THE EFFECT OF LEVEL OF SUPPLEMENTATION ON THE GROWTH PERFORMANCE OF RABBITS FED BASIC FORAGE DIETS.

by

Bakidambya Mutetikka David

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR A MASTER OF SCIENCE DEGREE IN ANIMAL PRODUCTION IN THE COLLEGE OF AGRICULTURE AND VETERINARY SCIENCES, UNIVERSITY OF NAIROBI

1987.
This thesis is my original work and has not been presented for a degree in any other University.

D. B. MUTETIKKA

This thesis has been submitted for examination with our approval as University supervisors.

Dr. M.M. Wanyoike.

Dr. A.B. Carles
DEDICATION

To my parents
# Table of Contents

Title ........................................................................................................ i
Declaration......................................................................................... ii
Dedication.......................................................................................... iii
Table of contents ................................................................................ iv
List of tables ....................................................................................... vii
List of figures ....................................................................................... viii
List of appendices ............................................................................... ix
Acknowledgements ............................................................................... x
Abstract ............................................................................................. xi

1. Introduction .................................................................................... 1

1.1. Objectives of the study ................................................................. 3

2. Literature Review ........................................................................... 5

2.1. Introduction .................................................................................. 5

2.2. World rabbit meat production and consumption. 6

2.3. Rabbit production in Kenya.......................................................... 7

2.4. Reproductive and development biology of the rabbit. .................. 10

2.5. The influence of breed on rabbit production. 12

2.6. The importance of nutrition in rabbit production ......................... 13

2.6.1. The relative importance of forages in rabbit production .......... 16

2.6.2. The relative importance of commercial concentrates in rabbit production 19

3. Materials and Methods................................................................... 22

3.1. Site of the experiments ................................................................. 22

3.2. General procedure ...................................................................... 22
3.3. Influence of breed type, litter size and litter birth weight on the pre-weaning growth performance of rabbits.............. 23

3.4. The influence of level of supplementation and forage type on the post-weaning growth performance of rabbits..................... 26

3:4:1. Experimental diets and their chemical composition............................... 26

3.5. Quantitative measurements and statistical analyses..................................... 28

3.6. Dressing percentage and meat to bone ratio.. 29

3.7. Economic evaluation of supplementation .... 30

4. Results.................................................. 31

4.0. Chemical composition of the diets................. 31

4.1. Pre-weaning growth performance.................. 31

4.2. Post-weaning growth performance................ 35

4.2.1. Liveweight gain and growth rate of animals fed on Chloris gayana hay.................. 35

4.2.2. Liveweight gain and growth rate of animals fed dry maize leaves.................... 41

4.2.3. Liveweight gain and growth rate of animals fed sweet potato vines.................. 47

4.2.4. Dressing percentage and meat to bone ratio of animals fed on Chloris gayana hay.... 53

4.2.5. Dressing percentage and meat to bone ratio of animals fed on dry maize leaves........ 53

4.2.6. Dressing percentage and meat to bone ratio for animals fed on sweet potato vines..... 56

4.2.7. Cost of post-weaning supplementation.......... 56

5. Discussion .................................................. 59

5.1. Dietary composition................................. 59

5.2. Effect of breed .......................................... 60
5.3. Effect of diet ........................................ 62
5.4. Cost of rabbit meat production .................. 66
6. Summary and conclusions .......................... 68
7. References ........................................... 70
8. Appendices .......................................... 82
List of Tables

2.1. Rabbit population and distribution in Kenya, 1979-1982.............................................. 8

3:1. Distribution of the different litter sizes for each of the three breeds .......... 25

4.0. Proximate composition of the various feeds.. 32

4:1. Analysis of variance and covariance and means of the weaning weight and pre-weaning liveweight increase of litters of the three breeds...................... 34

4:2. Analysis of variance and means of total liveweight gain and growth rate of animals fed on *Chloris gayana* hay................................. 36

4:3. Analysis of variance and means of total liveweight gain and growth rate of animals fed on maize leaves postweaning......................... 42

4:4. Analysis of variance and means of total liveweight gain and growth rate of animals fed on sweet potato vines postweaning...... 48

4:5. Analysis of variance of dressing percentage and meat to bone ratio of New Zealand white animals fed on the three forages and the three levels of supplementation .......... 54

4:6. Means of carcass weight, dressing percentage weight of bone and meat to bone ratio of animals on the three forages at the three levels of supplementation.................. 55

4:7. Cost of post weaning supplementation for animals fed diets of the different forages... 58
List of figures.

4:1. Liveweight and age of the three breeds at the high level of supplementation for animals on a diet of *Chloris gayana* hay ..... 38

4:2. Liveweight and age of the three breeds at the medium level of supplementation for animals on a diet of *Chloris gayana* hay .. 39

4:3. Liveweight and age of the three breeds at the low level of supplementation for animals on a diet of *Chloris gayana* hay ... 40

4:4. Liveweight and age of the three breeds at the high level of supplementation for animals on a diet of dry maize leaves........ 44

4:5. Liveweight and age of the three breeds at the medium level of supplementation for animals on a diet of dry maize leaves.... 45

4:6. Liveweight and age of the three breeds at the low level of supplementation for animals on a diet of dry maize leaves....... 46

4:7. Liveweight and age of the three breeds at the high level of supplementation for animals on a diet of sweet potato vines...... 50

4:8. Liveweight and age of the three breeds at the medium level of supplementation for animals on a diet of sweet potato vines...... 51

4:9. Liveweight and age of the three breeds at the low level of supplementation for animals on a diet of sweet potato vines .... 52
List of appendices

1. Means of weekly liveweight gain of grower rabbits of the three breeds fed on *Chloris gayana* hay and supplemented at the three levels........................................ 82

2. Means of weekly liveweight gain of grower rabbits of the three breeds fed on maize leaves and supplemented at the three levels.. 83

3. Means of weekly liveweight gain of grower rabbits of the three breeds fed on sweet potato vines and supplemented at the three levels........................................ 84
I wish to express sincere gratitude to my academic supervisors Drs. M.M. Wanyoike and A.B. Carles for their advice, criticism, and contribution during the course of this study and preparation of this report. The contribution of Dr. Kayongo Male and Mr. Ogenga Latigo are acknowledged.

Sincere thanks to the staff of the Faculty of Agriculture, Makerere University for the valuable contribution to my undergraduate training, nomination and coming to Nairobi. I am grateful to the staff of the Deans office, Faculty of Agriculture and Department of Animal Production, University of Nairobi, for the part they played in arranging my sponsorship, instruction and advice in the execution of this programme.

This study was financed by DAAD to whom I am very grateful. The assistance of fellow classmates, particularly Drs., R. G. Wahome, C.K. Gachuiiri, and Mr. P. Tharamba and the staff of the National Rabbit Breeding Centre, Ngong, are highly appreciated. I wish to thank Mr. E. Sartorius and the GTZ-GAT for the assistance in securing the animals used in the study. The contribution of many others is also acknowledged.
ABSTRACT

The pre-weaning litter growth in New Zealand white, California and Kenya white breeds of rabbits, and the 7 weeks post weaning performance on diets of *Chloris gayana* hay, maize leaves and sweet potato vines respectively were studied. The forages, fed *ad libitum* were supplemented with commercial concentrate at three levels.

Both genotype and litter size had a significant \((P < 0.05)\) influence on pre-weaning litter weight gain. Mean litter weight gain was \(3745 \pm 158\) grammes with New Zealand white animals having the highest gain of \(4020 \pm 1657\), California with \(3908 \pm 1494\) and Kenya white \(3491 \pm 1477\) grammes.

For the postweaning trials there were significant \((P < 0.05)\) differences between breeds in liveweight gain. No significant \((P > 0.05)\) interaction between genotype and diet was observed. Means of liveweight gain for the New Zealand white and California grower rabbits were not significantly \((P > 0.05)\) different. Growth rate was improved as the level of supplementation was increased. Dressing percentage and meat to bone ratio were significantly \((P < 0.05)\) influenced by level of supplementation and both parameters tended to decrease as the level of concentrate supplement fed was reduced. Cost of
producing a kg of edible carcass was reduced as the amount of concentrate supplement fed was decreased.
CHAPTER 1.

INTRODUCTION

The domestic rabbit (*Oryctolagus cuniculus*), is a member of the vertebrate family Laporidae (Order: Lagomorpha), and is descended from wild rabbits of Western Europe and North West Africa (Harkness and Wagner, 1983).

The importance of the rabbit as a source of meat stems from the fact that these animals are efficient producers of meat under extremely varying conditions. The rabbit is adaptable to almost all climatic, feeding and holding conditions (Schlolaut, 1980).

Unlike most other monogastric animals, the rabbit can survive on low-energy high-fibre feed from weaning to slaughter (Butcher *et al.*, 1983) and they can utilise diets with up to 30% fibre (Davison and Spreadbury, 1975). Their protein requirement is also known to be low. For instance, although the amino acids need of rabbits seem to resemble that of chicken, their protein requirement at 12-16% is substantially less than that of chicken at 23% (Adamson and Fisher, 1975; Cheeke *et al.*, 1985).

Rabbits are efficient converters of feed into body protein and their growth rates are comparable to those of chicken (Kao *et al.*, 1977). In comparing rabbits with other livestock reared for meat Schlolaut (1981), Cook (1976) and Sharkey (1973) noted that their energy requirement per unit of growth is below
that determined for sheep and cattle, that slaughter weight is reached relatively quickly, that annual meat production of the dam is greater than for any other meat producing herbivore and that protein production per unit area is higher than in lambs. Furthermore, the quality of rabbit meat may be superior to that of most other animals (USDA, 1973). From other studies Spedding (1975) concluded that of all the domesticated mammals the rabbit is the most efficient meat producer.

Rabbits have an additional advantage because of their size. Being small and therefore of low individual value, rabbits have limited risk in investment (Cheeke and Patton, 1981) and can easily be afforded by low income households with regard to purchase price and care. Furthermore the small size of carcass does not present the storage problems associated with other livestock (Owen, 1981).

Even though in many developing countries the human animal protein needs are not adequately met (Cianci and Hashi, 1985), the potential role of rabbit meat as a source of protein to improve human nutrition remains to be exploited. The rabbit owes its suitability for meat production in these countries to its ability to effectively convert forage feed into animal protein. Since these animals can efficiently subsist on roughage based diets (Cheeke and Patton,
1981) a farmer on a small holding can make better use of his limited land by feeding crop-residues to such animals (Rastogi, 1986).

With the rapidly increasing human population in developing countries such as Kenya, the trend towards more intensive and semi-intensive rearing of domestic animals has to be extended to rabbit production (Stotz, 1983). To effect these transformations, research should be aimed at identifying ways of maximising the utility of rabbits. Such studies should be aimed at selecting breeds of rabbits suited to various management practices, enhancing their complementarity with, and integration into crop-cultivation, and reducing their competition with man for vegetable and other human food resources (Mosi and Lambourne, 1982).

1.1. Objectives of the study.

The studies reported here were an attempt to evaluate the influence of breed type, litter size, litter weight at birth, and the effects of feeding concentrate supplement at different levels to three forage diets on the performance of rabbits reared for meat. The specific objectives were:

i) to evaluate the differences in breed performance of rabbits reared on basic forage diets with minimal supplementation:

- determine growth performance associated
with each breed prior to weaning;
-determine growth performance after weaning as influenced by level of supplementation of various forages;
-evaluate influence of level of supplementation on carcass yield and the ratio of meat to bone;
ii) to evaluate the economic implications of different levels and patterns of concentrate feeding in combination with forages.
CHAPTER 2.

LITERATURE REVIEW

2.1: Introduction

In East Africa very few studies on domestic rabbit meat production have been published. Thus there is lack of information on breed characteristics, genetic potential, performance levels and environmental tolerance under conditions similar to those in the region (Kiwuwa, 1984). Such information would be used as a basis for identifying strains with high reproductive rates, early maturity and low death rates.

Little is also known in the region about nutrition and management factors influencing rabbit production in terms of growth rate, feed efficiency and feeding economics (Nsubuga, 1979). Besides, the value of tropical crop residues for rabbit meat production has not been fully assessed (Raharjo et al., 1986). In Kenya for example, Stotz (1983) working at the National Rabbit Breeding Centre: Ngong, observed that besides nutritional factors considerable breed differences exist in the growth potential of rabbits.

Of all the factors of animal production, feed accounts for the biggest fraction of total cost, and its optimum utilisation is influenced by the breed of
the animal used. It is thus necessary that rabbit production programmes should combine the cheapest feeding system with the most productive animal breed. It is believed that small-scale farmers could usefully and profitably integrate small-scale rabbit production into their activities by utilising crop-residues and forages in combination with minimal supplementation with commercial concentrates (Rastogi, 1986; Butcher et al., 1983). In Kenya, considerable quantities of crop residues that could be used in rations for rabbits at present go to waste. Intensified crop production in which legume crops are used in fallow areas would further increase suitable feed for such stock (Oram, 1973).

2.2: World rabbit meat production and consumption.

Recent estimates (Roche Information Service, 1982) show that annual rabbit meat production worldwide is in excess of 1 million tonnes. The same estimates show that the largest producer of rabbit carcasses is the Soviet Union (240,000 tonnes/annum) followed by France (180,000), Italy (150,000), Spain (120,000), and China with more than 40,000 tonnes. Other large producers are Hungary (40,000 t/annum), Poland (35,000), Portugal and German Democratic Republic (20,000 t/annum each), and West Germany, Great Britain and USA each with 15,000 tonnes per annum.
The highest annual per capita consumption of rabbit meat is in Malta at 8.0 kg. The estimated per capita consumption for France is 6.0 kg, Italy and Spain 2-3.0 kg, Switzerland 1.0 kg and West Germany 0.2-0.3 kg (Roche Information Service, 1982).

World production figures however clearly show that apart from France and Italy, large scale rabbit production is associated with the relatively less advanced economies of Western Europe, Communist Europe and China. It is further evident that rabbits are still not significant as sources of meat in developing countries.

2.3: Rabbit production in Kenya.

In Kenya, available data suggest that although the level of production is still low, the population of rabbits is increasing at a fast rate. This trend is set out in Table 2.1. Thus while in 1979 the estimated rabbit population in the country was 41,600, this had increased to about 82,000 in 1982. The largest number of rabbits are found in Central and Eastern Provinces (Table 2.1), and about 70% of all breeding animals are found in rural areas under semi-intensive system of rearing (Stotz, 1983).
Table 2.1: Rabbit population and distribution in Kenya 1979-1982 (in thousands)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>16.8</td>
<td>36.3</td>
<td>36.6</td>
<td>40.0</td>
</tr>
<tr>
<td>Rift Valley</td>
<td>3.2</td>
<td>3.4</td>
<td>4.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Eastern</td>
<td>8.2</td>
<td>9.7</td>
<td>10.1</td>
<td>15.5</td>
</tr>
<tr>
<td>Western</td>
<td>2.0</td>
<td>2.0</td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Nyanza</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Coast</td>
<td>3.8</td>
<td>4.0</td>
<td>6.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Nairobi</td>
<td>5.0</td>
<td>5.5</td>
<td>5.6</td>
<td>6.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>41.6</td>
<td>63.5</td>
<td>70.0</td>
<td>82.0</td>
</tr>
</tbody>
</table>

While there is a definite trend towards increased rabbit production in the country, there are major limitations to increased rabbit production (Stotz, 1983). These include:-

i) high cost of commercial feed
ii) seasonal availability of palatable and nutritious forages
iii) high coccidial risk to animals from indiscriminately gathered forages and
iv) poor housing and general management practices.

In Kenya, three rabbit production systems can be distinguished depending on the level of production inputs purchased by the producer and the degree of commercialisation (Stotz, 1983). These are extensive, semi-intensive and intensive.

Stotz (1981) noted that the extensive system is the most widely practised form of rabbit keeping and is characterised by the keeping of one or two local rabbits for home consumption. The feed consists of garden weeds. Lukefahr and Goldman (1985) have described a similar system being practiced in Cameroon.

Under semi-intensive conditions animals are kept for both market and home consumption (Schlolaut, 1985). In this system hutches with wire floors are used for accommodation and animals are fed a
combination of forages and concentrates (Cheeke, 1983a).

The intensive system involves keeping rabbits in wire cages and feeding them commercial concentrates (Stotz, 1981, 1983). This system is common in developed countries, but in Kenya, as in most other developing countries, intensive rabbit keeping is rare (Lukefahr and Goldman, 1985).

For increased rabbit production in developing countries studies must be conducted to adapt the various production systems in order to exploit the available resources.

2.4: Reproductive and development biology of the rabbit.

The expression of liveweight gain and the growth rate of the main tissues depend on the breeds biological characteristics and on the production factors such as feeding (Lebas et al., 1986). The age at first breeding of female rabbits is dependent on the nutrition level and the corresponding body development (Paufler, 1985). Thus there is a range in age at first breeding from 4 months with a diet of pelleted concentrates, to 8-10 months on forage feed.

Gestation is dependent on the proper function of corpora lutea and lasts 31-32 days. After the 18th day of gestation the doe shows signs of preparing for kindling by nest building (Sandford, 1975). The young
are born naked and blind and remain dependent on the does' care until they are about 3 weeks of age. At this age they begin to consume solid feed (Cheeke, *et al.*, 1982). On average a well maintained doe can produce 7-9 litters per year consisting of 8-9 young per litter (Partridge *et al.*, 1984). The progeny is ready for slaughter at 10-12 weeks of age under average conditions of management. Cantier *et al.* (1969) cited by Lebas *et al.* (1986) noted that as bone tissue in rabbits develops first followed by muscle and fat a poor feed will slow overall muscle gain as most nourishment will be used for skeletal development. These authors noted that the fastest growing animals in a population will have the best carcass composition (muscle/bone ratio, fat percentage) at slaughter age or weight.

Pre-weaning growth performance is one of the important traits for rabbit meat production (Chen, *et al.*, 1978). The trait has a direct influence on weaning weight which can in turn be employed to determine meat production per doe per year (Roche Information Service, 1982). The pre-weaning growth rate and weaning weight in the rabbit are determined by several factors; including breed size, weight at birth, litter size, and maternal effects such as nutrition and milk production (Kazzorenova and Solovkina, 1985; Vakulenko, 1985; Taylor, 1980).
2.5. The influence of breed on rabbit production.

The growth rate of young rabbits is strongly correlated with adult size and weight where there has been no marked dietary deficiency (Lebas et al., 1986). Adult size is largely determined by breed. For example, under similar conditions of management, young small Himalayan rabbits (adult weight of 2.5 kg) were reported to have a slower growth rate than that of the New Zealand white breed (adult weight 4 kg), (Harkness and Wagner, 1983).

Animal genotype has been shown in many species to affect pre-weaning growth. In the rabbit the tendency is for large breeds to weigh more at weaning than light ones (Razzorenova and Solovkina, 1985). Birth weight is also an important determinant of growth performance, and weight at weaning. Thus rabbit birth weight has been shown to be genetically positively correlated with weaning weight (Lukefahr, et al., 1984) and heavier litters at birth will have correspondingly higher weights at weaning.

Inspite of the above relationships, weaning weight in rabbits is more a reflection of the mothering ability of the doe than that of the potential of the young since it is strongly influenced by maternal effects such as nutrition and milk production (Cowie, 1969; Lebas et al., 1986). From the above it can be concluded that a large fraction of the variation in growth rate prior to weaning can be
accounted for by the differences in milk yield of the dams. In addition to this, it is known that litter size influences pre-weaning growth rate by putting a limit to the amount of milk available to each kit (Vakulenko, 1985).

2.6. The importance of nutrition in rabbit production

As for other animals, rabbit nutritional requirements entail an adequate and balanced supply of amino acids, energy, minerals and vitamins necessary for the growth and development of the animal. The content of protein and energy in the diet have been reported to have an influence on liveweight gain (Chawan et al., 1982). For the rabbit, the proportions of the body parts can also be manipulated by dietary means (Sastry and Mahajan, 1982; Spreadbury and Davison, 1978).

Nutrition has an influence on the sexual development of the rabbit. Differences in nutrition cause a variation in the age at first breeding of female rabbits from 4 months with a diet of pelleted concentrates to 8-10 months on forage feed (Paufler, 1985).

For rapid and efficient growth, the rabbit requires at least 17-18% crude protein and an energy food source equivalent to 3600-3700 Kcal/Kg in the diet (Roche Information Service, 1982). Campos et al.
(1977) working with weaner rabbits of the New Zealand white breed, reported that weight gains were significantly increased by raising the protein content of the diet at energy levels of between 3330 and 3935 Mcal GE/Kg. In another study, Ouhayoun et al. (1981) used two diets of 13 and 16% crude protein and similar energy value to feed weaner rabbits of the California breed. They reported that animals fed 13% crude protein took 6 days longer to reach 2.2 Kg body weight although efficiency of feed utilisation was similar between groups when calculated over the duration of the experiment. Corregal and Nikuma (1985) observed no significant differences among groups and between sexes in body weight gain and feed conversion efficiency in a comparison of weaner rabbits fed diets of 14, 17 and 21% crude protein. It was reported that weight gain and feed efficiency tended to decrease with increasing dietary protein.

Lebas et al. (1986) noted that slaughter yield improves with age and that animals with a high growth rate, receiving more balanced feed generally have a better carcass yield. The level of protein in the diet also influences dressing percentage. Dressing percentage was reported to increase with increasing protein levels (Chawan et al., 1982). After feeding rabbits on diets containing 18.9 and 16.4% crude protein and 12.03 and 18.21% crude fibre respectively, Zaragoza and Vallejo (1982) reported dressing...
percentages of 59.9 and 57.4 from the two groups of animals respectively. In an earlier study, however, Ouhayoun et al. (1981) found no significant differences in carcass weights and the muscle to bone ratio between groups of California rabbits offered diets of 13 and 16% crude protein. The diets had a similar energy and crude fibre content.

Variation of source, amounts and proportions of crude fibre in the rabbit diet may also influence the growth and meat production of these animals. By varying the proportions of sunflower husks in the diet, Gippert et al. (1985) obtained rations with crude fibre contents varying from 10 to 16%. The greatest body weight gains were recorded for rabbits fed rations containing between 11.6 and 13.8% crude fibre.

To a limited extent, the efficiency of feed utilisation is improved by increasing the percentage of fibre in the diet (Bedekar et al., 1985). For instance rabbits fed diets containing 28, 54 and 74% alfalfa in the diet yielded dressed weights of 46.7, 48.7 and 46.8% respectively (Holmes et al., 1984). Using diets in which commercial concentrate was replaced with whole maize plant pellets at levels of 20 and 40%, Auxilia et al. (1981) found no significant difference in mean daily body weight gain between treatments and the control. Efficiency of feed
utilisation was greater for rabbits given 40% maize plant pellets than for controls.

In other studies, feeding rabbits increased quantities of crude plant materials such as hay resulted in reduced carcass yields (Mendes et al., 1983; Zaragoza and Vallejo, 1982). Furthermore, while there is a tendency for dressing percentage to increase with increasing protein levels, the visceral weights increase with increasing fibre levels in the diet (Chawan et al., 1982). It is, therefore, clearly evident that nutrition is a vital component of rabbit meat production.

2.6.1. The relative importance of forages in rabbit production.

As livestock production gains importance and the cost of cereal based commercial feeds continues to rise in developing countries including Kenya, forages may play a valuable role in the supply of high quality human food after being converted into meat (Owen, 1976; Farell and Raharjo, 1984). Forages are cheap and abundant throughout the year in high rainfall areas of Kenya, and can be preserved for the dry period in the low rainfall areas (Kayongo-Male, 1984). Furthermore the chemical composition of their leaves offers considerable potential as a major source of nutrients for herbivorous animals (Skerman, 1977; Telek and Martin, 1983).
The potential of forages is particularly significant for rabbits, an emerging livestock species (Cheeke and Patton, 1981), as they are capable of digesting leaf proteins effectively (Cheeke and Myer, 1975; Slade and Hintz, 1969). It has been shown that young rabbits will consume sufficient quantities of low energy high fibre diets to grow from weaning to slaughter at 2.2 Kg liveweight (Butcher et al., 1981). These authors noted that in a practical low input system, such diets would have to support growth from conception to slaughter. Using a simulation model, Cheeke and Patton (1979) computed that rabbits can produce five times more meat than cattle from the same amount of an alfalfa based diet. The role of fibre in rabbit nutrition has been appraised by Cheeke (1983b) and Lang (1981). High fibre material which is usually a constraint in poultry diets is beneficial to rabbits for preventing enteritis (Cheeke and Patton, 1980) and, well preserved roughage reduces digestive problems and improves palatability of the diet (Martina, 1985). In addition, Lebas (1983) noted that although rabbits are not able to obtain as much energy as ruminants, from forage diets they are able to consume these in quantities sufficient to meet their energy requirements. However, the nutrient content of forages varies greatly among species, among cultivars within species (Skerman, 1977) and even among stages.
of growth in the same cultivar (Crowder and Chedda, 1982). This variation in nutritive values can be evened out by some form of supplementation.

Where rabbits are fed on concentrate feed, inclusion of forage material is highly beneficial. For instance, Harris et al. (1985) reported a reduction in feeding costs without affecting performance by adding hay to the diet to reduce the intake of concentrate feed. In these studies, a combination of concentrates with lucerne or grass hay resulted in daily body weight of 40.9 and 32.8 gm respectively, compared to 36.4 gm for animals fed on concentrate pellets alone. Intake was highest for animals fed on pellets alone and hence the respective feed conversion efficiency was 2.99 and 3.19 for diets containing lucerne and grass hay, and 3.6 for pelleted feed. In another study, Mendes et al. (1983) found that replacing the commercial concentrate with grass hay at levels of 0, 25, and 50% resulted in average growth rates of 22.3, 22.1 and 6.5 gm per day respectively. Thus replacing concentrate with grass hay up to 25% does not affect growth rate.

The level at which a forage should be included in the diet depends on its quality. Martina (1985) found no effect on daily gain performance by including vine residues (42.7% CF) in the diet at 5% but reported a 4-5 gm decrease in daily gain when the
content of vine residues was increased to 10%. On the other hand, rabbits given a mixed diet with or without 10 or 20% soyabean hulls (26% crude cellulose) or sunflower hulls (45% crude cellulose) gave gains similar to those of the controls. Bedekar et al. (1985) reported a difference of only 6.1 gm in daily gains between diets consisting entirely of either lucerne or concentrates. The type and quality of forage used are therefore important factors to consider in rabbit feeding.

2.6.2. The relative importance of commercial concentrate in rabbit production.

Forage consumption alone is usually not sufficient to fully exploit the rabbit's potential for growth (Cheeke, 1983b). This is because the domestic rabbit lacks facilities for selective ingestion of plants and plant parts with high nutrient density (Schlolaut, 1985). Besides, the capacity of digestive organs as a ratio of body weight is very low for the medium weight breeds of rabbits which are chiefly used for meat production (Schlolaut, 1985). This means that the capacity for a rabbit to compensate for a low concentration of nutrients in the fodder by increasing intake is limited.

The intake limiting effect caused by insufficient protein content in forages can be compensated by minimal supplementation (Rastogi,
Young animals, however, need a higher proportion of concentrate feed in their ration as their ability to compensate for a lower concentration of nutrients in the feed by increasing intake is even less than in the adult (Schlolaut, 1985).

When concentrate supplementation is constant, growth performance is influenced by the forage material used for feeding the rabbits. Gomez de varella et al. (1985) reported mean daily weight gains of 39.7, 31.6, and 39.7 gm when concentrate pellets were used to supplement lucerne (*Hedicago sativa*), kudzu (*Pueraria phaseoloides*) and groundnut (*Arachis hypogea*) tops respectively. Mean daily feed intake was highest for the diet with lucerne and lowest for the diet with groundnut tops.

Because of economic and other management considerations, Sartorius (1986) noted that the amount of commercial concentrate feed a rabbit farmer is recommended to give to his animals cannot be based solely on results from nutrient balance studies. While the optimum level of feeding has to be defined in economic terms, it is also necessary to limit the amount of commercial concentrate in the ration of both fattening and breeding animals. This is because the high feed intake obtained for pelleted concentrate, apart from increasing the cost of production causes extensive fat formation which has a detrimental effect on carcass quality and the reproductive performance of
breeding animals (Schloiaut, 1985). There is therefore a clear need to combine forage and concentrate components in rabbit diets in such a way that costs are minimised and performance maximised.
breeding animals (Schlolaut, 1985). There is therefore a clear need to combine forage and concentrate components in rabbit diets in such a way that costs are minimised and performance maximised.
CHAPTER 3

MATERIALS AND METHODS

3.1: Site of the experiments.

The experiments were carried out at the National Rabbit Breeding Centre, situated within the Ministry of Livestock Development Farm at Ngong. The farm is located in Rift Valley Province of Kenya. It is approximately 1°N and 37°E and about 25 km West of Nairobi. Ngong farm is situated in an agro-climatic zone with a bimodal rainfall distribution with the long rains from March to May, and the short rains from October to December with a three months dry period in between. The mean monthly temperatures range from 22°C during the month of July to 28°C in the month of January. The mean annual rainfall is about 550mm.

3.2: General procedure.

The experiments were conducted during the period from November 1985 to September 1986. The purpose of these experiments was to assess the pre-weaning and post-weaning growth performance of rabbits in relation to breed type, litter size and litter birth weight, and to different forages fed with supplement.

Three breeds were used in all the experiments. The New Zealand white and California were exotic breeds while the Kenya white was a local breed. From these breeds does born during 1984 were selected for breeding to minimise the effects of dam age. The does
were fed a mixture of commercial concentrate and *Chloris gayana* hay and watered *ad libitum*.

The experiments were conducted in a large well aerated house with a corrugated galvanised iron sheet roof. The house had a service corridor in the middle, and a door leads from the service corridor to the outside via a foot dip containing a disinfectant. The whole unit was surrounded by a drainage canal that leads to a pit into which urine flows.

Rabbits were kept in wire cages, each measuring 0.75 m by 1 m placed in the house on either side of the corridor. The cages had hinge doors that opened into the corridor and were each fitted with a water container and forage rack.

To ensure good health for the rabbits, the house and cages were thoroughly cleaned and disinfected at the start of each experiment and once every four weeks thereafter. Animal droppings and waste forage were removed from the cages every morning. Twice a day the water containers were emptied, cleaned and filled with clean fresh water.

### 3.3. Influence of breed type, litter size and litter birth weight on the pre-weaning growth performance of rabbits.

This experiment was conducted to assess the pre-weaning growth performance (birth to 5 weeks of age)
of three breeds and its relation to litter size and litter birth weight.

To facilitate uniform management and reduced seasonal effects, all litters used for each experiment were of the same age group. In all 6 dams of the California, 12 dams of New Zealand and 15 dams of Kenya white with 25, 26 and 44 litters respectively were included in the observation. The distribution of the different litter sizes is summarised in Table 3.1. The does, individually housed, were included in the observations in a completely randomised arrangement. No creep feed was provided to the young before weaning.
Table 3.1. Distribution of the different litter sizes for each of the three breeds.

<table>
<thead>
<tr>
<th>Breed</th>
<th>1-3</th>
<th>4-6</th>
<th>7-9</th>
<th>10-12</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand white</td>
<td>6</td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>California</td>
<td>2</td>
<td>9</td>
<td>13</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Kenya white</td>
<td>5</td>
<td>21</td>
<td>17</td>
<td>1</td>
<td>44</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13</td>
<td>45</td>
<td>34</td>
<td>3</td>
<td>95</td>
</tr>
</tbody>
</table>
3:4. The influence of level of supplementation and forage type on the post-weaning growth performance of rabbits.

The purpose of these experiments was to evaluate the feed value of three forage crops; Rhodes grass, *Chloris gayana*, Maize (*Zea mays*), and Sweet potato (*Ipomea batatas*) vines for grower rabbits of the three breed types with minimal supplementation. Attempts were also made to establish the levels at which the commercial concentrate could be economically supplemented to the forage to obtain reasonable rabbit meat production under small scale management practices.

The weaner rabbits were individually weighed at the beginning of each experiment. These animals were housed in groups of four per cage. For each forage type groups of four animals of the same breed were placed on each of the three supplementation levels. Each was of a completely randomised design using a factorial arrangement. Randomisation was by allocation of the animals within each breed to the experimental cages.

3:4:1. Experimental diets and their chemical composition.

The rabbits were fed three types of forages consisting of *Chloris gayana* hay, dry maize leaves and wet sweet potato vines, with concentrate supplements.
Water and the forage feeds were given to the animals ad libitum, while the commercial concentrate supplement was given at three levels.

The *Chloris gayana* hay used in these experiments was obtained from the Ministry of Livestock Development Farm at Ngong. This was ordinary field hay from a crop of Rhodes grass pasture and was fed to the rabbits without further processing.

Maize leaves fed to the rabbits were obtained from both the Embu Research Station, and the Faculty of Agriculture, Field Station, Kabete. The leaves were collected, dried and preserved as described by Kayongo-Male (1984) and Kayongo-Male and Abate (1982).

Potato vines were obtained from plantings at the National Rabbit Breeding Centre. Vines meant for feeding were harvested and kept overnight to allow for a reduction in the water content of the leaves.

The commercial concentrate supplement given to the rabbits consisted of pellets manufactured by Unga Feeds Limited of Nairobi. The supplement was given to rabbits fed each of the three forages at the levels of 10.0, 7.5 and 5.0% of body weight per day for the first two weeks of experimentation. Thereafter, the concentrate levels were fixed at 100.0, 75.0 and 50.0 gm per rabbit per day. These levels were adopted as recommended by Schlolaut (1985) and are hereafter denoted high, medium and low respectively. In a
preliminary trial attempts were made to determine performance on forage (Chloris gayana hay and maize leaves) without providing supplement. Very high mortality rates of animals resulted on this treatment and the treatment was dropped.

Proximate composition analyses for representative samples of the forages and commercial concentrate were carried out in the Nutrition Laboratory, Department of Animal Production, Kabete, in accordance with the procedures of the Association of Official Analytical Chemists (A.O.A.C, 1975).

3.5. Quantitative measurements and statistical analyses.

In order to evaluate the growth performance of the various litters; litter size at birth, litter weight at birth (within 12 hours of kindling) and litter weight at weaning (5 weeks of age) were recorded during the experimental period. The animals were weighed using an Avery scale. Litter liveweight gain was obtained as the difference between litter weight at birth and at weaning.

For the post-weaning experiments weekly records of liveweight gain were maintained up to twelve weeks of age. Liveweight gain was obtained by weighing each individual animal every week and determining the weekly difference in weight. Mean weekly liveweight gain per breed and diet, was calculated as a mean of
the four animals. Mean growth rate per treatment was that of four animals on each treatment.

The data obtained was subjected to least square analysis of variance and covariance using Sysnova computer programme written by Seebeck (1975) and based on Harvey (1966). For the pre-weaning trial the fixed effect was breed while litter size and litter weight at birth were used as covariates. In the case of the post-weaning trials the fixed effects were diet and breed and the weight at weaning was used as the covariate. The residual mean square was used to test the significance of all effects. Linear contrasts were used for mean separation.

3:6. Dressing percentage and meat to bone ratio.

Rabbit meat production under the different regimes expressed as dressing percentage and meat to bone ratio was determined at the end of the feeding period, at 12 weeks of age. To obtain the dressing percentage the animals of the New Zealand white breed were starved for twelve hours, weighed individually and slaughtered. The carcass from each animal was washed with water and kept in a cool well aerated room for twelve hours before weighing. The carcass weight was then expressed as a percentage of the body weight before slaughter.

To assess the meat to bone ratio, carcasses used for the determination of dressing percentage were
divided longitudinally into two. One half was randomly selected for each carcass and flesh was carefully separated from the bones by use of knives. The meat to bone ratio was obtained from the total weight of separated flesh and bone from the carcass. The data obtained was subjected to analysis of variance according to Steel and Torrie (1980).


The cost of supplementation was determined as the market value of the commercial concentrate offered to each animal throughout the post weaning feeding period. This figure was used to calculate the quantity of supplement and hence cost that would be required to produce a kg of edible carcass.
CHAPTER 4

RESULTS

4:0. Chemical composition of diets

Nutrient levels for the various forages and the commercial rabbit concentrate are summarised in Table 4:0. The average energy content of all samples analysed showed a small variation. Percent crude fibre ranged from 10.03 for the concentrate to more than 41 for the grass hay. Grass hay had the lowest crude protein content (2.65%). Sweet potato vines had a low dry matter content (16%).


The results of litter weaning weight and litter weight gain to weaning are presented in Table 4.1.

The overall mean litter size at weaning was 5.9±0.2 kits with an average litter birth weight of 338±14 grammes. These results showed that the litters of New Zealand white rabbits had the highest weaning weight and pre weaning litter weight gain. Animals of the Kenya white breed had the least weight at weaning and gained least weight during the same period. Overall means of litter weight at weaning and liveweight gain to weaning were 4083±166 and 3475±158 grammes respectively.
Table 4:0. Proximate composition of the various feeds.

<table>
<thead>
<tr>
<th></th>
<th>Concentrate</th>
<th>Grass hay</th>
<th>Potato vines</th>
<th>Maize leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter%</td>
<td>93.1</td>
<td>91.5</td>
<td>15.7</td>
<td>91.1</td>
</tr>
<tr>
<td>Crude protein%</td>
<td>16.7</td>
<td>2.65</td>
<td>15.3</td>
<td>12.5</td>
</tr>
<tr>
<td>Crude fibre%</td>
<td>10.03</td>
<td>41.09</td>
<td>19.64</td>
<td>25.89</td>
</tr>
<tr>
<td>Energy (GE) Kcal/Kg</td>
<td>3967</td>
<td>3669</td>
<td>3852</td>
<td>3848</td>
</tr>
</tbody>
</table>
The analysis of variance, Table 4:1, showed a highly significant (P<0.05) influence of both genotype and litter size on litter weight at weaning and liveweight gain to weaning. Each kit increase in the size of the litter was associated with a 407±101 grammes increase in litter weight at weaning.

Whereas the effect of litter weight at birth on weight at weaning was significant (P<0.05), the effects on liveweight gain to weaning was not significant (P>0.05). Litter weights at birth and at weaning were positively related. Each grammes increase in litter weight at birth was associated with a 3.8 grammes increase in weight at weaning.
Table 4:1. Analysis of variance and covariance, and means of the weaning weight and pre-weaning liveweight increase of litters of the three breeds.

a) Analysis of variance and covariance of weaning weight and liveweight gain.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>2</td>
<td>112x10^8*</td>
<td>112x10^8*</td>
</tr>
<tr>
<td>Litter size</td>
<td>1</td>
<td>177x10^8*</td>
<td>177x10^8*</td>
</tr>
<tr>
<td>Birth weight</td>
<td></td>
<td>609x10^7*</td>
<td>328x10^7</td>
</tr>
<tr>
<td>Residual</td>
<td>90</td>
<td>108x10^7</td>
<td>108x10^7</td>
</tr>
</tbody>
</table>

* P<0.05.

b) Mean weaning weight and liveweight gain for each breed (gm)

<table>
<thead>
<tr>
<th>Breeds</th>
<th>New Zealand</th>
<th>California</th>
<th>Kenya white</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of litters</td>
<td>26</td>
<td>25</td>
<td>44</td>
</tr>
<tr>
<td>Weaning weight</td>
<td>4302ᵃ</td>
<td>4249ᵃ</td>
<td>3860ᵇ</td>
</tr>
<tr>
<td>Liveweight gain</td>
<td>4020ᵃ</td>
<td>3908ᵃ</td>
<td>3491ᵇ</td>
</tr>
</tbody>
</table>

ab Means in the same row with different superscripts are significantly different (P<0.05).
The comparison of means of weaning weight and pre-weaning liveweight gain of litters of the three breeds of rabbits showed that litters born to Kenya white does had significantly (P<0.05) lower values than those born to New Zealand and California does. However the growth of young born to New Zealand white and California does was not significantly different (P>0.05). There was a weight difference of 529 grammes (15.15%) at weaning between litters born to New Zealand white and Kenya white does.


4:2:1. Liveweight gain and growth rate of animals fed Chloris gayana hay.

The results of liveweight gain and growth rate of grower rabbits fed on Chloris gayana hay as influenced by genotype and level of concentrate supplementation are presented in Table 4.2.

Total liveweight gain was lower for the Kenya white breed than for the California. The New Zealand white was intermediate. There was an average difference in gain of 155 gm between the two exotic breeds. The growth rates were significantly different with the Kenya white breed gaining 35 and 15 grammes/week more slowly than animals of the California and New Zealand white breeds respectively. These results showed that the Low level of concentrate
Table 4:2. Analysis of variance and means of total liveweight gain and growth rate for animals fed on *Chloris gayana* hay postweaning.

a) Analysis of variance for total liveweight gain

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>2</td>
<td>$1.08 \times 10^7$*</td>
</tr>
<tr>
<td>Breed</td>
<td>2</td>
<td>$2.00 \times 10^6$*</td>
</tr>
<tr>
<td>Weaning wt</td>
<td>1</td>
<td>$7.11 \times 10^5$*</td>
</tr>
<tr>
<td>Interaction</td>
<td>4</td>
<td>$3.0 \times 10^3$</td>
</tr>
<tr>
<td>Residual</td>
<td>26</td>
<td>$9.8 \times 10^2$</td>
</tr>
</tbody>
</table>

* $P<0.05$.

b) Means of total liveweight gain, and growth rate.

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Total liveweight gain (g)</th>
<th>Growth rate g/rabbit/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>727.5a</td>
<td>103.8a</td>
</tr>
<tr>
<td>California</td>
<td>882.1b</td>
<td>126.0b</td>
</tr>
<tr>
<td>Kenya white</td>
<td>625.8c</td>
<td>89.4c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of supplementation</th>
<th>Total liveweight gain (g)</th>
<th>Growth rate g/rabbit/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1040.4a</td>
<td>148.6a</td>
</tr>
<tr>
<td>Medium</td>
<td>768.3b</td>
<td>109.8b</td>
</tr>
<tr>
<td>Low</td>
<td>426.7c</td>
<td>60.9c</td>
</tr>
</tbody>
</table>

abc Within breeds and diets, means in the same column with different superscripts are significantly different ($P<0.05$).
supplementation supported growth rates which were 59% less than those achieved on the high level. At the medium level of supplementation animals gained 26.2% more slowly than those on the high level. These differences were significant (P<0.05).

The analysis of variance (Table 4:2) revealed that of the total variation observed, level of supplementation accounted for a much higher proportion than breed. The interaction between breed and diet was not significant (P>0.05). As indicated by the observations during these studies Figures 4.1, 4.2 and 4.3 show that on average animals of the New Zealand white weaned at a higher weight and were in all cases heavier than the other breeds at 12 weeks of age. Where the California started at a lower weight, they had overtaken the Kenya whites by the 7th week. There was a tendency for rate of gain to decrease after the tenth week except for animals on the low level of supplementation. This trend can also be observed in the changes in liveweight given in Appendix 1.
Fig. 4.1: Liveweight and age of the three breeds at the high level of supplementation for animals on a diet of *Chloris gayana* hay.
Fig. 4.2: Liveweight and age of the three breeds at the medium level of supplementation for animals on a diet of *Chloris gayana* hay.
Fig. 4.3: Liveweight and age of the three breeds at the low level of supplementation for animals on a diet of Chloris gayana hay.
Liveweight gain and growth rates of animals fed dry maize leaves.

The results of liveweight gain of grower rabbits fed on dry maize leaves as influenced by genotype and level of supplement feeding are presented in Table 4.3. Up to 12 weeks of age liveweight gain was significantly lower for rabbits of the Kenya white breed than California and New Zealand white animals. Means of total liveweight gain for levels of supplementation were significantly different (P<0.05). These results showed that animals supplemented at the low level suffered a 44.5% reduction in growth rate as compared to those on the high level. The corresponding reduction for animals on the medium level was 14.8%. Mean growth rates for the levels of supplementation were significantly different (P<0.05).

The analysis of variance (Table 4:3) revealed that level of supplementation accounted for the largest part of the variation observed. There was no significant (P>0.05) interaction between breed and diet.
Table 4:3 Analysis of variance and means of total liveweight gain and growth rate animals fed on maize leaves postweaning.

a) Analysis of variance of liveweight gain.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>2</td>
<td>641 x 10^5*</td>
</tr>
<tr>
<td>Diet</td>
<td>2</td>
<td>844 x 10^6*</td>
</tr>
<tr>
<td>Weaning wt.</td>
<td>1</td>
<td>218 x 10^4</td>
</tr>
<tr>
<td>Interaction</td>
<td>4</td>
<td>26 x 10^3</td>
</tr>
<tr>
<td>Residual</td>
<td>26</td>
<td>10 x 10^3</td>
</tr>
</tbody>
</table>

* P<0.05.

b) Means of total liveweight gain and growth rate.

<table>
<thead>
<tr>
<th>Total liveweight gain (g)</th>
<th>Growth rate g/rabbit/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>958.8a</td>
</tr>
<tr>
<td>California</td>
<td>991.3a</td>
</tr>
<tr>
<td>Kenya white</td>
<td>833.8b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of supplementation</th>
<th>Total liveweight gain (g)</th>
<th>Growth rate g/rabbit/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1161.7a</td>
<td>164.8a</td>
</tr>
<tr>
<td>Medium</td>
<td>982.1b</td>
<td>140.3b</td>
</tr>
<tr>
<td>Low</td>
<td>640.0c</td>
<td>91.4c</td>
</tr>
</tbody>
</table>

abc Within breeds and diets, means in the same column with different superscripts are significantly different (P<0.05).
In Figures 4.4, 4.5 and 4.6 mean liveweight is plotted against age for the animals of each breed on the respective levels of supplementation. One week after weaning, the weekly rate of gain increased. The rate for animals on the low level supplementation was slow in the first 3 weeks after weaning. However this rate picked up and continued to rise up to the end apart from the Kenya white animals where it slackened after the 11th week. These observations are clearly shown by the changes in liveweight given in Appendix 2.
Fig. 4.4: Liveweight and age of the three breeds at the high level of supplementation for animals on a diet of dry maize leaves.
Liveweight (kg)

Fig. 4.5: Liveweight and age of the three at the medium level of supplementation for animals on a diet of dry maize leaves.
Fig. 4.6: Liveweight and age of the three breeds at the low level of supplementation for animals on a diet of dry maize leaves.
Liveweight gain and growth rate of animals fed sweet potato vines.

Overall results of liveweight gain and growth rate of grower rabbits fed on sweet potato vines as influenced by genotype and level of supplementation are presented in Table 4.4.

From weaning (5 weeks) to 12 weeks of age liveweight gain was significantly lower \( (P<0.05) \) for rabbits of the Kenya white breed than California and New Zealand white animals. California rabbits gained 105.6 grammes more than New Zealand whites. Liveweight gain for the same period was greater for the high level of supplement feeding than for the medium level and the low level which had the lowest value of 1026.3 grammes.

On average animals of the Kenya white gained 50 and 35 grammes per week less than animals of the California and New Zealand white breeds respectively. Means of weekly liveweight gain for the local and exotic breeds were significantly different \( (P<0.05) \). These results showed that grower rabbits supplemented at the high level had a 25.5% increase in growth rate as compared to those on the low level. At the medium level of supplementation the corresponding advantage was 10.8%. Means of growth rates for the levels of supplementation were significantly different \( (P<0.05) \).
Table 4:4. Analysis of variance and means of total liveweight gain and growth rate of animals fed on sweet potato vines postweaning.

a) Analysis of variance for liveweight gain.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>2</td>
<td>$209 \times 10^6$ *</td>
</tr>
<tr>
<td>Diet</td>
<td>2</td>
<td>$381 \times 10^6$ *</td>
</tr>
<tr>
<td>Weaning wt.</td>
<td>1</td>
<td>$946 \times 10^4$</td>
</tr>
<tr>
<td>Interaction</td>
<td>4</td>
<td>$24 \times 10^3$</td>
</tr>
<tr>
<td>Residual</td>
<td>26</td>
<td>$19 \times 10^3$</td>
</tr>
</tbody>
</table>

* P<0.05

b) Means of total liveweight gain and growth rate.

<table>
<thead>
<tr>
<th>Breed</th>
<th>Total liveweight gain (g)</th>
<th>Growth rate g/rabbit/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>1203.3\textsuperscript{a}</td>
<td>171.9\textsuperscript{a}</td>
</tr>
<tr>
<td>California</td>
<td>1312.9\textsuperscript{a}</td>
<td>187.6\textsuperscript{a}</td>
</tr>
<tr>
<td>Kenya white</td>
<td>961.3\textsuperscript{b}</td>
<td>137.3\textsuperscript{b}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of supplementation</th>
<th>Total liveweight gain (g)</th>
<th>Growth rate g/rabbit/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1288.3\textsuperscript{a}</td>
<td>184.1\textsuperscript{a}</td>
</tr>
<tr>
<td>Medium</td>
<td>1162.9\textsuperscript{b}</td>
<td>166.1\textsuperscript{b}</td>
</tr>
<tr>
<td>Low</td>
<td>1026.3\textsuperscript{c}</td>
<td>146.6\textsuperscript{c}</td>
</tr>
</tbody>
</table>

\textit{abc} Within breeds and diets, means in the same column with different superscripts are significantly different (P<0.05).
The analysis of variance (Table 4:4) revealed that of the total variation observed, again the level of supplementation accounted for the largest fraction. The interaction between breed and diet was not significant (P>0.05).

It is indicated by the observations during these studies Figures 4.7, 4.8 and 4.9 that liveweight at 5 weeks was highest for the New Zealand white. This difference was narrowed by 12 weeks of age for the California animals due to their high growth rates. The weekly rate of liveweight gain was higher than in the case where maize leaves or hay were fed as can be observed from the figures in Appendix 3.
Fig. 4.7: Liveweight and age of the three breeds at the high level of supplementation for animals on a diet of sweet potato vines.
Liveweight and age of the three breeds at the medium level of supplementation for animals on a diet of sweet potato vines.

Fig. 4.8: Liveweight and age of the three breeds at the medium level of supplementation for animals on a diet of sweet potato vines.
Fig. 4.9: Liveweight and age of the three breeds at the low level of supplementation for animals on a diet of sweet potato vines.
4.2.4. Dressing percentage and meat to bone ratio of animals fed on *Chloris gayana* hay.

The results of dressing percentage and meat to bone ratio for animals fed on *Chloris gayana* hay as influenced by level of supplementation are summarised in Table 4.5a and 4.6a.

Mean liveweight at slaughter was 1611±305 gm with an average dressing percentage of 43.9±3.7. Mean weight of bone was 138±2 gm. Animals on the low level of supplementation had the lowest dressing percentage. Level of supplementation had a significant (P<0.05) effect on both dressing percentage and meat to bone ratio.

4:2:5: Dressing percentage and meat to bone ratio of animals fed on dry maize leaves.

The results of dressing percentage and meat to bone ratio for animals fed on dry maize leaves and supplemented at the three levels are summarised in Table 4.5b and 4:6b.

At slaughter (12 weeks of age), animals had a mean liveweight of 1886±277 gm with an average dressing percentage of 45.7±1.6. Means of dressing percentage and meat to bone ratio were significantly different (P<0.05). Mean weight of bone was 143.6±3.3 gm.
Table 4.5. Analysis of variance of dressing percentage and meat to bone ratio of New Zealand white animals fed on the three forages and the three levels of supplementation.

a) *Chloris gayana* hay

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>2</td>
<td>68.18*</td>
<td>6.59*</td>
</tr>
<tr>
<td>Residual</td>
<td>9</td>
<td>.43</td>
<td>.05</td>
</tr>
</tbody>
</table>

b) Dry maize leaves.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>2</td>
<td>51.88*</td>
<td>2.99*</td>
</tr>
<tr>
<td>Residual</td>
<td>9</td>
<td>2.11</td>
<td>.16</td>
</tr>
</tbody>
</table>

c) Sweet potato vines

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet</td>
<td>2</td>
<td>13.34*</td>
<td>.91*</td>
</tr>
<tr>
<td>Residual</td>
<td>9</td>
<td>2.06</td>
<td>.15</td>
</tr>
</tbody>
</table>

* P< 0.05
Table 4.6 Means of carcass weight, dressing percentage, weight of bone and meat to bone ratio for animals fed on the three forages at the three levels of supplementation.

a) *Chloris gayana* hay.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Level of supplementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Weight of carcass (g)</td>
<td>950&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>47.77&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight of bone (g)</td>
<td>141&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Meat:Bone</td>
<td>5.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

b) Dry maize leaves.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Level of supplementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Weight of carcass (g)</td>
<td>1000.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>47.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight of bone (g)</td>
<td>146.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Meat:Bone</td>
<td>5.8&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

c) Sweet potato vines.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Level of supplementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Weight of carcass (g)</td>
<td>1026&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>49.24&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight of bone (g)</td>
<td>147&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Meat:Bone</td>
<td>5.97&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

abc Means in the same row with different superscripts are significantly different (P<0.05).
Dressing percentage and meat to bone ratio of animals fed on sweet potato vines.

The results of dressing percentage and meat to bone ratio for animals fed on wet sweet potato vines and supplemented at the three levels are summarised in Table 4.5c and 4.6c.

At slaughter (12 weeks of age), the mean liveweight of the animals was 2067±196 gm with an average dressing percentage of 45.5±3.6. Level of supplementation had a significant (P<0.05) effect on both dressing percentage and meat to bone ratio. Means of dressing percentage and meat to bone ratio were significantly different (P<0.05). Mean weight of bone was 146±1 gm.

Cost of post-weaning supplementation.

The results of post weaning cost of supplementation for grower rabbits fed the three forages with supplement at the three levels are summarised in Table 4.7.

At the market price of KSh. 3/kg the cost of supplement to a rabbit at the high, medium and low levels from weaning to 12 weeks of age was 13.15, 9.70 and 6.55 respectively. These results showed that there was a reduction in cost as the level of supplementation was reduced.

Due to differences in growth rates, the cost of producing 1 kg of edible carcass decreased as the
quantities of supplement were decreased. The magnitude of this decrease was dependent on the type of forage fed.
Table 4:7. Cost of post-weaning supplementation for animals fed diets of the different forages.

<table>
<thead>
<tr>
<th>Level of supplementation</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrate offered (Kg)</td>
<td>4.4</td>
<td>3.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Concentrate cost KSh.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) For 3 mo. old rabbit</td>
<td>13.15</td>
<td>9.70</td>
<td>6.55</td>
</tr>
<tr>
<td>ii) For 1 kg edible carcass on; a) <em>Chloris gayana</em> hay</td>
<td>13.80</td>
<td>13.56</td>
<td>12.12</td>
</tr>
<tr>
<td>b) Dry maize leaves</td>
<td>13.10</td>
<td>10.60</td>
<td>9.40</td>
</tr>
<tr>
<td>c) Sweet potato vines</td>
<td>12.80</td>
<td>10.60</td>
<td>7.50</td>
</tr>
</tbody>
</table>

1 US$ =KSh. 16
Cost: KSh. 3/Kg Supplement.
CHAPTER 5

DISCUSSION.

5.1. Dietary composition.

The chemical composition values obtained for sweet potato vines, *Chloris gayana* hay and maize leaves used in this study are similar to those reported by Onim *et al.* (1984), Stotz (1983) and Kayongo-Male and Abate (1982) respectively. The values were in the range reported by Raharjo *et al.* (1986). Levels of gross energy (3840-3970 Kcal/Kg) in the different forages were higher than the 3600-3700 Kcal/Kg range recommended for rabbits (Roche Information Service, 1982). Digestibility of energy was not determined and therefore it remains to be established how much of the energy in the forages is actually available to the animals. The quantity of crude fibre (19-41%) in the forages was higher than the values (15-16%) recommended for rabbit diets (Roche Information Service, 1982). However the crude protein contents (2-15%) were lower than the 17.5% level needed for good growth (Cheeke *et al.*, 1985). The quantities of these two nutrients can easily be brought within the recommended range by a little supplementation. The crude fibre content was high and crude protein low for *Chloris gayana* hay as expected for a tropical pasture grass (Raharjo *et al.*, 1986).

The stage at which the maize leaves should be
harvested and preserved appears to be important. Kayongo-Male and Abate (1982) have shown that the crude protein content drops to less than 9% and crude fibre increases if the leaves are left to dry on the maize plant. In this study the leaves were collected before maturity of the maize crop and therefore the crude protein content was above 12%. Similar crude protein values were reported by Kayongo-Male (1984).

The content of crude fibre in the commercial concentrate was less than the 15-16% recommended for rabbits (Fekete and Gippert, 1985). As pointed out by Martina (1985) rabbit performance can be improved and utilisation of the concentrate maximised by feeding this concentrate in combination with a suitable fibre source.

5.2. Effect of breed.

There were differences in parity between the dams but it was not possible to account for this variation in the analysis. Parity is known to have a significant effect on growth of the young (Ribas, 1973). It was shown in this study that New Zealand white animals had greater weaning weights than the
other genotypes tested. Gain in litter weight is a good indication of the milk yield of the doe (Vakulenko, 1985). The advantage of the New Zealand white and California animals over the local Kenya whites could have been due to the inferior milk yields of the Kenya whites. Cowie (1969) described a linear relationship between litter weight gain and kilogrammes of milk consumed in New Zealand white and Dutch rabbits. The young born to comparatively large breeds within a species grow faster than their counterparts born to small breeds probably due to differences in maternal effects. In these studies New Zealand whites and Californians could be described as large compared to Kenya whites.

Among other traits, it may be advisable to select for breeding does on the basis of the pre-weaning performance of their litters. In this way one would be indirectly selecting for milk yield and hence increased weaning weights. Post weaning trials have shown that usually animals that are heaviest at weaning maintain their superior weight up to slaughter and hence yield heavier carcasses than their lighter counterparts.

A comparison of the litter weight at birth shows that litters born to Kenya white does were heavier than litters born to does of the other breeds. This can be attributed to the larger litter sizes at birth.
This advantage was however lost during the suckling period probably due to low milk production of the dams and/or limited amount of milk available to each individual kit as pointed out by Vakulenko (1985). This advantage could be exploited through cross-breeding of the Kenya white with the exotic breeds which have a fast growth rate.

As there was no significant interaction between breed and diet, selection of breed to be kept on diets such as the ones used in these studies would be the California, New Zealand white and lastly Kenya white in that order depending on availability of breeding animals.

5.3. Effect of diet.

It should be noted that the value of the basic diet (forages) was not experimentally compared but the relative values of liveweight gain and growth rate observed for the diets based on *Chloris gayana* hay, maize leaves and sweet potato vines used in the post weaning trials are probably a reflection of the relative feeding values of these forages. It appears that the low weekly liveweight gains obtained using *Chloris gayana* hay as a basic diet were associated with the poor quality of forage available to the animals. This suggests that the intake of total digestible nutrients may have been inadequate. It has been pointed out that growing rabbits utilise dietary
fibre relatively poorly and that they cannot increase their intake of fibrous diets to fully compensate for a reduction in nutrient concentration of the diet (Spreadbury and Davison, 1978; Cheeke, 1983b). Although fibre digestibility measurements were not made in the present studies it was clear from visual examination of the faeces of the animals fed on Chloris gayana hay that many long particles were passing through the digestive tract apparently undigested. For this reason traditional hay from grass after the flowering stage of development is likely to be a poor feedstuff for growing rabbits. Use of grass hay for feeding should therefore take into account the stage of growth to ensure that the material is of suitable quality for maximal utilisation.

Reyne and Salcedo-Miliani (1981) cited by Lebas et al. (1986) have demonstrated that if fed on both concentrate and forage ad libitum, rabbits do not consume enough forage for maximum growth. It was therefore recommended that a farmer faced with such a situation should limit the daily allowance of concentrate as it is partially replaced by the forage. This phenomenon is probably exhibited in animals fed on sweet potato vines and maize leaves used in this study. The growth rates of more than 25gm/day obtained for these forages are similar to those reported by Stotz (1983) when pellets alone were used. But a problem may arise with forages of low nutritive value.
In these trials, potato vines and maize leaves being of higher nutritive value than hay produced higher growth rates. Thus at all levels of concentrate supplement feeding the forages with high crude protein gave better results. However there appears to be a limit to which the forage can replace the concentrate (Martina, 1985). This limit depends on the feeding value of the forage.

Since growth rate decreased as the level of supplementation was reduced, animals fed supplement at the medium and low levels must be kept over a longer period to achieve the same slaughter weight as rabbits supplemented at high level. On the other hand the disadvantage of an extended period of rearing may be counterbalanced by reduced quantities and hence cost of commercial concentrate used. The growth rates of animals supplemented at the low level was far below the target of about 25 grammes per day outlined by Stotz (1983) and if kept to attain a slaughter weight of about 2 Kg may take a long time.

On all the forages, there was a reduction of the dressing percentage as the level of supplementation was decreased. Chawan et al. (1982) reported that weight of the viscera tended to increase as the level of fibre in the diet was raised. In pigs, Kuan et al. (1983) found that there was an increase in the empty weight of the gastro-intestinal tract as the
dietary proportions of cell wall material was increased. This was attributed to an adaptation to the increased bulk and/or proportion of fibre. Normally the dressing percentage decreases with increasing visceral weight. The results obtained in these trials appear to agree with the findings of Chawan et al. (1982) and Kuan et al. (1983). Rao et al. (1977) reported dressing percentages of 40.86-50.04 at 12 weeks of age which is similar to those obtained in these trials although those rabbits were creep fed and subsequently fed ad libitum on a commercial pelleted diet of 16.8% crude protein. In other studies higher yields of 59.92% and 57.38% were reported for diets containing 18.86 and 16.36% crude protein and 12.03 and 18.12% crude fibre respectively (Zaragoza and Valejjo, 1982). It can be observed that the level of fibre in the diet affects the dressing percentage.

The ratio of meat to bone was poorest on the lowest level of supplementation. These results agree with the findings of Cantier et al. (1981; cited by Lebas et al., 1986). These authors reported that a poor diet slows growth as most nutrients are used for skeletal development. The faster growing animals therefore will have the best carcass composition (muscle/bone ratio, fat percentage) at slaughter age. Rao et al. (1977) obtained similar values (2.86- 4.06) of meat to bone ratio for New Zealand white animals slaughtered at 12 weeks of age.
5.4. Cost of rabbit meat production.

It should be noted that figures of cost reported in these studies do not take account of forage fed and are based on the amount of concentrate offered. Commercial concentrate is the most costly portion of the diet. The figures thus give a reflection of the economic efficiency of meat production. A similar method of assessment was used by Rastogi (1986).

In evaluating grower rabbits for meat production, economy of gain and yield of meat must naturally receive most consideration. The advantage of increased carcass yield might be offset by low utilisation of feed. In these studies animals on the high level of supplementation had consistently higher gains but at higher costs of supplementation than the lower levels. Although the rate of growth was greater with every increase in the amount of concentrate offered, the gain at the medium level was satisfactory for diets of maize leaves and potato vines (Harris, et al., 1985).

During the whole period, animals on the highest level of supplementation used approximately 1.2 Kg more concentrate than those on the medium level. The same animals on a basic diet of Chloris gayana hay, maize leaves and sweet potato vines gained 272.1,
179.6 and 125.4 gm more weight than those on the medium level respectively. For every shilling invested in purchase of extra concentrate there was an average weight gain of 75.60, 49.90 and 34.90 gm on the high level as compared to 113.8, 114.0 and 45.50 on the medium level for Chloris gayana hay, maize leaves and sweet potato vines respectively. These results show that it was desirable to supplement at the medium level. The small scale farmer has an abundant supply of maize leaves, sweet potato vines and dry grass from the crop fields, communal grazing areas, and the roadside. It is suggested that as a way of minimising costs without affecting carcass quality feeding supplement at the medium level would be desirable. The savings on feed costs which can be realised from the use of these forages at the medium level of supplementation may offset the lower rate of growth. This should make the medium level of supplementation more attractive to the rabbit producer who plans to put his crop residues to maximum use.
CHAPTER 6

SUMMARY AND CONCLUSIONS.

Studies reported in this thesis were based on the need to develop an integrated crop-livestock production system aimed at increasing small-scale protein supply. This need was stressed in Chapter 1. The desirability of an integrated approach as a basis of improving nutrition in the face of the increasing human population and worldwide poverty has been emphasized. *Oryctolagus cuniculus* is known to be well suited for this approach (Owen et al., 1977). Because of the increasing cost of cereal based feeds various feeding and management strategies must be taken into consideration in order to ensure that animal production is achieved with the least cost. An invaluable first step is the utilisation of crop residues.

It has been observed and/or demonstrated within limits of the experimental conditions and procedures employed in the present studies that:-

a) under small scale farming conditions, the cost of rearing rabbits for meat can be substantially reduced by feeding crop residues supplemented with limited quantities of commercial concentrate feed. The observations seem to indicate that the *Chloris gayana* hay used was inferior to both maize leaves and sweet potato vines.

b) for satisfactory performance, forages should be
harvested in the early stages of growth before the crude protein content declines.

c) increasing the amount of supplement from the low to the medium and high levels produced marked increases in liveweight gain. This response was highest in animals on *Chloris gayana* hay where the quality of the forage was relatively poor.

d) lowering the amount of supplement feed led to a reduction in the dressing percentage, did not significantly influence growth of bone and produced a carcass with a low meat to bone ratio.

e) there were breed differences in growth response of young rabbits to the diets used in the trials. The New Zealand white and California breeds have faster rates of liveweight gain than the Kenya white before and after weaning though the latter produce larger litters. It would be advisable to use a suitable cross breeding programme in order to exploit these traits.

f) It is necessary to establish the efficiency of the rabbits’ digestion of various locally available forages. This information would be used to find the combination of forages that could best meet rabbit requirements. Sweet potato vines for example can only be fed fresh and are bulky. Work should be carried out to adopt suitable methods of preserving this forage under small scale farming conditions.
REFERENCES

J. Nutr. 103 : 1306.

Washington. D. C.


Trop. Anim. Prod. 6: 93
Anim. Prod. 36: 229


Cantier, J., Vezinhet, A., Rouvier, R. and Dauzier, L.
Allometrie de croissance chez le lapin (Oryctolagus cuniculus). I- Principaux organes et tissus.

Chawan, C. B., Ibeh, E. N., Rao, D. R. (1952) Influence of levels of energy, protein and fibre on the performance of weaned New Zealand white rabbits.
J. Anim. Sci. 55: 264

Feed. Manag. 31:12.

Cheeke, P.R. (1983a) Rabbit production in Indonesia.
J. Appl. Rabbit Res. 6: 80

Cheeke, P. R. (1983b) The significance of fibre in rabbit nutrition.
J. Appl. Rabbit Res. 6:103.


Cheeke, P. R., Sanchez, W. K., Patton, N. M. (1985) Protein requirements for optimal growth and reproduction of rabbits. J. Appl. Rabbit Res. 8: 139

Wld. Anim. Rev. 21: 77


J. Endocr. 44: 437


J. Appl. Rabbit Res. 6: 96.


Harris, D. J., Cheeke, P. R. and Patton, N. M. (1985) Effect on fryer rabbit performance of supplementing pelleted diet with alfalfa or grass hay. 

Agriculture Research Service; U.S.D.A., Washington, D. C.

Holmes, Z. A., Wei, S. F., Harris, D. J. and Cheeke, P.R. (1984) Proximate composition and sensory characteristics of meat from rabbits fed three levels of alfalfa meal. 


Anim. Prod. 36: 201

Feeding and management systems.

FAO Animal Production and Health Series, No. 21

J. Appl. Rabbit Res. 8:126
Anim. Prod. 38:293


Proc.4th small ruminant CRSP Kenya Workshop, Kakamega, Kenya pp:18


Owen, J. E. (1976) Rabbit production in Tropical developing countries.


Owen, J. E., Morgan, D. J., and Barlow, J. (1977) The rabbit as a producer of meat and skins in developing countries.


Anim. Prod. 39:465


Reyne, Y., and Salcedo-Miliani, V. H. Le lapin peut-il equilibrer seul son ingestion de cellulose ?. Cuniculture. 8: 26


Spreadbury, D. and Davison, J. (1978) A study of the need for fibre by the growing New Zealand white rabbits.


Ministry of Livestock Development, Nairobi.


USDA (1973) The ABC's of domestic farm raised rabbit meat.
Circular No. 549. Washington D.C.

Vakulenko, I. S. (1985) Milk yield of rabbits and the growth rate of the young.

8. APPENDICES.

Appendix 1. Means of weekly liveweight gain of grower rabbits of the three breeds fed on *Chloris gayana* hay and supplemented at the three levels.

Mean liveweight gains (grammes)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Diet</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>supplement level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NewZeland.</td>
<td>High</td>
<td>113</td>
<td>83</td>
<td>154</td>
<td>179</td>
<td>196</td>
<td>148</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>56</td>
<td>83</td>
<td>104</td>
<td>120</td>
<td>136</td>
<td>115</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>24</td>
<td>52</td>
<td>63</td>
<td>59</td>
<td>71</td>
<td>71</td>
<td>76</td>
</tr>
<tr>
<td>California</td>
<td>High</td>
<td>168</td>
<td>173</td>
<td>191</td>
<td>228</td>
<td>191</td>
<td>159</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>89</td>
<td>103</td>
<td>110</td>
<td>159</td>
<td>163</td>
<td>110</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>48</td>
<td>59</td>
<td>60</td>
<td>75</td>
<td>85</td>
<td>103</td>
<td>108</td>
</tr>
<tr>
<td>Kenya white</td>
<td>High</td>
<td>80</td>
<td>104</td>
<td>124</td>
<td>150</td>
<td>126</td>
<td>118</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>68</td>
<td>89</td>
<td>119</td>
<td>130</td>
<td>121</td>
<td>109</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>21</td>
<td>41</td>
<td>48</td>
<td>56</td>
<td>55</td>
<td>55</td>
<td>56</td>
</tr>
</tbody>
</table>
Appendix 2. Means of weekly liveweight gain of grower rabbits of the three breeds fed on maize leaves and supplemented at the three levels.

<table>
<thead>
<tr>
<th>Breed</th>
<th>Diet</th>
<th>Supplement level</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>High</td>
<td>133</td>
<td>215</td>
<td>231</td>
<td>204</td>
<td>170</td>
<td>151</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>110</td>
<td>136</td>
<td>174</td>
<td>185</td>
<td>171</td>
<td>150</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>81</td>
<td>75</td>
<td>84</td>
<td>103</td>
<td>119</td>
<td>116</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>High</td>
<td>139</td>
<td>173</td>
<td>195</td>
<td>219</td>
<td>199</td>
<td>189</td>
<td>164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>105</td>
<td>164</td>
<td>206</td>
<td>183</td>
<td>140</td>
<td>125</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>51</td>
<td>98</td>
<td>94</td>
<td>114</td>
<td>108</td>
<td>108</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>Kenya white</td>
<td>High</td>
<td>116</td>
<td>186</td>
<td>184</td>
<td>156</td>
<td>155</td>
<td>113</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>111</td>
<td>188</td>
<td>166</td>
<td>146</td>
<td>125</td>
<td>116</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>45</td>
<td>94</td>
<td>110</td>
<td>118</td>
<td>116</td>
<td>118</td>
<td>116</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3. Means of weekly liveweight gain of grower rabbits of the three breeds fed on sweet potato vines and supplemented at the three levels.

Mean liveweight gains (grammes)

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Diet</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>supplement level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>163</td>
<td>204</td>
<td>268</td>
<td>235</td>
<td>195</td>
<td>181</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>141</td>
<td>155</td>
<td>177</td>
<td>211</td>
<td>196</td>
<td>174</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>116</td>
<td>133</td>
<td>165</td>
<td>200</td>
<td>158</td>
<td>149</td>
<td>95</td>
</tr>
<tr>
<td>California</td>
<td>High</td>
<td>164</td>
<td>213</td>
<td>231</td>
<td>229</td>
<td>193</td>
<td>179</td>
<td>159</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>150</td>
<td>191</td>
<td>208</td>
<td>218</td>
<td>220</td>
<td>191</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>149</td>
<td>164</td>
<td>185</td>
<td>194</td>
<td>224</td>
<td>183</td>
<td>166</td>
</tr>
<tr>
<td>Kenya white</td>
<td>High</td>
<td>129</td>
<td>158</td>
<td>181</td>
<td>203</td>
<td>210</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>126</td>
<td>143</td>
<td>159</td>
<td>173</td>
<td>152</td>
<td>146</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>58</td>
<td>68</td>
<td>130</td>
<td>110</td>
<td>148</td>
<td>145</td>
<td>141</td>
</tr>
</tbody>
</table>