replacement of 20 g pelleted feed by white clover hay reduced the feed cost (12.41 per cent) without any adverse effect on body weight and performance of Angora rabbits.

Sese *et al.* (1999) calculated the cost of feed/gain and found that 60 per cent inclusion of dry cowpea testa was the most economical.

Uko and Ataja (1999) calculated that feed cost per kg gain was highest with maize grains and lowest with millet offals.

The economic analysis by Bhasin *et al.* (2000) showed that rearing weaners upto slaughter age in individual or batch system was profitable on mulberry leaves as roughage source, whereas individual rearing from 4-12 weeks on grass as roughage source was profitable while batch rearing led to a loss.

Gowda *et al.* (2000) suggested that the processed neem kernel meal could be completely substituted for groundnut meal in broiler rabbit diet for optimizing the cost of feeding under our agro-climatic conditions.

Kumar and Bhatt (2000a) noticed that replacing 20 g mash with 30 g lucerne hay and 40 g mash with 60 g lucerne hay considerably reduced the feed cost by 17.39 and 29.43 per cent respectively.

Kumar and Bhatt (2000b) estimated 11.37 and 19.71 per cent lower feed cost in groups where 20 g mash was replaced with 50 g and 100 g robinia leaves respectively.

Igwebuike *et al.* (2003) found that the cost of feeding growing rabbits could be lowered by incorporating up to 20 per cent of soaked *Acacia albida* pods in their diet.

The cost of production expressed per kg weight gain as calculated by Bhatt *et al.* (2004) was Rs.28.11 in 40 g concentrate per day group and Rs.31.36 in 60 g concentrate per day group both supplemented with *ad libitum* quantity oat fodder.

Shanmuganathan *et al.* (2004) concluded that enzyme supplementation was the most economical feeding strategy as feed cost can be reduced by 24 per cent on live weight basis and 39 per cent on dressed weight basis.

It appears that decreasing roughage:concentrate ratio beyond 0.61 is not advantageous in rabbit feeding as it increased the cost of concentrate feeding. The cost of production per kg was Rs.26.74, Rs.30.98 and Rs.42.04 in 50 g, 80 g and *ad libitum* concentrate fed rabbit groups respectively (Bhatt *et al.*, 2005).

Materials and Methods

3. MATERIALS AND METHODS

The resources and facilities available at the Department of Livestock Production Management, Rabbit Breeding Station and Centre of Excellence in Meat science and Technology of the College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy were utilized for the study.

3.1 LOCATION

The study 'Evolving low cost ration for commercial broiler rabbit production' was conducted at the Rabbit Research Station of Kerala Agricultural University, Mannuthy located seven km east to Thrissur and is geographically situated at longitude 76°,05" to 70°, 45" E (east), at latitude 10°, 20" to 10°,56" N (north) and at an altitude of 22.25m above mean sea level. The location of study was endowed with humid tropical climate with maximum rainfall by South West monsoon from June to August and North East monsoon from September to October.

3.2 DOCUMENTATION OF RABBIT PRODUCTION SYSTEM

Thirty rabbit farmers were identified from different parts of Thrissur district by employing purposive sampling method and utilized for documentation. The information regarding feeding, housing, health management and marketing strategies were collected from these rabbit farmers by personal interview and by using a well-designed questionnaire (Annexure I). The composite feed samples from all the selected rabbit units were collected for proximate analysis to ascertain the percentage of proximate principles in the feed.

3.3 DESIGN OF EXPERIMENT

Thirty weaned New Zealand White rabbits were selected from the Rabbit Research Station, Kerala Agricultural University, Mannuthy as uniformly as possible with respect to age and body weight and were utilized for the study. They were randomly divided into five groups of six animals each and allotted to one of the following treatments:

T1 - Rabbits fed with the ration (100 per cent concentrate) provided by the Rabbit Research Station, Mannuthy (Control).

T2 - Rabbits fed with 75 per cent concentrate and 25 per cent vegetable cuttings on dry matter (DM) basis.

T3 - Rabbits fed with 50 per cent concentrate and 50 per cent vegetable cuttings on DM basis.

T4 - Rabbits fed with 25 per cent concentrate and 75 per cent vegetable cuttings on DM basis.

T5 - Rabbits fed with 100 per cent vegetable cuttings on DM basis.

Other management practices prevailing in the farm were followed throughout the experimental period.

3.3.1 Body Weight

The weights of the rabbits were recorded at fortnightly intervals before feeding using a standard weighing balance with 5 gm accuracy and the body weight gains were calculated.

3.3.2 Daily Feed Intake

Daily feed consumption was recorded after subtracting the left over feed.

3.3.3 Feed Conversion Efficiency

Feed conversion efficiency of rabbit groups was worked out on dry matter basis of feed (Banerjee, 1998).

$$\text{Feed Efficiency} = \frac{\text{Feed consumed}}{\text{Body weight gain}}$$

3.3.4 Proximate Analysis of Feed Samples

Proximate composition namely moisture, dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract of the concentrate and vegetable cuttings were estimated (A.O.A.C, 1990) at fortnightly intervals.

3.3.5 Occurrence of Diseases

The occurrences of diseases in the treatment groups during the experimental period were observed.

3.3.6 Carcass Characteristics

At the end of the experiment, three rabbits from each group were slaughtered for evaluation of their carcass traits at the Centre of Excellence in Meat Science and Technology, College of Veterinary and Animal Sciences, Mannuthy.

3.3.7 Economics of Production

The cost of production per kilogram live body weight, from weaning to slaughter was calculated.

3.3.8 Statistical Analysis

The data obtained during the course of study were statistically analysed as described by Snedecor and Cochran (1994) and the results were interpreted.

4. RESULTS

4.1 RABBIT PRODUCTION SYSTEM

4.1.1 Socio Economic Status of Rabbit Farmers

The socio economic status of rabbit farmers in Thrissur district, expressed in percentage is presented in Table 4.1.1. Rabbit farmers from nuclear families (86.67%) readily took up rabbit farming. People employed in public sectors and those involved in business activities took an active interest in rabbit rearing, each with 26.67 % followed by agriculturists constituting 20%.

4.1.2 Rationale for Rabbit Farming

Rationale for rearing of rabbits is shown in Table 4.1.2. The main reason for rearing rabbits was for additional income and the value of keeping pets (53.33%). Raising rabbits as pets was the primary reason for 10% of the respondents and none were willing to rear rabbits for meat purpose alone. About 50% of the farmers are new to this field with their experience spanning one to six months but 23.33% of the respondents were involved in rabbit farming activities for over 3 years. Rabbits were looked after by both wife and children in 43.33% of the cases followed by only children taking an active part in rabbit rearing (30%).

4.1.3 Details of Breed, Source and Strength of Herd

Details of the breed, source and strength of herd are summarized in Table 4.1.3. New Zealand White was the most preferred rabbit breed followed by a combination of Grey Giant and Soviet Chinchilla. Rabbits were obtained mainly from local farmers (63.33%). A high percentage (43.33%) of the rabbit farmers

maintained a rabbit herd of 1 to 10 animals. Only 16.67% of farmers maintained a herd size of more than 20 animals.

4.1.4 Litter Traits

Most households documented had 6 to 10 litter size at birth (65.38%) and the range was similar for litter size at weaning (61.54%). Table 4.1.4 details the litter traits.

4.1.5 Feeding Strategies

A combination of concentrates with locally available leaves/grass was found to be the major feeding system (40%) followed by a combination of vegetables with leaves/ grass (26.67%). The particulars of feeding strategies are given in Table 4.1.5. Majority of the farmers tend to feed a ration of 100 – 125 g per day (46.67%). With regards to the feeding frequency, twice a day was found to be the most common. The proximate composition of composite feed samples (DM basis) reveals a crude protein and crude fibre content of 15.48±0.65 and 14.98±0.22 per cent respectively.

4.1.6 Watering Strategies

The watering strategies followed are listed in Table 4.1.6. Pan watering was found to be the most common (93.33%) type of watering.

4.1.7 Housing of Rabbits

Housing pattern adopted by rabbit farmers is shown in Table 4.1.7. Cage system (93.33%) was the most preferred type of housing with a cage size of 2 – 4 and 4 – 6 sq.ft. being preferred over the above 6 sq.ft. cage size. In majority of the cases, rabbit house was located adjoining the house.

4.1.8 Disposal of Rabbits

Rabbits were disposed by two months of age in 50% of the households and most rabbits (79.16%) were sold for a price of Rs.100 – 150 per pair. The particulars of disposal of animals are given in Table 4.1.8.

4.1.9 Health Management Practices

The health management practices of rabbit farmers in Thrissur district are presented in Table 4.1.9. Digestive disorders were the most frequently occurring disease (20%) followed by skin disease (16.67%). A majority of the farmers (43.33%) seek veterinary help for the treatment of various diseases.

4.1.10 Adoption of Scientific Management Practices

The scientific management practices adopted are summarized in Table 4.1.10. All the farmers documented used the nest box at the time of kindling and none of them vaccinated their stock.

4.2 GROWTH PERFORMANCE

4.2.1 Mean Fortnightly Body Weight of New Zealand White Rabbits

The mean fortnightly body weights (g) of New Zealand White (NZW) rabbits under different treatments are given in Table 4.2.1. Though there is no significant difference ($P>0.05$) in the initial body weights of each group, they begin to differ significantly ($P<0.05$) from the first fortnight onwards. There is no significant difference ($P>0.05$) between T1 and T3 from third to sixth fortnights.

4.2.2 Average Fortnightly Body Weight Gain of New Zealand White Rabbits

The average fortnightly body weight gains (g) of New Zealand White rabbits are shown in Table 4.2.2. There is significant difference ($P<0.05$) in average fortnightly weight gains between the different treatments.

4.2.3 Average Daily Gain of New Zealand White Rabbits

The average daily gain (ADG) of New Zealand White rabbits in grams is shown in Table 4.2.3. There is significant difference ($P<0.05$) in average daily weight gains between the different treatments. The ADG of T4 and T5 are lower as compared to the rest of the treatments.

4.2.4 Average Daily Feed Intake of New Zealand White Rabbits

The average daily feed intake (g) of New Zealand White rabbits on fresh and dry matter basis is presented in Table 4.2.4. There is significant difference ($P<0.05$) in average daily feed intake between the different treatments.

4.2.5 Feed Conversion Efficiency

The feed conversion efficiency (FCE) on dry matter basis under different treatments is presented in Table 4.2.5. There is significant difference ($P<0.05$) in FCE between the different treatment groups. The FCE increases with increase in the percentage inclusion of vegetable cuttings on DM basis. The overall FCE varies from 4.32 ± 0.39 in T1 to 8.72 ± 1.29 in T5.

4.3 PROXIMATE COMPOSITION OF FEED SAMPLES

The proximate composition of feed samples on dry matter basis is summarized in Table 4.3. The feed samples analysed included concentrate and

vegetable cuttings. Concentrates had a slightly higher crude protein (21.82±0.37 Vs 20.97±0.39) and much lower crude fibre (4.09±0.22 Vs 17.08±0.33) content as compared to vegetable cuttings.

4.4 OCCURRENCE OF DISEASES

The occurrence of diseases in the different treatment groups during the experimental period is shown in Table 4.4. Results indicate that while digestive disorders and mange occurred in all the treatments, nutritional deficiencies were seen only in T3, T4 and T5.

4.5 CARCASS CHARACTERISTICS

The carcass characteristics like slaughter weight (g), carcass weight (g), dressing percentage and body components that are expressed as percentage of slaughter weight is presented in Table 4.5. There is significant difference ($P<0.05$) in carcass traits between the different treatment groups.

4.6 ECONOMICS OF PRODUCTION

The cost of production per kg live weight of New Zealand White rabbits reared under various treatments is furnished in Table 4.6. As the per cent DM inclusion of vegetable cuttings increases, the cost of production is found to decrease. It ranges from Rs. 47.52 in T1 to Rs. 8.72 in T5.

Table 4.1.1 Socio economic status of rabbit farmers

Family status	Nuclear family	86.67
	Joint family	13.33
Employment status	Public sector	26.67
	Private sector	16.67
	Business	26.67
	Agriculture	20.00
	Others	10.00

Values in percentage

Table 4.1.2 Rationale for rabbit farming

Reasons for rabbit rearing	Additional income alone	13.33
	Meat purpose alone	0.00
	As pet animal	10.00
	For self employment	6.67
	Additional income + meat	13.33
	Additional income + pet	53.33
	Additional income + employment	3.33
Experience in rabbit rearing	1 – 6 months	50.00
	7 – 12 months	3.33
	1 – 3 years	23.33
	Above 3 years	23.33
Responsibility of rearing	Husband	3.33
	Wife	23.33
	Children	30.00
	Wife and Children	43.33

Values in percentage

Table 4.1.3 Details of breed, source and strength of herd

Rabbit breed	New Zealand White (NZW)	50.00
	NZW + Grey giant (GG)	16.67
	NZW + Soviet Chinchilla (SC)	3.33
	GG + SC	23.33
	Cross bred rabbits	6.67
Source	KAU rabbit farm	13.33
	Distribution by Panchayat	23.33
	Local rabbit farmers	63.33
Herd strength	1 – 10	43.33
	11 – 20	40.00
	Above 20	16.67

Values in percentage

Table 4.1.4 Litter traits

Litter size at birth (no.)	1 – 5	19.23
	6 – 10	65.38
	Above 10	15.38
Litter size at weaning (no.)	1 – 5	38.46
	6 – 10	61.54

Values in percentage

Table 4.1.5 Feeding strategies

Type of feeding	Concentrate + vegetables	16.67
	Concentrate + leaves/ grass	40.00
	Concentrate + vegetables + leaves/grass	16.67
	Vegetables + leaves/grass	26.67
Ration per day	75 – 100 g	33.33
	100 – 125 g	46.67
	125 – 150 g	20.00
Feeding frequency	Once a day	16.67
	Twice a day	83.33
Proximate composition of composite feed samples on DM basis	**Proximate principles**	**Composite feed**
	Moisture	74.66±0.90
	Dry matter	25.34±0.90
	Crude protein	15.48±0.65
	Crude fibre	14.98±0.22
	Ether extract	1.74±0.27
	Total ash	2.93±0.14
	N.F.E	64.88±0.97
	Acid insoluble ash	0.43±0.10

Values in percentage

Table 4.1.6 Watering strategies

Type of watering	Pan watering	93.33
	Nipple watering	6.67

Values in percentage

Fig.1. Rabbit fed with a combination of concentrate and leaves

Fig. 2. Rabbits fed with locally available grasses

Table 4.1.7 Housing of rabbits

Type of housing	Cage system	93.33
	Deep litter system	6.67
Cage size	2 – 4 sq. ft.	39.29
	4 – 6 sq. ft.	32.14
	Above 6 sq. ft	28.57
Location of the housing	Adjoining the house	43.33
	Within 1 – 15 ft from house	33.33
	Above 15 ft from house	23.33

Values in percentage

Table 4.1.8 Disposal of rabbits

Age at sale	1 month of age	37.50
	2 months of age	50.00
	Above 2 months of age	12.50
Sale price per pair	Below Rs. 100/-	8.33
	Between Rs.100 - 150/-	79.16
	Above Rs. 150	12.50

Values in percentage

Fig. 3. Nipple watering system

Fig. 4. Flat deck housing system

Table 4.1.9 Health management practices

	Disease	Frequent	Less frequent	Rare
Occurrence of diseases	Digestive disorders	20.00	33.33	46.67
	Skin disease	16.67	40.00	43.33
	Respiratory infection	0.00	23.33	76.67
	Pre weaning mortality	10.00	16.67	73.33
	Post weaning mortality	13.33	20.00	66.67

Multiple responses not to total; values in percentage

Treatment by whom	Veterinary doctors	43.33
	Livestock Inspectors	13.33
	Experienced farmers	13.33
	Veterinary doctors and farmers	30.00

Values in percentage

Table 4.1.10 Adoption of scientific management practices

Management practices	Use of nest box	100.00
	Deworming	36.67
	Vaccination	0.00
	Daily cage cleaning	56.67
	Spraying ectoparasiticide	13.33
	Manure disposal	70.00

Multiple responses not to total; values in percentage

Fig. 5. Multi-tier cage system

Fig. 6. Cage housing with nest box

Table 4.2.1 Mean fortnightly body weight of New Zealand White rabbits, g

Fortnights	T1	T2	T3	T4	T5
0	624.00±2.14 [a]	625.83±3.00 [a]	622.50±2.81 [a]	623.33±2.78 [a]	622.50±3.09 [a]
1	817.50±3.59 [b]	835.00±4.08 [a]	790.83±3.27 [c]	763.33±1.66 [d]	727.50±4.95 [e]
2	1027.50±10.22 [b]	1100.83±5.97 [a]	1001.67±5.11 [c]	931.67±2.47 [d]	839.16±5.23 [e]
3	1263.33±9.37 [b]	1425.00±10.72 [a]	1253.33±3.8 [b]	1128.33±2.47 [c]	965.00±3.42 [d]
4	1526.66±7.92 [b]	1759.17±10.03 [a]	1534.16±3.00 [b]	1324.16±3.00 [c]	1105.00±3.65 [d]
5	1806.67±5.87 [b]	2081.67±8.43 [a]	1810.97±2.81 [b]	1513.33±3.57 [c]	1235.00±4.28 [d]
6	2071.17±4.42 [b]	2390.00±6.71 [a]	2061.39±2.39 [b]	1695.83±3.51 [c]	1361.67±4.22 [d]

Mean values bearing different superscript in a row differ significantly

Table 4.2.2 Average fortnightly body weight gain of New Zealand White rabbits, g

Fortnights	T1	T2	T3	T4	T5
1	193.50±1.82 [b]	209.17±1.53 [a]	168.33±1.05 [c]	140.00±1.82 [d]	105.00±2.88 [e]
2	210.00±6.83 [b]	265.83±3.00 [a]	210.83±2.39 [b]	168.33±1.05 [c]	111.67±1.05 [d]
3	235.83±2.39 [c]	324.17±6.76 [a]	251.67±1.66 [b]	196.67±1.05 [d]	125.83±2.01 [e]
4	263.33±2.11 [c]	334.17±2.01 [a]	280.83±1.53 [b]	195.83±0.83 [d]	140.00±2.24 [e]
5	280.00±3.16 [b]	322.50±5.73 [a]	276.81±1.66 [b]	189.16±2.01 [c]	130.00±2.24 [d]
6	264.50±2.39 [b]	308.33±2.79 [a]	250.42±1.05 [c]	182.50±2.45 [d]	126.67±1.05 [e]

Mean values bearing different superscript in a row differ significantly

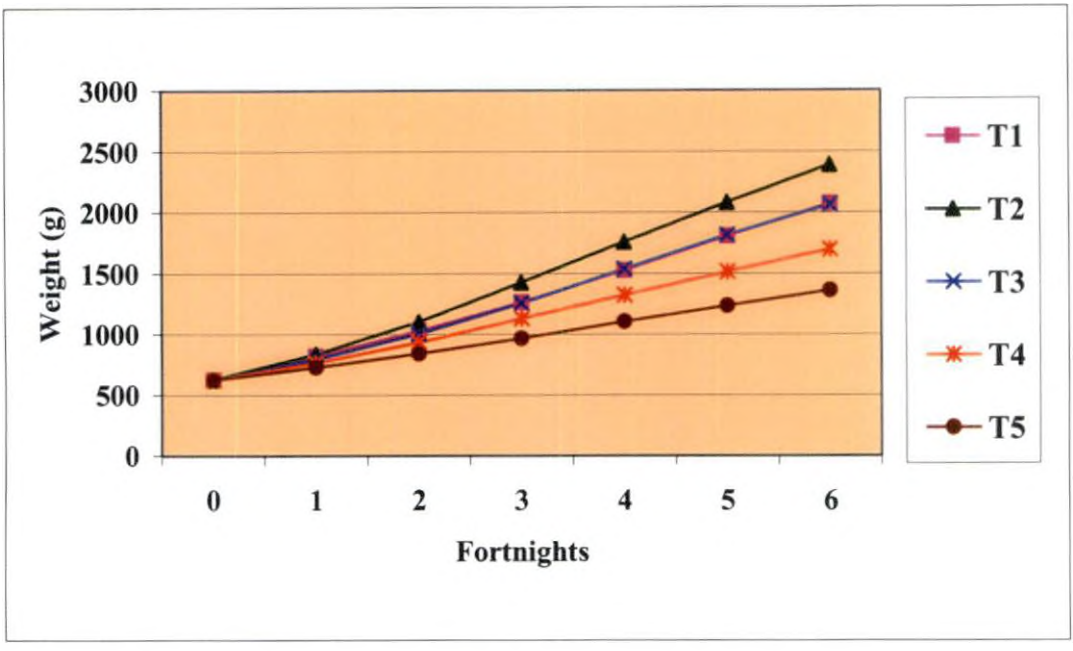

Fig. 7. Mean fortnightly body weight of NZW rabbits, g

Fig. 8. Rabbits maintained on concentrate alone

Fig. 9. Rabbits fed with concentrate and vegetable cuttings

Fig. 10. Rabbits maintained on vegetable cuttings alone

Table 4.2.3 Average daily gain of New Zealand White rabbits, g

Fortnights	T1	T2	T3	T4	T5
1	13.82±0.13 [b]	14.94±0.11 [a]	12.02±0.07 [c]	10.00±0.13 [d]	7.50±0.20 [e]
2	15.00±0.49 [b]	18.99±0.22 [a]	15.06±0.17 [b]	12.02±0.07 [c]	7.98±0.07 [d]
3	16.84±0.17 [c]	23.15±0.48 [a]	17.97±0.12 [b]	14.05±0.07 [d]	8.98±0.14 [e]
4	18.81±0.15 [c]	23.87±0.14 [a]	20.06±0.11 [b]	13.99±0.06 [d]	9.99±0.16 [e]
5	19.99±0.23 [b]	23.03±0.41 [a]	19.77±0.12 [b]	13.51±0.14 [c]	9.28±0.16 [d]
6	18.89±0.17 [b]	22.02±0.20 [a]	17.88±0.07 [c]	13.03±0.18 [d]	9.05±0.07 [e]

Mean values bearing different superscript in a row differ significantly

Table 4.2.4 Average daily feed intake of New Zealand White rabbits, g

Fort nights	T1		T2		T3		T4		T5	
	DM	FM	DM	FM	DM	FM	DM	FM	DM	FM
1	54.50 ±1.53 [a]	60.50 ±1.71 [e]	54.50 ±1.53 [a]	112.84 ±3.20 [d]	54.50 ±2.01 [a]	165.51 ±6.13 [c]	54.50 ±2.01 [a]	218.17 ±7.78 [b]	54.50 ±2.39 [a]	270.83 ±11.93 [a]
2	60.83 ±2.39 [c]	67.59 ±2.65 [e]	79.17 ±2.01 [a]	164.93 ±4.18 [d]	73.33 ±1.66 [ab]	224.07 ±5.09 [c]	70.83 ±1.53 [b]	285.29 ±6.19 [b]	62.50 ±2.81 [c]	312.50 ±14.06 [a]
3	71.67 ±2.11 [c]	79.63 ±2.34 [d]	111.67 ±2.47 [a]	232.63 ±5.15 [c]	95.83 ±2.01 [b]	292.82 ±6.13 [b]	91.67 ±2.47 [b]	369.21 ±9.95 [a]	73.33 ±1.66 [c]	366.67 ±8.33 [a]
4	81.67 ±2.47 [e]	90.74 ±2.75 [c]	124.17 ±1.53 [a]	258.67 ±3.20 [b]	116.67 ±2.11 [b]	301.48 ±5.33 [b]	98.33 ±2.47 [c]	396.06 ±9.95 [a]	88.33 ±2.47 [d]	441.67 ±12.36 [a]
5	88.33 ±2.47 [d]	98.14 ±2.75 [e]	128.33 ±1.66 [a]	267.36 ±3.47 [d]	120.83 ±1.53 [b]	369.21 ±4.69 [c]	101.67 ±2.47 [c]	409.49 ±9.95 [b]	90.00 ±1.82 [d]	450.00 ±9.13 [a]
6	93.33 ±2.47 [d]	103.69 ±2.75 [c]	130.83 ±0.83 [a]	272.57 ±1.74 [b]	124.17 ±1.53 [b]	329.45 ±5.26 [b]	105.00 ±1.82 [c]	422.92 ±7.35 [a]	95.00 ±1.82 [d]	475.00 ±9.13 [a]

Mean values bearing different superscript in a row differ significantly
DM: Dry matter, FM: Fresh matter

Table 4.2.5 Feed conversion efficiency on dry matter basis

Fortnights	T1	T2	T3	T4	T5
1	3.91±0.09 ^{d}	3.65±0.07 ^{d}	4.53±0.16 ^{c}	5.45±0.24 ^{b}	7.27±0.31 ^{a}
2	4.06±0.13 ^{d}	4.17±0.11 ^{d}	4.87±0.08 ^{c}	5.89±0.11 ^{b}	7.84±0.36 ^{a}
3	4.26±0.15 ^{d}	4.83±0.13 ^{c}	5.33±0.14 ^{c}	6.52±0.17 ^{b}	8.18±0.31 ^{a}
4	4.35±0.16 ^{e}	5.20±0.09 ^{d}	5.82±0.12 ^{c}	7.02±0.16 ^{b}	8.85±0.31 ^{a}
5	4.42±0.12 ^{e}	5.58±0.07 ^{d}	6.11±0.09 ^{c}	7.53±0.21 ^{b}	9.69±0.19 ^{a}
6	4.94±0.14 ^{e}	5.94±0.08 ^{d}	6.94±0.11 ^{c}	8.06±0.17 ^{b}	10.50±0.18 ^{a}
Overall	**4.32±0.39** ^{e}	**4.89±0.89** ^{d}	**5.60±0.90** ^{c}	**6.74±1.03** ^{b}	**8.72±1.29** ^{a}

Means values bearing different superscript in a row differ significantly

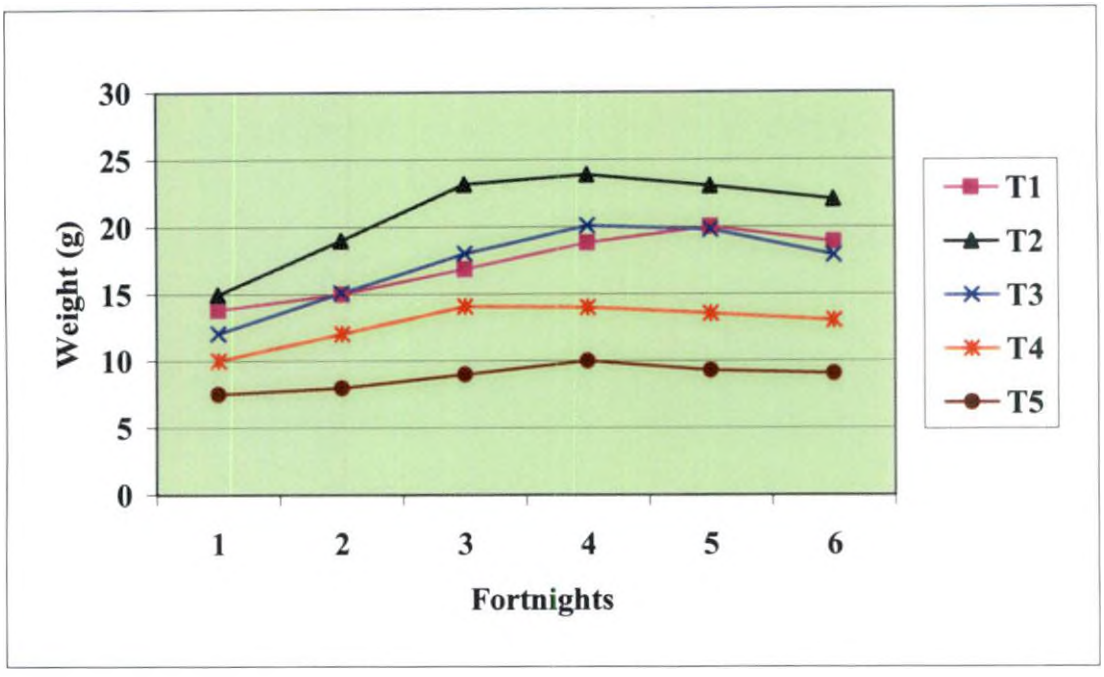

Fig. 11. Average daily gain of NZW rabbits

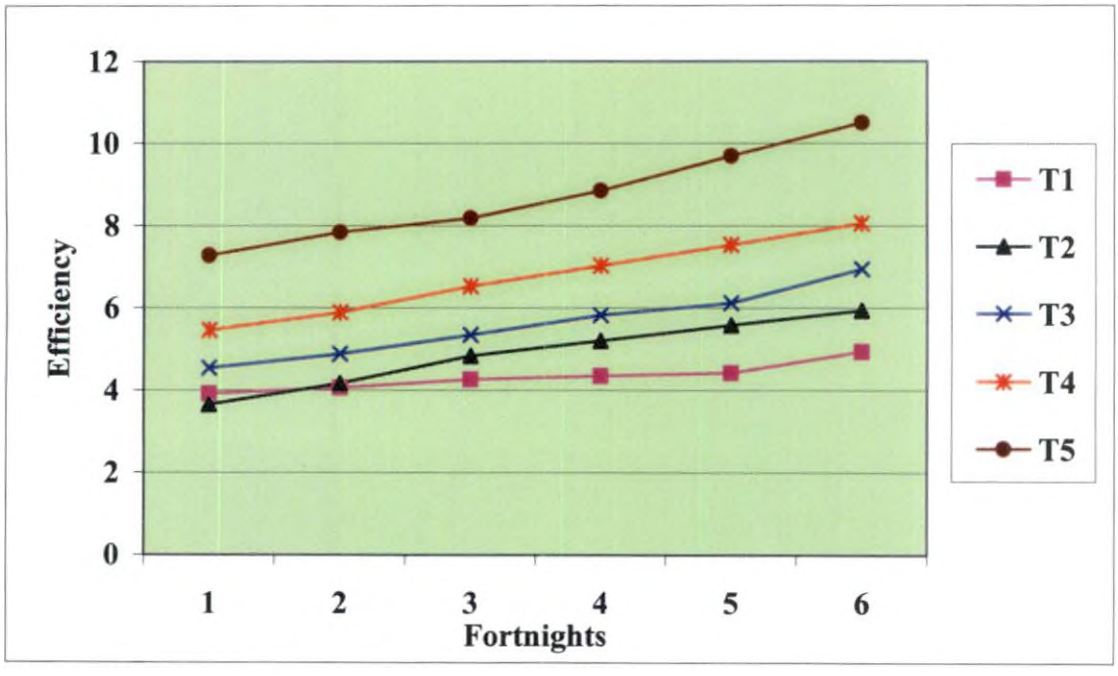

Fig.12. Feed conversion efficiency on DM basis

Table 4.3 Proximate composition of feed samples on DM basis

Proximate principle	Concentrate	Vegetable cuttings
Moisture	10.75±0.60	79.63±0.53
Dry matter	89.25±0.60	20.37±0.53
Crude protein	21.82±0.37	20.97±0.39
Crude fibre	4.09±0.22	17.08±0.33
Ether extract	3.02±0.14	1.75±0.24
Total ash	3.57±0.15	9.58±0.29
N.F.E	67.50±0.38	50.64±0.36
Acid insoluble ash	0.52±0.09	0.55±0.12

Table 4.4 Occurrence of diseases in different treatment groups

Treatments	Digestive disorders	Mange	Nutritional deficiency
T1	1	1	-
T2	2	2	-
T3	3	1	1
T4	4	1	1
T5	4	1	1

Numerals indicate the frequency of occurrence of disease in a group

Fig. 13. Concentrate and vegetable cuttings

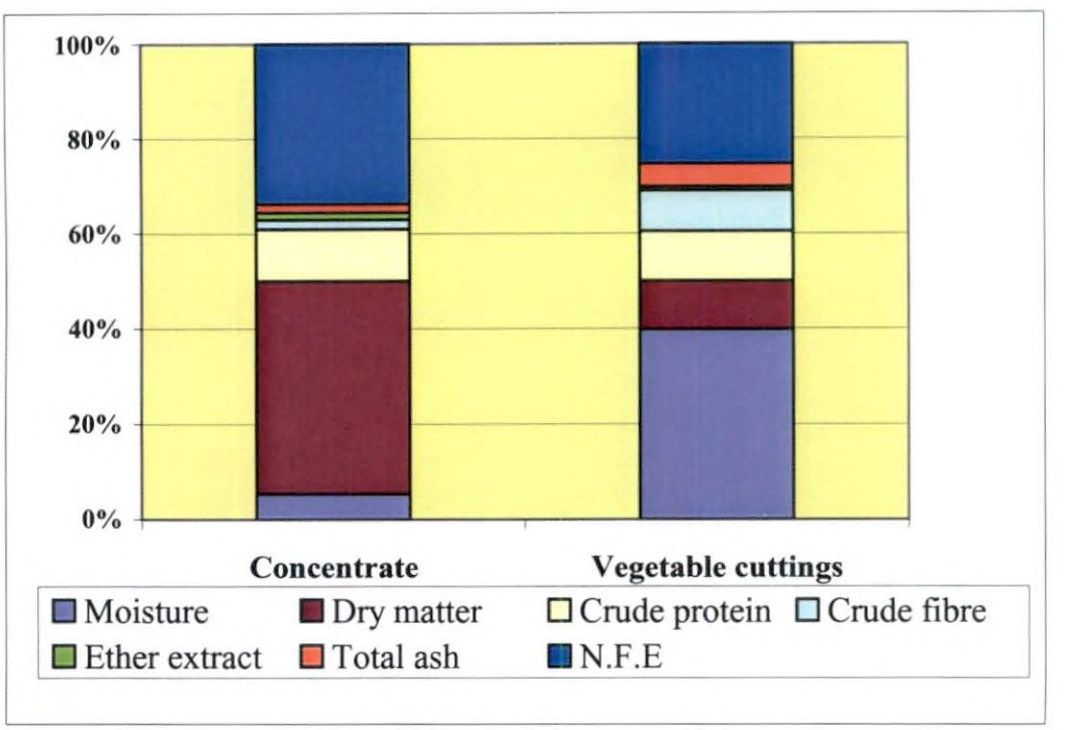

Fig. 14. Proximate composition of feed samples on DM basis

Table 4.5 Carcass characteristics of New Zealand White rabbits

Parameters	T1	T2	T3	T4	T5
Slaughter weight (g)	1972.50±4.42 [b]	2290.00±6.71 [a]	1959.17±2.39 [c]	1595.83±3.51 [d]	1261.67±4.22 [e]
Carcass weight (g)	1015.55±6.07 [b]	1197.36±8.24 [a]	988.24±2.51 [c]	742.21±2.92 [d]	571.66±3.11 [e]
Dressing percentage	51.48±0.19 [b]	52.27±0.21 [a]	50.44±0.07 [c]	46.51±0.08 [d]	45.31±0.09 [e]
Pelt (%)	11.58±0.07 [a]	11.20±0.10 [b]	11.00±0.06 [b]	10.13±0.09 [c]	10.08±0.08 [c]
Head (%)	8.77±0.06 [a]	8.58±0.07 [a b]	8.50±0.06 [b]	8.05±0.09 [c]	7.75±0.06 [d]
Feet (%)	3.51±0.03 [a]	3.18±0.03 [b]	3.51±0.03 [a]	3.72±0.03 [b]	3.13±0.04 [b]
Stomach and Intestine (%)	11.54±0.09 [e]	12.80±0.15 [d]	13.78±0.18 [c]	18.80±0.13 [b]	24.57±0.16 [a]
Liver (%)	2.66±0.05 [c]	3.63±0.07 [a]	2.92±0.06 [b]	2.51±0.08 [c]	2.33±0.04 [d]
Kidney (%)	0.89±0.06 [b]	1.26±0.13 [a]	1.04±0.11 [a b]	0.94±0.05 [b]	0.84±0.04 [b]
Heart + Lungs + Spleen (%)	1.16±0.01 [a]	1.14±0.004 [a b]	1.13±0.004 [b]	1.10±0.04 [c]	1.07±0.02 [d]

Body components are expressed as percentage of slaughter weight

Table 4.6 Cost of production per kg live weight on feed basis

	T1	T2	T3	T4	T5
Number of rabbits	6	6	6	6	6
Total initial body weight (kg)	3.745	3.755	3.735	3.740	3.735
Total final body weight (kg)	12.48	14.33	12.34	10.16	8.16
Total body weight gain (kg)	8.74	10.53	8.61	6.43	4.43
Total feed intake (kg)	41.82	109.83	149.90	175.93	193.35
Total feed cost (Rs.)	460.02	549.16	422.46	297.27	193.35
Cost of feed per kg (Rs.)	11.00	8.50	6.00	3.50	1.00
Feed conversion ratio	4.32	4.89	5.60	6.74	8.72
Cost of production on feed basis (Rs.)	**47.52**	**41.56**	**33.6**	**23.59**	**8.72**

Fig. 15. Carcass and offals of rabbits

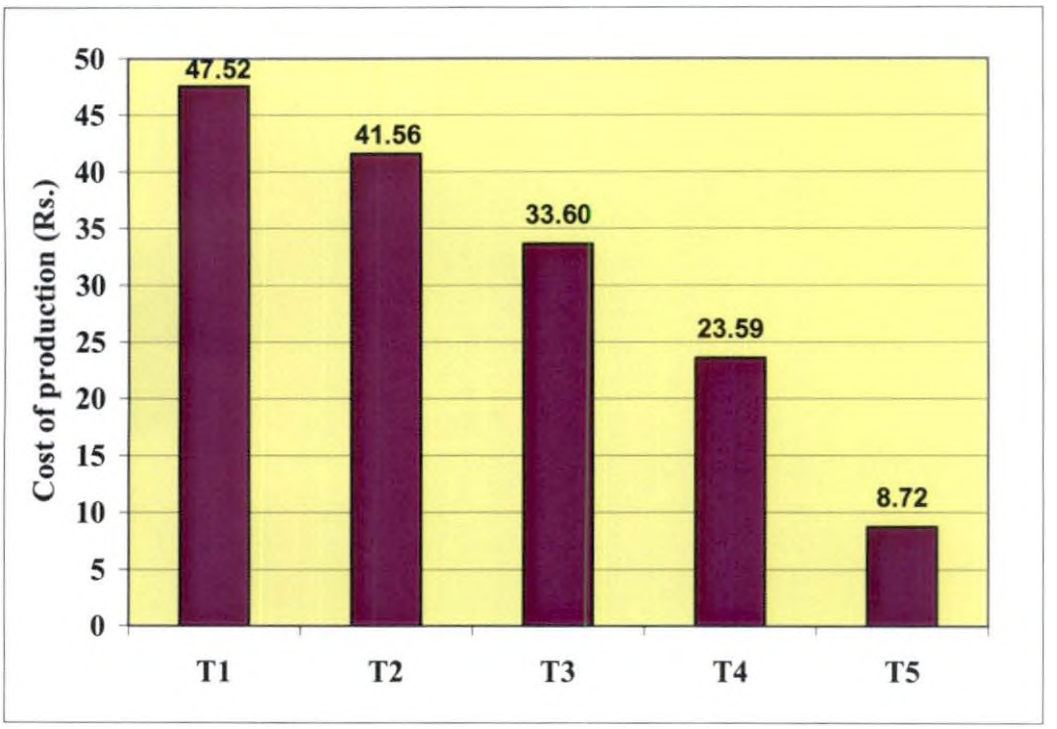

Fig. 16. Cost of production per kg live weight on feed basis

Discussion

5. DISCUSSION

5.1 RABBIT PRODUCTION SYSTEM

5.1.1 Socio Economic Status of Rabbit Farmers

The socio economic status of rabbit farmers of Thrissur district (Table 4.1.1) revealed that people living in a nuclear family system readily adopted rabbit farming as compared to those living in a joint family system. This could be attributed to the availability of more leisure time and the willingness and financial capability to spend on pets, which is an increasing trend in nuclear families. Persons employed in public sector and those involved in business, practiced rabbit rearing at 26.67% each. Agriculturists closely followed this at 20%. This trend could be due to higher income received in public sector and business activities and rabbit rearing might provide additional income to agriculturists. These results are in close agreement with the findings of Prathap and Ponnusamy (2006). They reported that people belonging to middle and high income groups possessed favourable attitude towards rabbit rearing.

5.1.2 Rationale for Rabbit Farming

Rationale for rearing of rabbits (Table 4.1.2) revealed that 53.33% of the respondents kept rabbits for additional income and as pets but none were rearing for meat purpose alone. This finding is in contrast with Lopez *et al.* (1999) who stated that rabbits were reared mostly for household consumption in Mexico. The high price of rabbit meat could be a hindrance to raising rabbits for meat purpose alone, which is supported by Hoffmann *et al.* (1992). About 50% of the farmers are new to this field with an experience of 1 to 6 months and only 23.33% of the farmers have been involved in rabbit farming activities for over 3 years. The primary responsibility of rabbit rearing in 43.33% of the households falls on wife and children indicating the keeping of rabbits as pets and also the easiness of

rabbit rearing. This is in close agreement with Lopez *et al.* (1999). Involvement of children alone in rearing rabbits accounts for 30% of the households.

5.1.3 Details of Breed, Source and Strength of Herd

New Zealand White (NZW) was the most popular breed (50%) followed by a combination of Grey Giant (GG) and Soviet Chinchilla (23.33%), NZW and GG (16.67%) and least was NZW and Soviet Chinchilla (3.33%). Crossbred rabbits also existed in the field (6.67%). This was similar to the findings of Lopez *et al.* (1999). Rabbits were obtained mainly from local farmers (63.33%). Herd size of 1-10 (43.33%) and 11-20 (40%) were comparable and was found to be the preferred strength for small-scale rabbit farming in Thrissur district. This is in accordance with the reports of Gulyani *et al.* (2000). They suggested that small-scale backyard rabbit rearing could be a useful enterprise to improve the health and socio economic conditions of the tribals and the rural and urban poor. Only 16.67% of farmers maintained a herd size of more than 20 animals (Table 4.1.3).

5.1.4 Litter Traits

Among the rabbit farming systems documented, the litter size at birth and at weaning ranged from six to ten (65.38 and 61.54 per cent respectively) which showed that the litter trait performance are optimum (Table 4.1.4). This could be due to availability of better breeding stock and efficient management practices. This is in tune with the findings of Kumar *et al.* (2001). They reported that better performance could be achieved by avoiding unnecessary stress to the rabbits.

5.1.5 Feeding Strategies

In rabbit farming, a major portion of the cost of production is contributed by the feed cost, when fed on concentrate alone. To reduce the feed cost, 40% of the farmers replaced a part of concentrate with locally available grass and plant

leaves. Another 26.67% of the farmers replaced the whole of concentrate with household waste like vegetable cuttings and locally available grass and plant leaves. The combination of concentrate and vegetables (16.67%) and concentrate, vegetables and leaves/grass (16.67%) were found to be the least adopted practice of feeding in rabbits. Farmers, to increase their economic advantage adopted various feeding combinations. This is in accordance with survey results of Lopez *et al.* (1999). They stated that fresh lucerne, commercial feed, tortilla, maize, wheat bran, native grasses and household wastes were utilized for feeding rabbits. Majority of the farmers tend to feed a ration of 100 – 125 g per day (46.67%), followed by 75-100 g (33.33%) and 125-150 g (20%). With regards to the feeding frequency, twice a day was found to be the most common. The availability of feed and the leisure time of the family labour play a major role in the frequency of feeding. The proximate composition of composite feed samples (DM basis) reveals a crude protein and crude fibre content of 15.48±0.65 and 14.98±0.22 respectively (Table 4.1.5). With this protein level in the composite feed, rabbits can obtain adequate nutrients for growth and maintenance.

5.1.6 Watering Strategies

Table 4.1.6 showed that 93.33% of the farmers provided water in pans rather than in bottles (6.67%). Though they were aware of nipple watering system, the non-availability, the cost of installing nipple watering system and difficulty in cleaning the bottles forced the farmers to adopt pan watering.

5.1.7 Housing of Rabbits

The study on the housing pattern of rabbits showed that farmers generally rear rabbits in cages (93.33%) with a floor space of 2-4 sq. ft. (39.29%) and 4-6 sq.ft. (32.14%). Preference of cages to deep litter could be due to the easy cleaning and control of diseases practically experienced by the farmers. Most of rabbit housing is constructed adjoining the house probably to protect the rabbits

from adversities of the environment (Table 4.1.7). Lukefahr and Cheeke (1990), revealed that a suitable shelter for rabbits might be a veranda or empty room of the family compound, or a complete hutch or outdoor shed with narrow width with open sides to facilitate natural ventilation, although Suc *et al.* (1996) confirmed that the underground housing system for rabbits were markedly superior to the conventional cage system in North Vietnam.

5.1.8 Disposal of Rabbits

Table 4.1.8 disclosed that 37.5% of the farmers preferred to sell their bunnies by 1 month of age, 50% by two months of age and only 12.5% sold rabbits above this age. Sale at one or two months of age could be due to the demand for bunnies. The small per cent sold above two months of age could be sold as adults for breeding and meat purpose. A majority (79.16%) of the household sold bunnies at Rs. 100 – 150 per pair, which is very reasonable and affordable to the buyer.

5.1.9 Health Management Practices

The health management practices of rabbit farmers in Thrissur district (Table 4.1.9) revealed that digestive disorders is the major problem in rabbits contributing to 20% of the frequently occurring diseases. It could be due to a change in the feed given or due to its poor quality at the time of feeding. With 16.67%, skin disease is the second most frequently occurring disease. This could be due to unhygienic management practices. Incidence of respiratory infection was less frequent in the study indicating adaptability of rabbits in this hot and humid climate. Pre and post weaning mortality accounted for 10-13%, which could be due to poor mothering ability of dams, lack of sufficient milk, large litter size and due to stressful conditions in the field. These figures project a low incidence of disease in rabbits reared as small-scale family units, which is similar to results obtained by Owen (1976). Lopez *et al.* (1999) revealed that scabies,

diarrhoea and catarrh were common which were treated with conventional medicines (54%), home remedies (21%) or not at all (25%). About 43.33% of the farmers consulted veterinary doctors for treating the disease while 30% were seeking the help of both veterinary doctors and experienced farmers. This reflects the literacy and awareness of the farmers with respect to health management practices. Some of the farmers were seeking help from experienced farmers and livestock inspectors (each 13.33%), which may be due to the close proximity with them.

5.1.10 Adoption of Scientific Management Practices

The study on scientific management practices adopted by rabbit farmers showed that awareness (Table 4.1.10) was lacking in vaccination and control of ectoparasites. But use of nest box, manure disposal, daily cage cleaning and deworming (100, 70, 56.67 and 36.67 per cent respectively) were scientifically practiced in higher proportions. The results of this study revealed that scientific management practices is receiving more attention than disease preventive measures like vaccination and spraying ectoparaciticide. This could be due to the awareness of farmers of the importance of hygiene on economic production. This is in close agreement with Lopez *et al.* (1999). They observed that most of the producers (80%) cleaned cages periodically as a means to prevent illness.

5.2 GROWTH PERFORMANCE

5.2.1 Mean Fortnightly Body Weight of New Zealand White Rabbits

The mean fortnightly body weight of New Zealand White rabbits (Table 4.2.1) showed that there was significant difference ($P<0.05$) between treatments from first fortnight onwards. This is in agreement with Singh *et al.* (2004) who opined that the effect of feeding level becomes significant ($P\leq0.15$) as early as 50 days of age. The animals showed a progressively increasing weight with

advancing age. The mean body weights at sixth fortnight ranges from 1361.67 g to 2390.00 g. T2 had the highest body weight (2390.00 g) among all treatments whereas T1 and T3 showed no significant weight difference. These results are similar to those obtained by Bhatt *et al.* (2000) who observed that robinia leaves at 25% level inclusion gave higher growth whereas at 50% level, the performance was comparable with control group and De *et al.* (2001) who confirmed that cabbage waste can be utilized as rabbit feed to produce as good a performance as when supplemented with a 50% concentrate mixture. T5 showed the least growth (1361.67 g) that is in agreement with Saikia *et al.* (2004). They stated that the sole feeding of Paragrass could not meet even the maintenance requirement of rabbits. The lower body weight of T5 may be due to increased dietary fibre content that decreases the protein digestibility and thus increased the requirements for protein and lowered the growth rate. Hence, it can be concluded that 50% of the concentrate can be replaced with vegetable cuttings without affecting the growth performance as compared to 100% concentrate, although the maximum growth rate was seen with a 25% replacement.

5.2.2 Average Fortnightly Body Weight Gain of New Zealand White Rabbits

The results on the average fortnightly weight gains (Table 4.2.2) revealed that there is a significant difference ($P<0.05$) between the treatments. A positive weight gain was observed in all the treatments. The groups fed with a portion of vegetable cuttings reached their peak faster than the control group. This could be attributed to the interest in feeding due to the palatability of vegetable cuttings. The total weight gain was lower in T5 as compared to the treatments supplemented with concentrate. This is in close agreement with Sastry and Mahajan (1982). Better weight gains were observed upto 50% replacement of concentrate with vegetable cuttings, which is similar to the findings by Gupta (1992), Bhasin *et al.* (2000), Bhatt *et al.* (2000), Rohilla and Bujarbaruah (2000a) and De *et al.* (2001).

5.2.3 Average Daily Gain of New Zealand White Rabbits

The average daily weight gain (ADG) showed significant difference ($P<0.05$) between treatments (Table 4.2.3). The ADG was highest for T2 followed by T1 and T3, which showed almost similar weight gains numerically, then T4 and T5 that showed the least ADG. This could be due to the fact that as the proportion of fibre increases, the total digestibility and the digestibilities of the various constituents of food reduces, thus leading to reduced weight gain (Sandford, 1996). The higher ADG upto T3 may be due to the high CP percentage of the composite feed. These results are in close agreement with Bora *et al.* (1996), Igwebuike *et al.* (1999a), Kumar and Bhatt (1999), Rohilla *et al.* (2000) and De *et al.* (2001). The ADG of T1 and T2 at the final fortnight are comparable to the results obtained by Rohilla and Bujarbaruah (2000a), which were 18.52 and 20.78 g for groups fed on 100% and 75% concentrate.

5.2.4 Average Daily Feed Intake of New Zealand White Rabbits

The average daily feed intake (g) of New Zealand White rabbits on fresh and dry matter basis (Table 4.2.4) had significant difference ($P<0.05$) between the different treatment groups. The daily feed intake had a linear increase from first to the sixth fortnight in all the treatment groups. DM intake of T1 and T5 were not significantly different ($P>0.05$) though rabbits fed with vegetable cuttings alone, consumed higher quantity of feed on fresh basis when compared with the feeding of concentrate alone. This might be due to lower dry matter content of vegetable cuttings and in order to meet the dry matter requirement, it consumed more. This is closely related to the reports by Alawa *et al.* (1990). They stated that increase in fibre levels of diets resulted in increased feed intake to compensate for the reduced energy density of such diets. The DM consumption of T2 was the highest, closely followed by T3, then T4. Similar trend was also reported by earlier workers Bora *et al.* (1996), Prasad and Singh (1996), Bhatt *et al.* (1999), Sese *et al.* (1999) and Rohilla *et al.* (2000).

5.2.5 Feed Conversion Efficiency

The feed conversion efficiency (FCE) on dry matter basis (Table 4.2.5) had a significant difference ($P<0.05$) between the treatment groups. The FCE increases with increase in the percentage inclusion of vegetable cuttings on DM basis. This was similar to the reports by Bhatt *et al.* (2000). The overall FCE varies from 4.32±0.39 in T1 to 8.72±1.29 in T5. This was very close to the findings of Bora *et al.* (1996) who reported a feed efficiency of 4.11 to 6.88 for various ratios of pellets and legumes. However the present findings are contrary to the reports of Bhatt *et al.* (2005). In the present study, poor feed efficiency was found in T5 group. This was in conformity with Sastry and Mahajan (1982), who found lower weight gain and higher intake resulting in lower feed efficiency in New Zealand White rabbits kept completely on roughage diet. The efficiency of feed conversion reduced as age advanced and at the sixth fortnight it ranged between 4.94 in T1 and 10.50 in T5.

5.3 PROXIMATE COMPOSITION OF FEED SAMPLES

The proximate compositions of concentrate and vegetable cuttings (DM basis) were analysed (Table 4.3) and found that the moisture content of vegetable cuttings (79.63) was higher than concentrate (10.75). The crude protein content was almost similar in both concentrate (21.82) and vegetable cuttings (20.97). The crude protein content of concentrate in the study was the same for pelleted concentrate mixture (21.8) as analysed by Bhatt *et al.* (2004). Vegetable cuttings had higher crude fibre and total ash (17.08 and 9.58) than concentrate (4.09 and 3.57) but lower ether extract (1.75) and nitrogen free extract (50.64). The proximate principles for vegetable cuttings are in close conformity with the results of Gupta *et al.* (1992) who estimated that the ricebean fodder contained CP-18.36, CF-21.79, EE-1.42 and NFE-50.63 per cent on dry matter basis.

5.4 OCCURRENCE OF DISEASES

Table 4.4 reveals that digestive disorders were the frequently encountered disease, closely followed by mange. Rai and Singh (1987) also reported a similar trend. These diseases were found to occur in all the treatment groups. The incidence of digestive disorders increased with the increase in inclusion of vegetable cuttings. This could be due to the day-to-day change in quality of feed given. This is in conformity with Loliger (1987) who reported that the risk of feedborne disorders increases by the use of self harvested or collected feedstuffs in cases of rotting or contamination with toxic articles. Mange was also common to all treatments though its frequency of occurrence was mostly limited to one. Though rabbits are highly susceptible to mange, its incidence during the experiment was kept low due to proper cleaning of the cages and timely intervention. This is in close agreement with Harikrishnan *et al.* (1996). Nutritional deficiency like splay legs were absent from T1 and T2 and the incidence was seen in groups fed with more percentage of vegetable cuttings. As vegetable cuttings might not be able to provide all the essential nutrients required by rabbits, nutritional deficiency could have occurred in T3, T4 and T5.

5.5 CARCASS CHARACTERISTICS

The carcass characteristics like slaughter weight (g), carcass weight (g), dressing percentage and body components that are expressed as percentage of slaughter weight (Table 4.5) had significant difference ($P<0.05$) in carcass traits between the different treatment groups. The dressing percentage varied from 45.31 in T5 to 52.27 in T2. The dressing percentages of T2, T3 (50.44) and T4 (46.51) are in close agreement with Bhatt *et al.* (2000) where, concentrate and robinia leaves were given in similar ratios to that of the present study, the dressing percentages were 53.55, 51.19 and 47.65. Pelt percentage was highest for T1 that may be due to increased fat deposition in concentrate feeding (Bhatt

et al., 2005). It was comparable to the 11.9% obtained by Onwudike (1995). The stomach and intestine percentage increased (11.54 to 24.57) with increase in percentage incorporation of vegetable cuttings. This is in accordance to Lebas *et al.* (1986), who found that too much of roughage in the diet tended to overdevelop the digestive tract, thereby lowering the feed efficiency.

5.6 ECONOMICS OF PRODUCTION

The cost of production is the basic measure of economic efficiency in rabbit husbandry. Since feed is the major factor contributing to the cost of production, the economics has been calculated based on feed cost. Table 4.6 showed a gradual reduction in cost of production with increase in incorporation of vegetable cuttings. Hence the cost of production of one kg of rabbit meat ranges from Rs. 47.52 in T1 to Rs. 8.72 in T5. This has been supported by the works of Sese *et al.* (1999), Kumar and Bhatt (2000b) and Bhatt *et al.* (2004). Though T2 has a higher weight and feed conversion efficiency, the cost of production of Rs. 41.56 is high to obtain profit from a rabbit enterprise. Since T3 has been on par with T1 in weight gain, and cost of production is lower by Rs. 13.92, it can be concluded that rearing rabbits on a combination of 50% concentrate and 50% vegetable cuttings can be profitable for commercial broiler rabbit production.

Summary

6. SUMMARY

The research work was conducted to study the present rabbit-farming scenario in Thrissur district and to evolve a low cost ration for rabbits utilizing concentrates and vegetable cuttings in different ratios. The documentation was conducted on thirty rabbit farmers, employing purposive sampling method. A well-designed questionnaire and personal interview supplemented the documentation. The socio-economic status of the rabbit farmers and management practices including feeding, housing and marketing were studied. The composite feed samples fed to rabbits were collected and the percentage composition of proximate principles were analysed.

Thirty weaned New Zealand White rabbits were selected from the Rabbit Research Station, Kerala Agricultural University, Mannuthy as uniformly as possible with respect to age and body weight and were utilized for the study, to evolve a low cost ration for rabbits. They were randomly divided into five groups of six animals each and allotted to one of the following treatments: T1 – Rabbits fed with the ration (100 per cent concentrate) provided by the Rabbit Research Station, Mannuthy (Control). T2 – Rabbits fed with 75 per cent concentrate and 25 per cent vegetable cuttings on Dry Matter (DM) basis. T3 - Rabbits fed with 50 per cent concentrate and 50 per cent vegetable cuttings on DM basis. T4 - Rabbits fed with 25 per cent concentrate and 75 per cent vegetable cuttings on DM basis. T5 - Rabbits fed with 100 per cent vegetable cuttings on DM basis.

The different parameters studied included fortnightly body weight, fortnightly body weight gain, average daily gain, average daily feed intake on dry and fresh matter basis, feed conversion efficiency, proximate analysis of concentrate and vegetable cuttings, occurrence of diseases, carcass traits and economics of production.

The documentation of rabbit production systems revealed that majority of the people who took up rabbit farming lived in a nuclear family system and were employed either in public sector or were involved in business activities. The reason for engaging in rabbit rearing was for additional income generated and the pleasure of keeping rabbits as pets. Most of the farmers are relatively new to this field with only 1-6 months experience and the responsibility of rearing rested with both wife and children. New Zealand White was the preferred breed and the rabbits were mostly obtained from local rabbit farmers. Most farmers maintained herd strength of less than 20. The litter size before and after weaning ranged from 6-10.

The major type of feeding was a mixture of concentrate and locally available leaves and grasses. The common feeding frequency was twice a day and most rabbits were fed 100-125 gm ration daily. The proximate composition of composite rabbit feed revealed a crude protein percentage of 15.48, Crude fibre of 14.98 and Ether extract of 1.74. Pan watering was the common method of watering. Cage system was the preferred type of housing. Cage size of 2-4 sq.ft. and 4-6 sq.ft were most popular. Majority of the cages were located adjoining the house. Most rabbits were sold at 2 months of age at Rs. 100-150 per pair. Digestive disorders were the frequently occurring disease encountered and a high percentage of farmers approached veterinary doctors for treating rabbits. Use of nest box, manure disposal and daily cage cleaning were the commonly adopted scientific management practices. Deworming and spraying ectoparasiticide were less popular and none practiced vaccination.

The experiment conducted to evolve a low cost ration for rabbits revealed that there was significant difference between the treatments in all the parameters studied. T2 had the highest body weight among all treatments whereas T1 and T3 showed no significant weight difference. The animals showed a progressively increasing weight with advancing age. The mean body weights at sixth fortnight ranged from 1361.67 g for T5 to 2390.00 g for T2. A similar trend

was seen in average fortnightly weight gain and average daily gain with T2 having the highest gain and T5 the least gain. The average fortnightly weight gain in the sixth fortnight ranged from 126.67 to 308.33 and the ADG for the same period was 9.05 to 22.02.

The average daily feed intake (g) of New Zealand White rabbits on fresh and dry matter basis had significant difference ($P<0.05$) between the different treatment groups. The daily feed intake had a linear increase from first to the sixth fortnight in all the treatment groups. The feed conversion efficiency (FCE) on dry matter basis reveals a significant difference ($P<0.05$) in FCE between the different treatment groups. The FCE increases with increase in the percentage inclusion of vegetable cuttings on DM basis. The overall FCE varies from 4.32±0.39 in T1 to 8.72±1.29 in T5. Analysis of proximate composition of concentrate and vegetable cuttings showed that the moisture content of vegetable cuttings (79.63) was higher than concentrate (10.75). The crude protein content was almost similar in both concentrate (21.82) and vegetable cuttings (20.97). Vegetable cuttings had higher crude fibre and total ash (17.08 and 9.58) than concentrate (4.09 and3.57) but lower ether extract (1.75) and nitrogen free extract (50.64).

Disease occurrence in the trial conditions also followed a similar pattern as that encountered in the field conditions. The carcass characteristics like slaughter weight (g), carcass weight (g), dressing percentage and body components that are expressed as percentage of slaughter weight shows that there was significant difference ($P<0.05$) in carcass traits between the different treatment groups. The dressing percentage varies from 45.31 in T5 to 52.27 in T2. On calculating the economics of production, it was found that the cost of production of one kg of rabbit meat ranges from Rs. 47.52 in T1 to Rs. 8.72 in T5. Though T2 has a higher weight and feed conversion efficiency, the cost of production of Rs. 41.56 is too high to obtain profit from such a rabbit enterprise. Since T3 has been on par with T1 in weight gain, and the cost of production is

lower by Rs. 13.92, it can be recommended that rearing rabbits on a combination of 50% concentrate and 50% vegetable cuttings can be profitable for commercial broiler rabbit production.

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Appendix

ANNEXURE I

Questionnaire

1. Name :
2. Age :
3. Address :
4. Family details :

Sl.No.	Name of members	Age	M/F	Educational qualification	Occupation

5. Reason for rabbit farming (Please tick) :
   Additional income alone/ Meat purpose alone/ As pet animal/
   For self employment/ Additional income + meat/ Additional income + pet/
   Additional income + employment

6. Experience in rabbit rearing (Please tick) :
   1 – 6 months/ 7 – 12 months/ 1 – 3 years/ Above 3 years

7. Responsibility of rearing rests with Husband/ Wife/ Children/ Wife and Children (Please tick)

8. Details of rabbits (Please tick)
   A. Breed :
   B. Source : KAU rabbit farm/ Panchayat/ Local rabbit farmers
   C. Herd strength : 1-10/ 11-20/ Above20

9. Litter size: A. At birth
   B. At weaning

10. Feeding strategies (Please tick) :

A. Type of feeding: Concentrate + vegetables/ Concentrate + grass or leaves/ Concentrate + vegetables + grass or leaves/ Vegetables + grass or leaves

B. Daily ration : 75-100g/ 100-125g/ 125-150g

C. Frequency of feeding: Once/ twice/ others

11. Watering strategies: Pan watering/ Nipple watering (Please tick)

12. Housing of rabbits (Please tick)

A. Type of housing : Cage/ Deep litter

B. Cage size : 2-4/ 4-6/ Above 6 sq.ft.

C. Location of the house :

13. Disposal of rabbits : A. Age at sale

B. Price per pair

14. Health management practices :

A. Occurrence : Frequent/ less frequent/ rare (Please tick)

B. Disease : Digestive disorders/ skin diseases/ respiratory disease/ pre-weaning mortality/ post-weaning mortality (Please rank)

C. Treatment : Veterinary doctors/ Livestock inspectors/ Experienced Farmers (Please tick)

15. Adoption of scientific management practices (Please rank)

Use of nest box/ Deworming/ Vaccination/ Daily cage cleaning/ Spraying ectoparasiticide / Manure disposal

EVOLVING LOW COST RATION FOR COMMERCIAL BROILER RABBIT PRODUCTION

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ABSTRACT

A study was conducted to document the present rabbit farming scenario in Thrissur district and to evolve a low cost ration for rabbits utilizing concentrates and vegetable cuttings in different ratios. The documentation was conducted on thirty rabbit farmers using a well-designed questionnaire and personal interview. The socio-economic status of the rabbit farmers and management practices were studied. The composite feed samples fed to rabbits were analysed.

The rabbit farmers mostly lived in a nuclear family system and were employed either in public sector or owned business. The reason for engaging in rabbit rearing was for additional income generated and for the value of keeping rabbits as pets. Most of the farmers had only 1-6 months experience and the responsibility of rearing rested with wife and children. New Zealand White was the preferred breed and the rabbits were mostly obtained from local rabbit farmers. Most farmers maintained herd strength of less than 20. A mixture of concentrate and locally available leaves and grasses was the major feeding method with a feeding frequency of twice a day and most rabbits were fed 100-125 g ration daily. The crude protein, crude fibre and ether extract of composite rabbit feed was 15.48%, 14.98% and 1.74% respectively. Pan watering was the common method of watering. Cage system was the preferred type of housing with a cage size of 2-4 sq.ft. and 4-6 sq.ft. Majority of the cages were located adjoining the house. Most rabbits were sold at 2 months of age at Rs. 100-150 per pair. Digestive disorders were the frequently occurring disease and rabbits were mostly treated by veterinary doctors. Use of nest box, manure disposal and daily cage cleaning were the commonly adopted scientific management practices.

Thirty weaned New Zealand White rabbits were selected and utilized for the study. They were divided into five groups of six animals each and allotted to one of the following treatments: T1 – Rabbits fed with the ration (100 per cent concentrate) provided by the Rabbit Research Station, Mannuthy (Control). T2 –

Rabbits fed with 75 per cent concentrate and 25 per cent vegetable cuttings on Dry Matter (DM) basis. T3 - Rabbits fed with 50 per cent concentrate and 50 per cent vegetable cuttings on DM basis. T4 - Rabbits fed with 25 per cent concentrate and 75 per cent vegetable cuttings on DM basis. T5 - Rabbits fed with 100 per cent vegetable cuttings on DM basis.

The parameters like fortnightly body weight, fortnightly body weight gain, average daily gain, average daily feed intake on dry and fresh matter basis, feed conversion efficiency, proximate analysis of concentrate and vegetable cuttings, occurrence of disease, carcass traits and economics of production showed significant difference between the treatments. T2 had the highest body weight among all treatments whereas T1 and T3 showed no significant weight difference and T5 had the least weight. A similar trend was seen in average fortnightly weight gain and average daily gain, with T2 having the highest gain and T5 the least gain. The daily feed intake had a linear increase from first to the sixth fortnight in all the treatment groups. The feed conversion efficiency (FCE) increases with increase in the percentage inclusion of vegetable cuttings on DM basis.

Vegetable cuttings had a higher percentage moisture, crude fibre and total ash (79.63, 17.08 and 9.58) than concentrate (10.75, 4.09 and 3.57) but lower crude fat (1.75) and nitrogen free extract (50.64). The percentage crude protein content was almost similar in both concentrate (21.82) and vegetable cuttings (20.97). Digestive disorder was the commonly observed disease closely followed by mange. The dressing percentage varies from 45.31 in T5 to 52.27 in T2. The cost of production of one kg of rabbit meat ranges from Rs. 47.52 in T1 to Rs. 8.72 in T5. T2 has a higher weight and feed conversion efficiency, but the cost of production of Rs. 41.56 is high compared to T3, which is on par with T1 in weight gain and lower by Rs. 13.92 in its production cost. Hence rearing rabbits on a combination of 50% concentrate and 50% vegetable cuttings can be recommended for commercial broiler rabbit production.