WASTE DISPOSAL BY FEEDING RUMEN INGESTA TO RABBITS AND SENSORY EVALUATION OF MEAT FROM THE RUMEN INGESTA-FED RABBITS

BY

SUNDAY CHIWUIKE EGEGE

1994.

DECLARATION

The work presented in this thesis is original and was carried out by me under the supervision of Professor J.U. Umoh, Dr. A.A. Aganga of Faculty of Veterinary Medicine and Dr. V.J. Umoh of Department of Microbiology, Ahmadu Bello University, Zaria.

Reference is made to the work of other investigators duely acknowledged. No part of this thesis has previously been submitted for a degree or diploma.

DIGITIZED

19/1/94

DR. SUNDAY CHIWUIKE EGEGE
AHMADU BELLO UNIVERSITY
ZARIA

This thesis titled "Waste Disposal by Feeding Rumen Ingesta to Rabbits and Sensory Evaluation of Meat from the Rumen Ingesta-Fed Rabbits" by Dr. S.C. Egege meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello Unversity and is approved for its contribution to knowledge and literary presentation.

External Examiner

19/1/94

Prof. A.E.J. Okoh,
(D.V.M.,M.P.V.M, Ph.D)
Dept. of Vet. Medicine,
Usmanu Dan Fodiyo
University,
Sokoto.

Supervisory Committee

Prof. J.U. Umoh,
(D.V.M., MSPH., Ph.D)
Major Supervisor,
Dept. of Vet. Public Health
and Preventive Medicine,
Ahmadu Bello University,
Zaria.

Dr. V. J. Umoh,
(B.Sc., M.Sc., Ph.D)
Supervisor,
Dept. of Microbiology,
Ahmadu Bello University,
Zaria.

Dr. F. O. Mosimabale,
(D.V.M., DVPH, M.Sc.)
Supervisor,
Dept. of Vet. Public Health
and Preventive Medicine,
Ahmadu Bello University,
Zaria.

15/1/94

Dr. D. Mohammed
(BA; Ph.D)
Professor and Dean
Postgraduate School
Ahmadu Bello University
Zaria.

DEDICATION

To my wife, Abi, my God-given wife.

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ABSTRACT

Rumen ingesta (RI), 40% Rumen ingesta + 60% Poultry growers mash (RIGM) and Poultry growers mash (GM) were fed daily for 49 days to three groups of weaned cross-bred rabbits as a means of waste disposal. Protein levels were 17.5%, 18.0% and 19.1% for RI , RIGM and GM respectively; fat levels were 4.2%, 3.0% and 1.4% while fibre contents were 27.2%, 22.4% and 17.7% for RI, RIGM and GM respectively. All the rabbits fed on RI died within three weeks of feeding. There was a significant difference in feed consumption for rabbits fed on RIGM and those fed on GM ($P< 0.05$). Feeding on RIGM gave a significantly lower weight gain (10.6g/day) than those fed on GM (16.8g/day) ($P<0.05$). Meat from both feeding regimes were evaluated organoleptically on a ten point Hedonic scale by an eight-member sensory panel. Meat from feeding GM was judged slightly better (7.8, Good) than meat from feeding RIGM (6.9, Very fairly good). Feeding regime significantly affected relative organ weights. Mean dressing percentages were 68.0% (RIGM) and 69.8% (GM). Water, fat and protein contents were significantly different for meat from the two feeding regimes ($P<0.05$) with meat from rabbits fed on RIGM having lower values. Citrobacter diversus was cultured from rumen ingesta, intestinal and bile samples.

This study demonstrates that rumen ingesta may be successfully fed to weaned rabbits at 40% level of supplementation thus

helping to rid the abattoirs of such wastes to reduce associated environmental health hazards.

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CHAPTER ONE

INTRODUCTION

1.0 Nigeria has started battling with problems of environmental pollution. Pollution from abattoir wastes does not seem to have received any major attention by the State Governments. After the slaughter and evisceration of animals in the abattoir, ruminal contents are usually heaped within the premises. The premises of such abattoirs are often visited by dogs, rodents and reptiles constituting menace and danger to human life. The wastes provide niches for various parasites and intermediate hosts. Disposal of these wastes requires a major effort both financially and otherwise. Managing animal wastes could be by utilization as by-products to industries and laboratories (Thornton, 1962). It may also be utilized as feed (Messersmith et al, 1974). Disposal of ruminal wastes may be achieved by incorportation into livestock feeds.

In Nigeria today, the cost of popular sources of animal protein for man is too high for most people to afford. This high cost partly stems from the depleting cattle population and also due to the exorbitant cost of imported animal feeding ingredients. Livestock also compete with man for scarcely available grains. The rabbit, a pseudo-ruminant, may be the answer to the much needed cheap animal protein in Nigeria. Their high reproductive rate makes them potentially more efficient than other livestock at converting forage into meat (Spedding et al, 1976). Rabbit meat has high

protein, low fat, low energy and cholesterol content (Ticca, 1977; Rao et al, 1978; MAFF, 1978). Rabbit producers use poultry mash to raise their rabbits (Ekpenyong, 1984; Spreadbury and Davidson, 1978).

Since the problem of feed has been identified as one of the limiting factors in adequate availability of protein, the necessity to investigate alternative sources becomes more obvious. The abundance of rumen contents in the abattoirs may provide needed alternative. In the rumen, nutrients such as cellulose and non-protein nitrogen are converted by the microbes into microbial protein, so that the rumen acts as a natural continuous culture system for the production of single cell protein (Jovanovic and Cuperlovic, 1977). Some available data according to Antongiovanni et al (1973) and Jovanovic and Cuperlovic (1974), show that rumen contents collected at slaughter houses contain 10 - 20% dry matter composed of: crude fibre (30-40%), crude protein (10-25%), fat (2-6%), nitrogen free extract (38% or less) and ash (8-13%). Some attempts have been made to dry rumen contents collected from slaughter houses and include them in diets for ruminants (Messersmith et al, 1974) or poultry (Jarnicka- Postek et al, 1973; Jovanovic and Cuperlovic, 1977). Rumen ingesta is composed of grasses, pentosans, cellulose, concentrates and legumes fermented by rumen microbes into microbial proteins. Abdo et al (1964) found that the biological value of ruminal microbial proteins to rats was relatively high and the amino acid composition was good. The excreta of animals have been effectively incorporated into

animal feed and such feed reported as acceptable; for instance, poultry litter has been incorporated into livestock feeds (Preston and Lang, 1987). Poultry waste has been shown to serve as a significant source of crude protein and is rich in calcium and phosphorus (Comingham, 1976). The beneficial value of dried poultry manure has been established (Ogunmodede and Aninge, 1975; Trakulchang and Balloun, 1975). Recycling of rabbit manure as a feedstuff has been found to be beneficial (Swick et al, 1978; Cheeke, 1979; Fekete, 1984). Both livestock manure and municipal wastes can be recycled and fed to animals and these, besides serving as nutrients, minimize environmental problems (Ekpenyong and Biobaku, 1986). Some workers have reported the beneficial effects of activated sewage sludge on the growth of some classes of livestock (Firth and Johnson, 1955; Scott and Adams, 1975; Klein, 1962; Cheeke and Myer, 1973; Klinzell et al, 1977; Beaudounin et al, 1980). It is obvious, therefore, that manure from livestock production has been shown to be a potential source of feed nutrients (Cheeke et al, 1977; Muller, 1980; Shah and Muller, 1982).

The Objectives of this study therefore were to:-

i. Compare the performance of rabbits fed rumen ingesta with those fed poultry growers mash with respect to feed consumption, weight gain, proximate values, carcass characteristics and quality.

ii. Determine the effects of feeding 40% rumen ingesta and 100% poultry growers mash on sensory properties of different cuts of rabbit meat.

iii. Determine the advisability of using the feeding of rumen ingesta to rabbits as a means of disposing such abattoir wastes.

accessible to vectors such as mosquitoes causing malaria, yellow fever, dengue and encephalitis; fleas spreading typhoid fever, enteric diseases, tularaemia, anthrax, miasis and parasitic worms; spiders, though not as vectors but capable of biting to inject venoms; ticks, causing tick fever; bed bugs as severe nuisance and rodents as reservoirs for leptospirosis, salmonellosis, hosts of fleas and mites which are vectors of plague (Savage, 1971). Animals may offer a solution to the potentially serious problem since many waste materials which pollute the environment can also be utilized as nutrients for animals. The re-cycling of these materials through animals offers an opportunity for their conversion to a pallatable feed (Forrest et al, 1975).

2.2 RUMEN INGESTA AS FEED INGREDIENTS FOR ANIMALS.

Excreta from all types of livestock have been used in livestock rations (Preston and Lang, 1987). Interest is increasing in utilization of the nutrient potential of livestock wastes through re-feeding to farm animals. Feeding of poultry wastes has been intensively investigated whereas studies with cattle wastes utilized as feed are limited (Bhattacharya and Taylor, 1975). The concept of producing food from wastes has become of great interest within the last few years as a result of increasingly frequent food shortages and price rises (Tannenbaeum and Pace, 1976). Environmental pressures also lend support to this concept which is attractive and creates many opportunities for inventive proposals.

Several workers have examined the nutritional value of dried cattle waste to sheep (Tinnimit et al, 1972) and cattle Buchaltz et al, 1971; Lucas et al, 1975). According to Jansen et al, (1977), the invitro digestibility of the dried rumen ingesta is the most important measure of its value as an animal feed. This was however exceptionally low in their study and they concluded that rumen ingesta has very little value as ruminant feed. Excreta from ruminants are high in refractory cell wall carbohydrates with smaller amounts of microbial cells and urea if the urine is incorporated with the faeces. Harpster et al (1978), compared the value of lambs and growing finishing cattle of ration containing ensiled cattle waste (ECW) and corn silage (CS) in sheep metabolism and steer growth trials; ECW contained approximately 60% cattle excreta and 40% chopped hay in fresh weight basis. Heat treatment of faecal waste may lower digestibility (Lucas et al, 1975). Furthermore, many livestock producers may lack the equipment necessary to dry sufficient quantities of wastes for re-feeding.

According to Coleman et al (1984), the extent of digestion of feedstuff in the rumen is a function of the digestible fraction, digestion rate and residue time. The rumen contains both liquid and semi-digested solids and is inhabited by a dense and varied microbial population (mainly bacteria and protozoa) whose function is to break down plant materials, particularly the tough cell wall that could not be digested by the host animal (Czerkawski, 1986). Microb-

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The feed resources for ruminants include: fibrous residues from cereal production particularly from rice, maize and sorghum, fermentable carbohydrate-rich by-products from agro-industries such as mollases from sugar extraction and bran from cereal processing and pastures. Fermentative digestion is buffered by salivary secretions. The rumen micro-organisms receive substrates (forage) directly and ferment them (Preston and Lang, 1987).

In the rumen, the main agents that break-down carbohydrates are anaerobic bacteria, protozoa and fungi. Bauchop (1980), stated that phycomycetous fungi in the rumen were extremely important initiators of fermentative break-down of insoluble plant cell wall materials while protozoa are preferentially retained in the rumen, mostly the small entodineomorphs (largely Entodinia spp). and the large holotrich protozoa (mainly Isotricha or Dasytricha spp). Bacteria are normally the largest microbial biomass in the rumen, the most important for fibre digestion being Ruminococcus flavefaciens, Ruminococcus albus, Bacteriodes succinogenes and Butyrivibrio fibrisolvens (non-spore formers). In some situations, Cillobacterium cellulosolvens and various Clostridium spp become relevant as Hungate (1966), isolated Clostridium Lochhaedii from rumen of cattle fed salt-treated forages. Salmonela typhimurium has been isolated from the rumen of clinically healthy cattle (Thornton, 1962). Other organisms such as mycoplasmas and viruses are all present in the rumen probably as infective agents of the major species.

According to Hungate (1975), rumen microbial populations vary within an animal with time after feeding, between days in the same animal and apparently in animals in different countries on similar feeds.

Although the diet of adult ruminants is similar to and may be identical with that of other herbivores, the ruminal fermentation preceeding digestion and absorption removes hexose from the ingesta. Under normal conditions, the fermentation is so effective that it has been estimated that only 5-6g of glucose per day is available for intestinal absorption in a hay-fed sheep. Under normal circumstances dietary protein is largely fermented and the nitrogen appears as ammonia (McDonald, 1948). The ammonia may be utilized by bacteria (Bryant and Robinson, 1963) or absorbed through the rumen wall (McDonald, 1948). Fermentation of particulate proteins, according to Preston and Lang (1987), depends on the lenght of time that they are in the rumen and factors such as their rates of solubilization and enzymatic degradation.

Insoluble feed materials entering the rumen must be colonized by organisms before fermentation can begin. Good quality forage provides cellulose which is readily accessible to micro-organisms. With straws and lignocellulose crop residues, the fibre components are insoluble (Preston and Lang, 1987). Without rumination, the rate of passage of coarse fibre through the alimentary tract of ruminants is reduced very substantially and may adversely

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2.3 RATIONS AND FEEDING STUFF FOR RABBITS.

Rabbits are herbivores which efficiently utilize roughage diets, eat most types of green vegetation, hay, grains, tubers and roots. They have the ability to utilize fibrous feedstuff that cannot be effectively consumed by humans (Aduku and Olukosi, 1990).

Rabbits appear to require relatively high dietary fibre level but digestion is very poor when compared with ruminants (Lang, 1981). Rabbits eliminate fibre and digest non-fibrous components of the feed but the digestion of cellulose is low (Lang, 1981). The level of crude fibre usually recommended for an all-purpose rabbit ration is 12- 14% as feed (Aitken and Wilson, 1962; Goman et al, 1970; Colin et al 1976; MAFF, 1978).

If fed a low energy diet, the rabbit eats more feed; if fed a high energy diet, it eats less but in both cases the caloric intake is about the same since it adjusts its feed intake to meet its caloric needs (Cheeke et al, 1982). Crude fibre level of 10-17% was found to support weight gain with the optimum level of crude fibre supporting optimum weight gain of 41.3g/day per animal being 14.3%. A crude fibre level exceeding 17% reduces performance by limiting energy intake (Cheeke et al, 1982). The digestive system of rabbits is adapted to obtain maximum nutrients from fibrous diets of low nutritive value. Digestive adaptation of rabbits to fibrous diets permits a high intake capacity and

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the feed and can be supplied from fats, grains and fibrous feeds (Aduku and Olukosi, 1990).

Feeding of green feeds to rabbits is useful, helping to reduce the amount of purchased feed needed. Feeding greens free-choice reduced voluntary intake of pelleted feed by about 50% without affecting growth rate (Pote et al, 1980; Cheeke, 1984; Harris et al, 1984). Oke et al, (1986), found that 15% dried cassava peels meals in diets fed to rabbits produced weight gain equal to rabbits fed control diet. It has been proved that urea or poultry manure contributes to growth of rabbits (Aduku and Olukosi, 1990).

Rabbit feeding had all along been based on feeding pelleted feed ad libitum. The exclusive feeding of pelleted concentrates risks a shortening of the lifespan of rabbits due to the development of hair balls in the stomach, adiposis and dysentery (Schlolaut, 1987). Most proprietory compound rabbit rations are formulated as "all-purpose" for all classes of stock and are intended for use as the sole diet. Nevertheless, a small quantity of hay or straw is sometimes fed in addition to prevent boredom and to provide bulk when the rabbits are on a restricted regime (Lang, 1981).

A typical all-purpose compound feed will consist of about 60% cereals, 10% grass meal and varying proportions of high protein feeds, a source of fibre and a mineral and vitamin supplement (Lang, 1981). In some areas, by-products from the brewing, milling or vegetable processing industries commonly replace cereals as the major components in animal

compound feeds. Young weaned rabbits were found to grow well (about 39g/day) on diets containing up to 100% of several types of dried forage (Walsingham and Large, 1977).

Particle size of diets is known to affect digestibility and rate of passage in most species. In the rabbit, Spreedbury and Davidson (1978), noted that differences in particle size of the fibrous constituents of diets have been suggested as possibly contributing to differences in digestibility of the diets. Fine grinding of the diet is known to retard digestive transit and reduce intake (Lang, 1981).

2.4 RABBIT MEAT

Domestic rabbit meat has higher consumer demand in many European and Asiatic countries (Attifield, 1972). It has very good nutritional value being high in protein, low in fat, low in calories and low in sodium (U.S.D.A., 1963; Sunki et al, 1978). Aduku and Olukosi (1990), described rabbit meat as a source of healthful food having low cholesterol level of 50g/100g; fat (4g/100g) and energy (124 KCal/100g) and high protein level of 22g/100g. Rabbit incorporates more protein in its body than broilers and according to Rao et al (1979), because of its extremely low cholesterol and sodium levels (136mg and 393 ppm respectively), rabbit meat may play an important role in the prevention of vascular diseases.

The rabbit is a cheap source of meat and has a desirable meat to bone ratio (Rao et al, 1978). Rabbit meat is all

white, fine grained, delicately flavoured, nutritious and appetizing. Only about 20% of the dressed carcass is bone, so that meat yield is high compared with that of many meat animals. The carcass yield is about 74% if processed by scalding or roasting. Rabbits are weaned at 56 - 60 days with a weight of 1.81kg (4lb). NewZealand white rabbits weigh 4.1 - 5.4kg. at maturity (Cheeke et al, 1982). Rao et al (1978), gave the average dressed rabbit cacass range from 45.6% to 50.3% of live weight and ranges of various organs as: tail and feet (2.6 - 3.7%), head (8.0 - 9.7%), heart and lungs (1.2 - 1.8%), liver (3.7 - 4.5%), blood (1.4 - 1.9%), skin (11.7 - 13.3%) and alimentary canal (14.0 - 18.0%). They also gave the composition of the meat as: protein (18.6 - 19.4%), fat (7.9 - 10.9%) and moisture (68.5 - 72.0%). The composition of various meat is as shown below:

Composition of Various Meat

Meat	% Protein	% Fat	% Water	Cal/Ib
Rabbit	20.8	10.2	67.9	795
Chicken	20.0	11.0	67.6	810
Veal	18.8	14.0	66.0	910
Beef	16.3	28.0	55.0	1,440
Pork	11.9	45.0	42.0	2,050

Source: (USDA, 1963).

Taylor et al (1989) found that loin and legs were most valuable portions of rabbit carcass and cooking loss was least for hindlegs, 26.9% and greatest for the rack, 34.9%. If the rabbit is skinned, the skin, head and feet including blood, gut and gut contents are by-products but if roasted, the head, skin and feet form part of the carcass. The slaughter of rabbits involve stunning, bleeding, cleaning, evisceration and cutting. Cutting of rabbits usually involves 7 major cuts as: 2 thighs, loin, 2 backs and 2 shoulders (Aduku and Olukosi, 1990). Properly developing and conditioned fryers will average 1.7 - 2.0 kg (3.75 - 4.50 lb.) at 2 months of age and according to Cheeke et al (1982), fryer yields of carcasses vary from 50 - 60% of the live weight, 75-80% of which is edible. Head, skin and feet contribute about 10%, 11% and 3% respectively to skinned carcass (Aduku et al, 1986a).

2.5 SENSORY PROPERTIES.

Regardless of the nutritional excellence and acceptability of meat and meat products, meat will be consumed in adequate and increasing quantities only if it appeals to the palate. Meat palatability depends on such qualities as aroma and flavour, colour or appearance, tenderness and juiciness (Bratzler, 1971). Food acceptance and preference depend on human sensory responses. Many of our present day food taboos and food habits undoubtedly developed during the Nevolithic period (Simoons, 1961). According to Young (1949), food acceptance is regulated by the characteristics of the food object (palatability), by inorganic chemical conditions which themselves may or may not be directly related to metabolic needs. Balavoine (1948), noted that chemical and physical analysis of foods do not replace sensory examination. The price and eating quality of meat are usually determined by the content of connective tissue (Laakkanen, 1973).

Hedonic scale has been used extensively in the sensory evaluation of food (Peryam and Giardot, 1952). Organoleptic characteristics are good indicators of meat freshness (Kontou et al, 1966).

Taste should be clearly differentiated from odour as being exclussively the sensation perceived by the receptors on the tongue. Ageusia is not common but taste acuity and acceptability may be affected by disease and other factors such as age, hunger and smoking (Young, 1949). Modern psychological studies of taste support the functional independence of the

four taste qualities: sweet, sour, salty and bitter. Taste alterations are possible through phenomena like mixture interractions (Bartoshuk, 1977). Meat colour is influenced by a number of variables important in marketing such as animal age, pre and post slaughter handling and display environment (MacDougall, 1977).

Francis (1977) observed that colour (and general appearance) is one of the most important visual attributes in food. Often if the appearance is un-attractive, a potential consumer may never experience the other two major attributes (flavour and texture). Bratzler (1971), noted that in fresh meat, colour is not an important factor but for cooked meat, certainly any extreme variation from what is expected in the colour will have an influence on one's desire to taste it.

Each kind of meat has its characteristic flavour modified by changes in the condition of cooking such as roasting and boiling (Henrickson, 1978). According to Bratzler (1971), the nature and intensity of meat flavours depend in part on the type and on the length of time and temperature of cooking. Meat begins to cook at about 60^{o}C (140^{o}F), a process in which the flavour of the meat changes (Cecerani et al, 1982). Many of the psychological and physiological responses experienced when meat is being eaten are elicited by the flavour and aroma of the product. The meaty flavour and aroma stimulate the flow of saliva and gastric juice, thus aiding in the process of digestion (Forrest et al, 1975).

Tenderness, the ease of reducing an intact piece of meat to

fineness suitable for swallowing, is in part due to the degree of doneness. Another factor is the composition of protein in the piece of meat (Henrickson, 1978). Tenderness is influenced by the length of time and temperature of storage after slaughter (Bratzler, 1971). According to Bratzler (1971), overall impression of tenderness comes from at least three sources: the first is the ease with which the teeth sink into the meat when chewing begins, the second is the ease with which the meat breaks into fragments and the third is the amount of residue remaining after chewing. Tenderness and juiciness are closely related; the more tender the meat, the more quickly the juices are released by chewing (Bratzler, 1971). Meat tenderness is affected greatly by age of the animal; the younger, the more tender (Forrest et al, 1975). The perception of tenderness by human could be described in terms of certain conditions of the meat during mastication enumerated by Forrest et al (1975), as: softness to the tongue and cheek, resistance to tooth pressure, ease of fragmentation, mealiness, adhesion and residue after chewing.

Chewiness is the number of chews required to reduce the residue to a level that can be swallowed (Bratzler, 1971). Juiciness of cooked meat may be separated into two effects: the first is the impression of wetness during the first chews produced by the rapid release of meat fluids; the second is one of sustained juiciness apparently because of the slow release of serum and to the stimulating effect such

as fat on salivary flow (Bratzler, 1971). The same worker noted that juiciness scores for cooked meat from different cuts of meat vary greatly. He observed that sensation of juiciness in cooked meat is closely related to intramuscular fat content and any condition influencing intramuscular fat content of the cooked meat will be reflected in the juiciness score. Juiciness is dependent on the inherent water-holding capacity of meat and the amount of fat in it (Henrickson, 1978). Regardless of the other qualities of meat, the absence of juiciness severely limits its acceptability and destroys its unique palatability characteristics. In combination with water, the melted lipid constitutes a broth that, when retained in the meat, is released upon chewing (Forrest et al, 1975).

Because those cooking procedures that result in the greatest retention of fluids and fat yield the juiciest meat, juiciness varies inversely with cooking losses (Bratzler, 1971). Cooking loss occurs as juices come to the surface in cooking (Cecerani et al, 1982). Cooking loss refers to the weight lost when meat is cooked. It is related most closely to the moisture content of meat (Paul, 1964).

The ultimate test for the value of meat is the degree of acceptability to the consumer (Forrest et al, 1975). Theoretically, it is preferable to score only one factor at any testing session but several of these factors are so closely interrelated that it is often necessary to estimate them at the same time (Bratzler, 1971).

CHAPTER THREE

3. MATERIALS AND METHODS.

3.1 COLLECTION OF RUMEN INGESTA

Rumen ingesta was collected from fresh heaps of rumen ingesta within the premises of Kaduna Abattoir into two polythene bags at 7.00 a.m. each day for seven days. The maximum quantity collected each day was 90.0kg. The content of each bag was spread on concrete floor and sun-dried at College of Agriculture and Animal Science, farm area after each day's collection. The maximum temperature recorded throughout the drying period which lasted eleven days was 40^{o}C, Mean = 34.9^{o}C and the lowest was 28^{o}C, Mean = 21.2^{o}C. The ingesta was regarded as completely dry when each sample maintained a constant weight for three consecutive days. A total weight of 560.0kg wet rumen ingesta was collected and this gave 41.5kg dry rumen ingesta. The 41.5kg dry rumen ingesta was beaten with a piece of wood to reduce the lumps and then ground in a wooden mortar to reduce its coarseness. The resultant dry material was then collected with a plastic bucket into a 50.0kg poultry feed bag, labelled RI (Rumen Ingesta) and stored for feeding.

3.2 COLLECTION OF GROWERS MASH AND PREPARATION OF MIXTURE OF 40% RUMEN INGESTA AND 60% GROWERS MASH.

Four, 25.0kg bags of poultry growers mash (Guinea feeds ^{R}) were bought from a poultry feeds distributor in Kaduna, brought to the College of Agriculture and Animal Science farm area and emptied into one, 100.0kg feed bag and thor-

oughly mixed. The bag was then labelled GM (Growers Mash) and stored for feeding.

From the bag labelled RI, 19.6kg rumen ingesta was weighed out onto a concrete floor earlier washed and disinfected. From the bag labelled GM, 29.4kg growers mash was weighed out onto the RI on the concrete floor. The two feeds were very thoroughly mixed, using a clean disinfected shovel. The resultant mixture represented a ratio of 4:6. This feed was collected into a 50.0kg feed bag, labelled RIGM (40% Rumen Ingesta+ 60% Growers Mash) and stored for feeding.

3.3 SELECTION OF THE RABBITS.

Thirty weaned cross bred (NewZealand white X Local breed) rabbits aged four weeks and weighing between 620g and 634g were randomly assigned to groups A,B and C, each group consisting of 10 rabbits. Group A rabbits were numbered 1 - 10 and placed in hutches with corresponding labels. Group B rabbits were numbered 11 - 20 while group C rabbits were numbered 21 - 30. Each rabbit was placed in a hutch with corresponding numbering. Each rabbit was weighed and the weight noted.

3.4 CONDITIONING OF THE RABBITS

The rabbits were conditioned for seven days by gradually introducing them to the various feeds. Groups A and B rabbits were first started on a mixture of 20.0g rumen ingesta (RI) and 80.0g growers mash (GM) for the first two days; 30.0g RI mixed with 70.0g GM the next two days; 40.0g

RI mixed with 60.0g GM the following two days and a mixture of 50.0g RI and 50.0g GM on the seventh conditioning day. Group C rabbits were each presented with 100.0g GM daily throughout the seven days adjustment period. At the end of the adjustment period, each rabbit was weighed and the weight recorded as the initial weight for the experiment.

3.5 FEEDING OF THE RABBITS.

Each of the group A rabbits was fed daily with 100.0g RI (17.5% crude protein); each group B rabbit received 100.0g RIGM (18.0% crude protein) daily while each group C rabbit received 100.0g GM (19.1% crude protein) daily. Feeding of the rabbits was carried out each morning at 8.00 a.m. by filling each rabbit's feeder with appropriate feed samples 100.0g each). The rabbits were allowed feed ad libitum and voluntary intake determined. Water was introduced into the drinkers and was also allowed, ad libitum. Before each day's feeding, un-consumed feed was collected in a plastic poultry feeder, weighed to determine the quantity consumed and then discarded. The feeding period lasted 49 days. Data was collected daily on mortality and feed consumption and mean weekly feed consumption was calculated. The rabbits were weighed at the end of each week's feeding.

3.6 QUALITY ANALYSIS OF PREPARED FEEDS

3.6.1 PARASITOLOGICAL EVALUATION

Simple floatation, sedimentation and modified Beerman's methods were separately used to examine for helminths and protozoa in five representative replicate samples of RI, RIGM and GM at the end of the seven days' conditioning

period. Two replicate faecal samples from each rabbit were collected and examined for helminths and protozoa at the end of the conditioning period and during the twenty fourth day of the experiment.

For the simple floatation method, about 5g of each sample (feed and faeces) was put in a universal bottle and 5ml of magnesium sulphate added. Glass rod was ued to break the sample in the medium which was sieved into a centrifuge tube. More magnesium sulphate was added until a convex meniscus was formed. The centrifuge tube was covered with coverslip and left for 5 minutes. The coverslip was removed, placed on a glass slide and examined for helminth eggs or protozoan occysts.

Sedimentation was carried out by breaking 5g of each of the samples (feed and faeces) in water, sieving into a beaker and leaving on a bench for 1 hour. The supernatant was gently decanted and using Pasteur pipette and rubber teat, samples were taken from the deposits and examined for parasites.

For the modified Baerman's method, samples of faeces and feed were separately pounded with porcelain pestle and mortar. The pounded samples were loosely packed into a culture bottle wetted with water. The bottle was loosely covered and put in an incubator at 28^{o}C for 7 days. After 7 days, the bottle was taken out of the incubator and exposed to light from a 60 watt bulb for 30 minutes. The bottle was then filled with water and a petri dish placed on top while the bottle was placed upside down. Water was introduced

into the petridish and Pasteur pipette and rubber teat used to collect the liquid from the petri dish into centrifuge tubes. The tubes were centrifuged at 500rpm for 5 minutes and the sediments examined.

Scrappings were made from the mucous membranes of the small intestines and caeca of all the dead rabbits, smeared on microscope slides and examined under the microscope for coccidia oocysts.

3.6.2. MICROBIOLOGICAL EVALUATION

a. Sample tested:

The following samples were tested microbiologically:

i. Feed samples (RI,RIGM and GM)

ii. Organ samples of rabbits that died before the end of the experiment (Small intestines, Caecum, Lungs, Liver) and Bile.

b. Isolation and identification:

For each of the samples, 0.5g was inoculated into selenite broth and nutrient broth, incubated at 37^{o}C overnight and subcultured on to blood agar and MacConkey agar. Isolates from the blood agar and MacConkey agar were Gram stained, purified using nutrient agar and stored on nutrient agar slant at 40^{o}C for biochemical tests. The biochemical tests used included tripple sugar iron agar test (TSI), oxidation-fermentation test (O/F), methyl red test (MR), Vouges-Prousker test (VP) and nitrate reduction test. Others were citrate utilization test, urease test, motility test, and hydrogen sulphide production test.

The biochemical tests assisted in further identifying the

enteric organisms.

3.7 PROXIMATE ANALYSIS.

Proximate anlysis was carried out to determine the dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen and ash content of each of the three experimental feed (RI,RIGM and GM). For each test, each feed sample was replicated three times. The feeds were assayed using the methods described by AOAC (1972).

Five grammes of each ground sample were dried to a constant weight in an oven at 100°C to determine the moisture and dry matter contents. Loss in weight was reported as moisture on a percentage basis.

The temperature of the muffle furnace for the determination of ash was set to reach 600°C (AOAC, 1972).

Total nitrogen was derived by the Kjeldahl method and the percentage crude protein was derived by miltiplying the total nitrogen by 6.25. Crude fibre was determined with the fibre digestion apparatus using the formula:

$$\% \text{ Crude fibre} = \frac{\text{Loss in weight on igniting}}{\text{Weight of sample}} \times 100$$

Metabolizable energy and ether extract determination were also according to AOAC (1972).

3.8 NECROPSY.

Post mortem examination was carried out on all rabbits that died during the experiment. Scrappings from the duodenum

jejunum, ileum, caecum and colon were examined microscopically for coccidiosis. The small intestine, caecum, lungs and bile were collected for microbiological evaluation.

3.9 SLAUGHTER OF THE RABBITS.

At the end of the experiment, three rabbits from each of groups B and C were selected for slaughter on the basis of highest weight, least weight and mean weight of each group. Each of the rabbits was slaughtered according to the method described by Cheeke et al (1982). Each rabbit was first stunned by applying a sharp blow on the back of the head using a short piece of iron rod. It was then bled by severing the jugular vein with a sharp knife and suspended by the hock. The head was later cut off with a sharp knife and after bleeding, the carcass was cleaned by skinning. The tail, manus and pes were cut off and the carcass eviscerated by removing the gut. The carcass was washed in cold water to remove blood and hair and later weighed. The head, skin and legs as well as the heart, liver, lungs, kidneys and gastrointestinal tract were also weighed. The carcass was cut into seven major points representing four standard cuts: shoulders, backs, loin and thighs as described by Aduku et al (1986a). The length of each segment of the gastro-intestinal tract was measured. Each of the standard cuts was weighed and little chunks were collected from them for analysis in three replicates. The methods of analysis used for the meat were those described by AOAC

(1972) for protein, water and fat.

3.10 COOKING PROCEDURE.

All the cuts from each treatment were collected into two washing basins appropriately labelled B and C. From basin B, each cut was divided into two equal parts with a sharp knife and saw. Each half was washed and put in an aluminium pot ready for cooking. To one of the pots, 2.5g of cooking salt was added and the contents cooked by boiling for twenty five minutes. No salt was added to the other pot since some consumers cook without salt. The two pots were cooked simultaneously using a double gas cooker. As the water content of the meat cooked out, 145 mls of water was added to the contents of each pot and boiling continued for another twenty five minutes. The meat was tasted and confirmed done, it was removed from the broth, allowed to cool and weighed to determine the cooking loss. They were stripped from the bones according to the various cuts. Each deboned cut from the pot cooked with salt was sliced into 10g chunks for sensory evaluation and placed in plastic plates labelled RIGMS. The deboned cuts cooked without salt were similarly sliced and the plate labelled RIGMS^{-}. These procedures were repeated for cuts from the washing basin labelled C and the plates containing the 10g chunks were labelled GMS (cooked with salt) and GMS^{-} (cooked without salt). The plates of meat were kept in the freezing chamber of a refrigerator overnight to avoid spoilage.

3.11 SENSORY EVALUATION.

Eight, 10g slices from each of the major cuts (shoulders, backs, loin and thighs) from each feeding regime (RIGM and GM), cooked with and without salt, were made out from the plastic plates labelled RIGMS, RIGMS$^-$,GMS and GMS$^-$. A total number of 128 meat samples were thus derived and put in separate coded aluminium foils and wrapped using randomised 3 - digit coded numbers (Appendix 9). This was replicated twice. The sensory evaluation was for a period of four days, evaluating one major cut each day in the order: shoulders, backs, loin and thighs. Before the evaluation, thirty two coded samples from a particular cut representing the two feeding regimes cooked with and without salt were placed in correspondingly coded white serving plastic plates and served. This was after warming over water at 37^{o}C for five minutes in an aluminium pot.

Eight member sensory panel consisting of students selected from a Higher National Diploma Class of 76 students on the basis that they were willing to co-operate and be available for regular panel work, evaluated the samples. The selection of the panel was through a questionnaire (Appendix 10), administered on the class. The questionnaire was designed to identify among other information, each student's experience in food tasting, health and food prejudice. Two training sessions in form of briefings were used to familiarize panelists with the scoring system and increase their ability to recognize, identify and recall sensory characteristics.

A typical ten point hedonic scale (Williams, 1982) was used (Appendix 11) to evaluate colour, taste, juiciness, flavour, tenderness, chewiness and overall acceptability. On the ten point scale, 10 represented excellent, 5 represented indifferent and 1 represented very bad.

The tasting was carried out each day in the Animal Nutrition Laboratory which was well lit with flourescent tubes and devoid of distraction. The samples were served successively and all judges started evaluating at exactly 11.00 a.m. A maximum of 12 and a minimum of 8 minutes were spent in evaluating each specimen. After the last taster had scored, the next coded sample was presented (single sample presentation). Each replicate tasting lasted approximately 48 minutes.

3.11 STATISTICAL ANALYSIS.

Statistical analysis was based on the complete data recorded for groups B and C rabbits, since all rabbits in group A died by the third week. The means and standard deviations for weekly feed consumption and weekly weight gains were determined. Differences in feed consumption, weekly weight gain and the relationship between weight gain and feed consumption were determined by Student's t- test.

Means and standard deviations were computed for the sensory scores by the judges for all the cuts under the two cooking methods and the two feeding regimes. Means and standard deviations were computed for some parts and organs of the carcasses and for certain carcass characteristics.

Analysis of variance was used to determine significant

differences between means among feeding regimes and their interractions for the sensory characteristics.

The statistical analysis of data was accomplished by using the General Linear Models (GLM) procedure of SSPC (1986), at International Livestock Centre for Africa (ILCA) Kaduna. Least Significant Difference (LSD) test was used for multiple comparison of the means.

CHAPTER FOUR

RESULTS

4.1 FEED CONSUMPTION.

Daily feed consumption data of rabbits fed 100% rumen ingesta (RI), 40% rumen ingesta + 60% growers mash (RIGM) and 100% growers mash (GM) are presented in Appendix 3, Appendix 4, and Appendix 5 respectively. The mean weekly feed consumption ranged from 368.2g to 549.8g in group B rabbits (Appendix 7), representing 52.6g/day to 78.5/day of RIGM. The mean weekly feed consumption in group C rabbits ranged from 509.9g to 632.1g (Appendix 7), representing 72.8g/day to 90.3g/day of GM. The mean total feed consumption for group B was 65.6g/day while that of group C was 83.2g/day.

There was a significant difference in feed intake between groups B and C rabbits ($P<0.05$) (Appendix 12). Feed consumption was higher in group C. Student t- test revealed significant difference in weekly feed consumption for the two groups ($P<0.05$). Feed consumption dropped in group B in week 3 but thereafter increased steadily (Fig 1). In group C feed consumption dropped in week 5 but increased in subsequent weeks (Fig 1).

4.2 WEIGHT GAIN.

Weekly weight and weight gain data of rabbits fed RI, RIGM and GM are presented in Appendix 2 and Appendix 6 respectively. The mean weekly weight gain ranged from 56.0g to 100.2g in group B rabbits (Appendix 2), representing

8.0g/day to 14.3g/day. The mean weekly weight gain for group C rabbits ranged from 84.1g to 139.6g (Appendix 2) representing 12.0g/day to 19.9g/day. The mean total weight gain for group B was 74.2g/week or 10.6g/day while that of group C was 116.6g or 16.7g/day.

There was a significant difference in weight gain between the two groups ($P<0.05$) (Appendix 13). Weight gain was higher in group C. Student's t-test revealed significant difference in weekly weight gain ($P<0.05$) for the two groups. Weight gain increased steadily up to week 5 in group B rabbits, then dropped in week 6 and increased in week 7 (Figure 2). In group C, weight gain increased steadily throughout the seven weeks (Figure 2).

4.3 RELATIONSHIP BETWEEN WEIGHT GAIN AND FEED CONSUMPTION.

The relationship between weekly weight gain and weekly feed consumption was studied through correlation analysis using Pearson correlation. The weight gain was positively correlated with feed consumption ($r = 0.795$). Even when feed consumption dropped between weeks 2 and 3 (from 432.9g to 409.4g) in group B, weight gain still increased from 56.6g to 68.5g (Figure 3). During week 6 when feed consumption increased, there was a non significant decline in mean weight from 81.6g in week 5, to 79.7g in week 6, this was followed by a sharp rise (100.2g) in week 7 (Figure 3). In group C, there was weekly increase in mean weight despite the fact that feed consumption dropped from 591.8g in week 4 to 588.1g in week 5 (Figure 3).

Weight gain in week 2 was most significant ($P = 0.0007$)

(Appendix 13). The growth rate of rabbits in group B was found to be 1.7%/day and the feed consumption rate was 1.3%/day thus the feed efficiency ratio (FER) given as the gain in weight divided by the amount of feed consumed was found to be 0.16 (Table 1).

Figure 1: Mean and Standard deviation of weekly feed consumption for Groups B and C rabbits fed 40% Rumen ingesta + 60% Growers mash (RIGM) and 100% Growers mash (GM) respectively

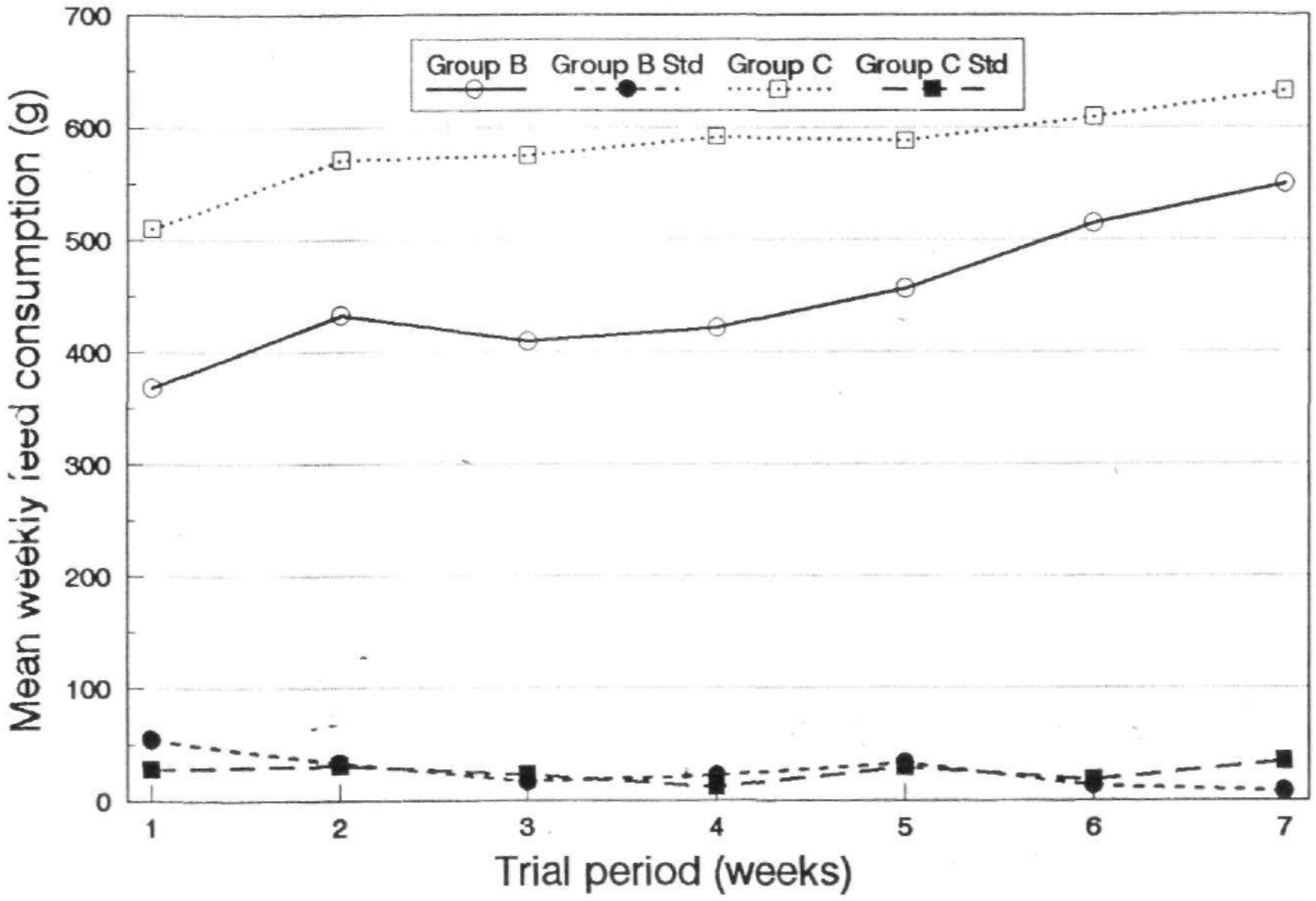


Figure 2: Mean and Standard deviation of weekly weight gain for Groups B and C rabbits fed 40% Rumen ingesta + 60% Growers mash (RIGM) and 100% Growers mash (GM) respectively

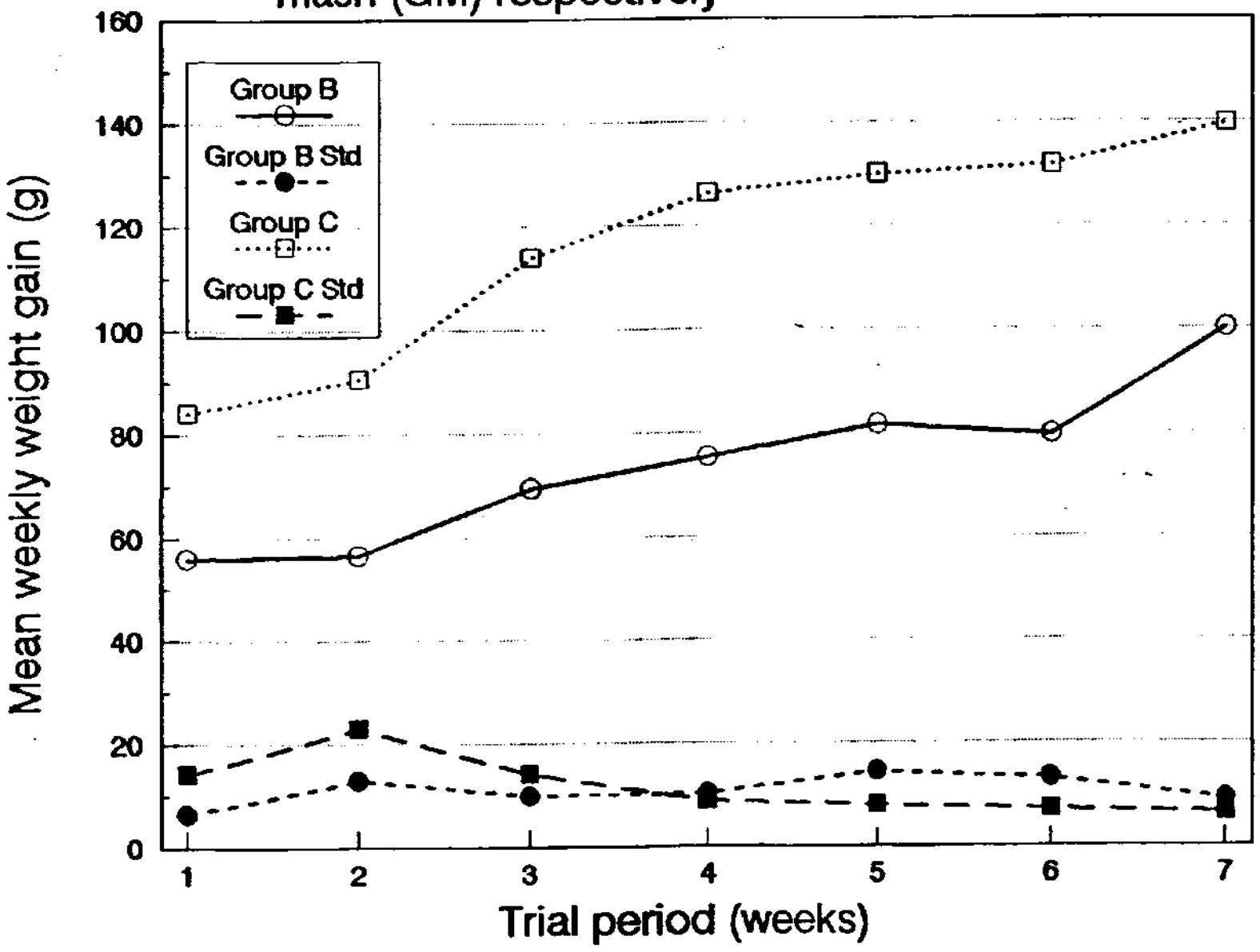


Figure 3: Relationship between weight gain and feed consumption in Groups B and C rabbits fed 40% Rumen ingesta + 60% Growers mash (RIGM) and 100% Growers mash (GM) respectively

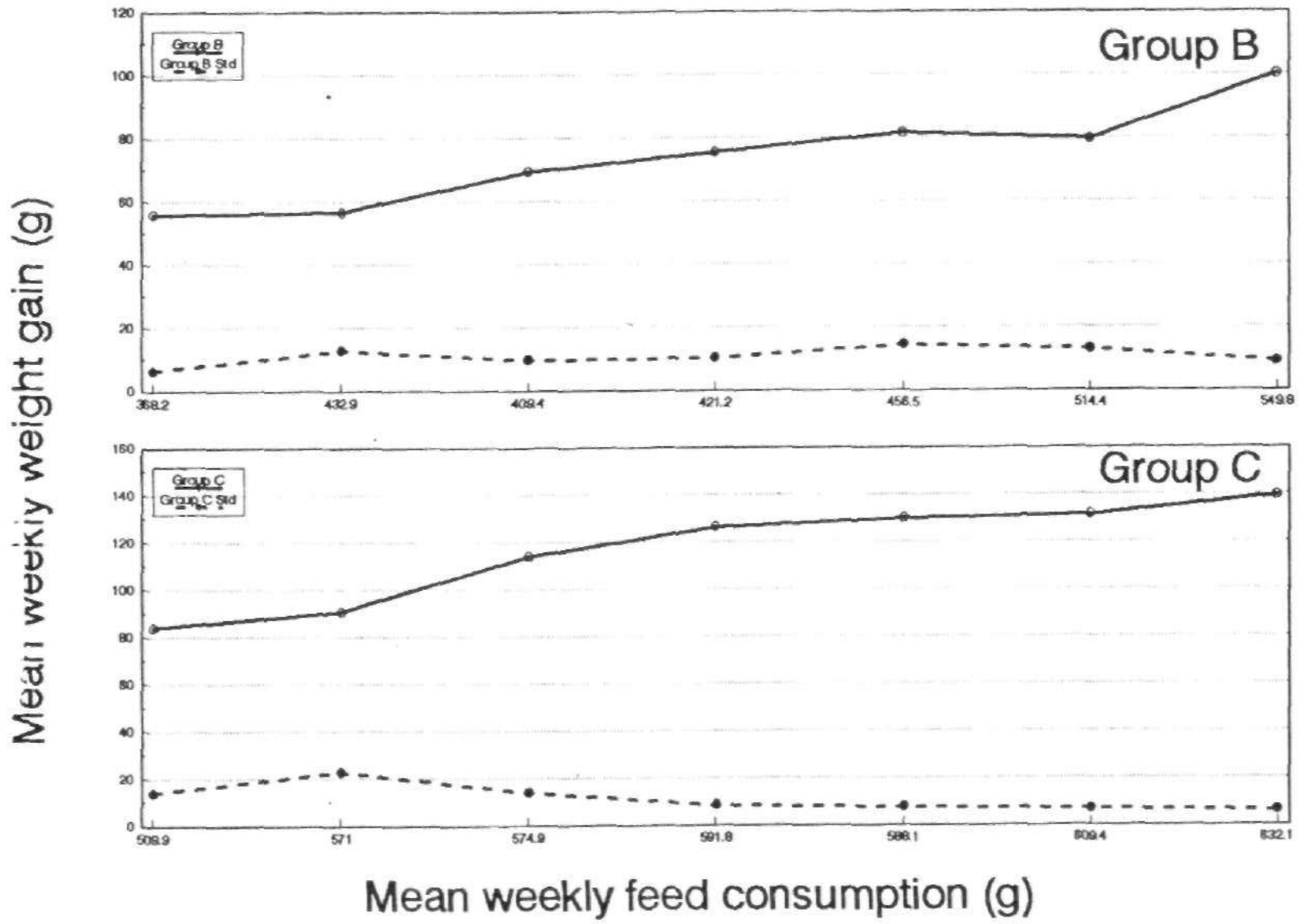


Table 1: Effect of two feeding regimes: 40% Rumen Ingesta + 60% Growers mash (RIGM) and 100% Growers mash (GM) on the growth performance of rabbits.

Performance Parameters	Feeding Regime		Remarks
	RIGM	GM	
No of rabbits	10	10	
Mean initial weight (g)	630.7 ± 2.0	629.1 ± 3.6	
Mean final weight (g)	1150.8 ± 18.7	1444.3 ± 43.7	
Mean weekly weight gain (g)	74.2 ± 17.9	116.6 ± 23.5	P<0.05
Mean feed consumption (g)	458.9 ± 65.0	582.5 ± 43.5	P<0.05
Mean feed consumption rate (%)	9.4	11.9	
Mean feed conversion	6.2	5.4	
Feed efficiency ratio (FER)	0.16	0.2	
Growth rate	0.82	1.30	
Growth rate (%)	11.8	18.5	
Mortality	0	0	

4.4 PROXIMATE COMPOSITION OF FEEDS.

The proximate analysis of RI, RIGM and GM is presented in Table 2. All the parameters compared except crude fibre (Nitrogen, Ether extract, Ash, Crude protein and Dry matter), were not significantly different between RI and GM. The three feeds did not differ significantly in their proximate composition.

Table 2: Means and Standard deviations of Proximate analysis parameters of three feeds.

Parameters	Feed		
	RI*	RIGM**	GM***
Nitrogen	2.8 ± 0.0[a]	2.9 ± 0.1[a]	3.1 ± 0.1[a]
Ether extreat	4.2 ± 0.2[a]	3.0 ± 0.0[a]	1.4 ± 0.0[a]
Crude fibre	27.2 ± 0.1[a]	22.4 ± 0.1[a]	17.7 ± 0.1[b]
Ash	10.7 ± 0.1[a]	12.6 ± 0.1[a]	14.8 ± 0.2[a]
Crude Protein	17.5 ± 0.1[a]	18.0 ± 0.3[a]	19.1 ± 0.3[a]
Dry matter	90.0 ± 0.0[a]	89.4 ± 0.3[a]	88.3 ± 0.2[a]

* Rumen Ingesta

** 40% Rumen Ingesta + 60% Growers Mash

*** 100% Growers Mash

a means with different superscript in row are significantly different ($P<0.05$).

4.5 PARASITOLOGICAL EVALUATION

Coccidia oocysts 60 epg, 20epg and Oepg were observed from samples of RI, RIGM and GM respectively by simple flotation technique. An average of 20epg of Coccidia oocysts and 20epg of Taenia eggs (oncospheres) was observed from the faecal samples examined by simple flotation. An average of 140epg of strongyles was observed from the sample of rumen ingesta. Some Paramphistomum (15), were picked out from the RI samples. Some coccidia oocysts and Taenia oncospheres were observed from faecal samples and samples of RI, RIGM and GM by the sedimentation and modified Beerman's methods. Scrappings from the small intestines were negative for coccidia oocysts while some oocysts were recovered from the caecum.

4.6 MICROBIOLOGICAL EVALUATION

Rough, flat colonies of Gram negative rods resulted from RI, RIGM, and GM samples as well as samples from the small intestine, caecum, lungs, liver and bile inoculated in selenite broth and nutrient broth subcultured on to Mac Conkey agar.

Biochemical tests on the isolates from both selenite broth and nutrient broth revealed fermenters from the oxidative/fermentative test and Acid TSI slant, Acid and gas TSI butt from the Tripple sugar iron agar test.

The isolates were positive for the following tests Methyl

red, citrate, urea, motility and Indole production. They were negative for the Vouges Prousker, Nitrate and Hydrogen sulphide tests.

The enteric organisims identified were Citrobacter diversus, Escherichia coli, and Enterobacter aerogenes.

4.7 NECROPSY

The dead rabbits appeared cachectic and there were no external gross abnormalities or lesions encountered at post mortem examination of the carcasses. The liver of three rabbits was pale. Most of the rabbits that died went off feed before death. There was no sign of enteritis, but four of the rabbits had caeca distended with blood.

4.8 CARCASS CHARACTERISTICS

Table 3 shows the carcass characteristics of slaughtered rabbits from two feeding regimes. The carcasses of the slaughtered rabbits averaged 1153.0± 29.0g and 1441.0 ± 74.1g for RIGM and GM respectively. The values of the percentage dressed weight which represent the main body parts for human consumption for the two feeding regimes were 68.0% (RIGM) and 69.8% (GM). The mean length of the GIT was 269.7cm (RIGM) and 350.2cm (GM).

Feeding regime significantly influenced relative organ weight (Table 4). Gastro intestinal tract (GIT) and its content comprised 16.7% (RIGM) and 19.6% (GM) of the body weight. The head, skin and feet contributed about 15.2%, 14.3% and 3.3% respectively in group B and 13.6%, 13.3% and 3.3% respectively in group C, of the live weight (Table 4).

Table 3: Carcass weight of two groups of rabbits on two feeding regimes: 40% Rumen ingesta + 60% Growers mash (RIGM) and 100% Growers mash (GM) for 49 days

Item	RIGM	GM
Mean live weight (g)	1153.0 ± 29.0	1441.0 ± 74.1
Mean dressed weight (g)	784.7 ± 17.1	1005.3 ± 47.7
Mean dressing %	68.0 ± 0.7	69.8 ± 0.5
Mean dressed weight of parts (g)		
Head	175.0 ± 4.6	195.7 ± 5.5
Skin	165.3 ± 6.8	177.3 ± 8.7
Legs	38.3 ± 4.2	48.0 ± 13.1
Shoulders	118.3 ± 2.5	145.3 ± 8.3
Backs	108.0 ± 3.0	135.7 ± 5.9
Loin	127.7 ± 2.5	151.7 ± 4.2
Thighs	198.0 ± 2.7	236.7 ± 7.6
Heart	4.0 ± 0.0	5.2 ± 1.3
Liver	17.7 ± 2.5	24.3 ± 4.7
Kidneys	6.7 ± 1.5	13.7 ± 0.6
Lungs	4.0 ± 0.5	8.2 ± 1.0
GIT	193.0 ± 7.0	282.3 ± 16.6
(Stomach)	65.3 ± 8.1	99.3 ± 16.0
Mean length of GIT (cm):		
Oesophagus	11.0 ± 2.0	17.3 ± 2.9
Stomach	5.5 ± 1.5	9.7 ± 1.9
Duodenum	32.8 ± 3.8	48.0 ± 9.6
Jejunum	107.3 ± 12.1	135.3 ± 7.2
Ileum	14.0 ± 2.0	19.2 ± 2.4
Caecum	23.3 ± 2.3	31.7 ± 2.5
Colon	68.0 ± 5.3	78.3 ± 5.5
Rectum	7.7 ± 1.0	10.7 ± 1.5

Table 4: Cuts, parts and organs as % Dressed weight and % Live weight of rabbits on two feeding regimes: 40% Rumen ingesta + 60% Growers mash (RIGM) and 100% Growers mash (GM).

Cut/Part/ Organ	$\bar{X}$ and SD of Dressed weight		% Dressed weight		% Live weight	
	RIGM	GM	RIGM	GM	RIGM	GM
Cuts:						
Shoulder	118.3 ± 2.5	145.3± 2.5	15.1	14.5	10.3	10.1
Backs	108.0 ± 3.0	135.7± 5.9	13.8	13.5	9.4	9.4
Loin	127.7 ± 2.5	151.7± 4.2	16.3	15.1	11.1	10.5
Thighs	198.0 ± 2.7	236.7± 7.6	25.2	23.5	17.2	16.4
Parts:						
Head	175.0 ± 4.6	195.7± 5.5	22.3	19.5	15.2	13.6
Skin	165.3 ± 6.8	177.3± 8.7	21.1	17.6	14.3	12.3
Legs	38.3 ± 4.2	48.0±13.1	4.9	4.8	3.3	3.3
Organs:						
Heart	4.4 ± 0.0	5.2± 1.3	0.5	0.5	0.4	0.4
Liver	17.7 ± 2.5	24.3± 4.7	2.3	2.4	1.5	1.7
Kidneys	6.7 ± 1.5	13.7± 0.6	0.9	1.4	0.6	1.0
Lungs	4.0 ± 0.5	8.2± 1.0	0.5	0.8	0.4	0.6
GIT	193.0 ± 7.0	282.3± 16.6	24.6	28.1	16.7	19.6
(Stomach)	65.3 ± 8.1	99.3± 16.0	8.3	9.9	5.7	6.9

4.9 CARCASS QUALITY

The effects of the two feeding regimes on the protein, water and fat contents of rabbit meat are presented in Tables 5. Proximate analysis values of fat, protein and water for the meat from the two feeding regimes varied slightly. Applying Student's t-test on the proximate analysis values, there was no significant difference between the meat from the two groups of rabbits for each of fat, protein and water contents (Table 5).

There were no significant differences in the fat, protein and water contents of the various cuts (shoulder, back, loin and thigh) from the two groups (Table 5).

Table 5: **Means and Standard deviation of the chemical composition of rabbit meat from two feeding regimes.**

Factor (%)	Feeding regime	Whole meat	Standard Cuts			
			Shoulder	Back	Lion	Thigh
Fat	RIGM[a]	7.7	7.7±0.1	7.7±0.1	7.6±0.0	7.7±0.1
	GM[b]	8.8	7.8±0.0	8.2±0.0	7.9±0.0	8.0±0.0
Protein	RIGM	19.8	19.8±0.0	19.7±0.1	19.8±0.0	19.7±0.1
	GM	20.4	20.7±0.1	21.0±0.0	20.0±0.1	20.0±0.1
Water	RIGM	72.1	72.0±0.0	71.9±0.1	72.1±0.3	72.5±0.2
	GM	70.5	70.5±0.7	69.8±0.4	71.8±0.0	70.0±0.0

a = Meat from rabbits fed 40% Rumen ingesta + 60% Growers mash
b = Meat from rabbits fed Growers mash

Table 6: **Mean values of sensory scores and physical measurements of four cuts of rabbit meat from two feeding regimes.**

Factors	Shoulder		Backs		Loin		Thigh	
	RIGN[b]	GN[c]	RIGN	GN	RIGN	GN	RIGN	GN
Sensory Score [a]								
Colour	*7.3±1.2	8.2±1.1	7.5±1.2	7.9±1.3	6.3±1.2	7.0±2.1	7.9±1.4	8.8±0.9
	**6.9±1.3	7.9±1.3	6.9±1.5	7.5±1.2	6.0±1.1	7.0±1.2	7.3±1.4	7.9±1.3
Taste	*7.5±1.3	8.4±1.3	7.3±1.2	7.3±1.2	7.8±1.4	5.9±1.1	7.1±1.6	8.3±1.2
	**6.4±1.7	7.1±1.4	6.3±1.6	6.8±1.6	5.4±1.5	6.5±1.5	5.8±1.6	6.5±1.2
Juiciness	*7.5±1.2	8.1±1.5	6.8±1.5	7.4±1.9	6.3±1.2	6.8±1.1	7.1±1.4	8.2±1.2
	**6.8±1.3	7.3±1.5	6.1±1.4	6.7±1.4	6.3±1.4	6.3±1.6	7.1±1.2	7.0±1.4
Flavour	*7.0±1.5	8.0±1.1	6.8±1.4	7.7±1.5	6.5±1.3	6.7±2.0	7.1±1.6	8.2±1.3
	**6.6±1.2	7.5±1.4	6.2±1.2	6.9±1.5	5.9±1.5	6.2±1.8	6.2±1.4	7.0±1.4
Tenderness	*7.2±1.3	8.0±1.1	6.5±1.8	7.4±1.7	6.0±1.6	6.8±1.9	7.4±1.4	8.3±1.4
	**6.7±1.3	7.1±1.6	6.4±1.1	6.9±1.3	5.6±1.2	6.3±1.7	6.3±1.1	7.2±1.0
Chewiness	*6.9±1.5	7.7±1.5	6.0±1.2	8.0±1.5	6.5±1.5	7.2±1.8	6.9±1.7	8.3±1.1
	**6.4±1.2	7.0±1.1	6.4±1.4	7.0±1.5	6.2±1.4	6.2±1.5	6.1±1.4	7.6±1.1
Overall	*7.9±1.4	8.4±1.2	7.0±1.4	7.8±1.4	6.0±1.6	7.1±1.8	7.3±1.4	8.0±1.0
Acceptability	**6.7±1.6	7.7±1.2	6.3±1.3	6.9±1.5	6.4±1.3	6.9±1.4	6.8±1.2	7.3±1.4
Physical Measurements:								
Cooking Loss %	26.7	28.7	18.3	16.0	36.0	33.3	56.3	43.3
% Weight	29.1	24.6	20.4	13.4	39.3	28.1	39.7	22.4
Weight	91.7±6.8	116.7±11.9	89.7±1.2	119.7±7.8	91.7±9.5	118.3±8.5	141.7±5.5	193.3±3.8

a = Based on a ten point scale with 10 as the highest score.
b = Meat from rabbits fed 40% Rumen ingesta + 60% Growers Mash.
c = Meat from rabbits fed Growers Mash.
* = Cooked with salt.
** = Cooked without salt.

4.10 SENSORY EVALUATION

The mean values of sensory scores are presented in Table 6.

The thigh and loin lost more weight during cooking, 56.3g and 36.0g respectively for RIGM and 43.3g, 33.3g respectively for GM than did the shoulders and backs, 26.7g and 18.3g respectively for RIGM and 28.7g and 16.0g respectively for GM. Raw weights of the 4 cuts of carcass of rabbits fed on GM were significantly higher. (Table 6). When expressed as a percentage of raw weights, the backs lost the lowest proportion of their weight, an average of 13.4% and 20.4% for GM and RIGM respectively.

The mean values of sensory scores for meat cooked with salt were 7.8±1.6 (GM) and 6.9±1.5 (RIGM) while the mean score values for meat cooked without salt were 7.0±1.5 (GM) and 6.4±1.4 (RIGM).There was no significant difference between the mean values of sensory scores for meat from RIGM and GM.

Table 7 shows the mean score values for the various cuts cooked with and without salt. The values were comparatively higher in cuts cooked with salt and also in favour of GM.

Meat from the two feeding regimes were compared with respect to the sensory properties and the results were presented in Table 8. The mean score for each of taste, flavour and tenderness was 6.9 (very fair) while that of chewiness and juiciness were 7.0 (moderately full and moderately juicy respectively).

The colour of meat from rabbits fed growers mash and cooked with salt (GMS), differed significantly from GMS^{-}, RIGMS and $RIGMS^{-}$ ($P<0.05$).

Table 7: **Mean values of overall sensory scores for various cuts of rabbit meat from two feeding regimes cooked with salt and without salt.**

	Type of feeding			
	Cooked with salt		Cooked without salt	
	RIGM	GM	RIGM	GM
Shoulders	7.3±1.4	8.1±1.3	6.6±1.4	7.4±1.4
Backs	6.9±1.4	7.7±1.5	6.4±1.4	6.9±1.4
Loin	6.2±1.4	7.0±1.9	6.0±1.4	6.5±1.6
Thighs	7.2±1.5	8.3±1.2	6.5±1.4	7.2±1.3

Table 8: Comparisons of sensory scores of cooked meat from rabbits fed RIGM and GM.

Feeding Comparisons	Colour	Taste	Juici-ness	Flavour	Tender-ness	Chewi-ness	Overall Accept-abiliy.
Score mean	7.4	6.9	7.0	6.9	6.9	7.0	7.2
MSE[a]	1.7	2.0	2.1	2.1	1.9	2.0	2.0
LSD[b]	0.3	0.3	0.4	0.4	0.3	0.3	0.3
GMS vs GMS$^-$	+	+	+	+	+	+	+
GMS vs RIGMS	+	+	+	+	+	+	+
GMS vs RIGMS$^-$	+	+	+	+	+	+	+
GMS$^-$ vs GMS	+	+	+	+	+	+	+
GMS$^-$ vs RIGMS	+	-	-	-	-	-	-
GMS$^-$ vs RIGMS$^-$	+	+	+	+	+	+	+
RIGMS vs GMS	+	+	-	+	+	+	+
RIGMS vs GMS$^-$	+	-	-	-	-	-	-
RIGMS vs RIGMS$^-$	+	+	+	+	+	+	+
RIGMS$^-$ vs GMS	+	+	+	+	+	+	+
RIGMS$^-$ vs GMS$^-$	+	+	-	+	+	+	+
RIGMS$^-$ vs RIGMS	+	+	+	+	+	+	+

a = Mean standard error
b = Least significant difference
+ = Significant at the 0.05 level
- = Not significant at the 0.05 level
Degree of Freedom (DF) = 493.
GMS = Meat from rabbits fed growers mash cooked with salt.
GMS$^-$ = Meat from rabbits fed growers mash cooked without salt.
RIGMS = Meat from rabbits fed 40% rumen ingesta + 60% growers mash cooked with salt.
RIGMS$^-$= Meat from rabbits fed 40% rumen ingesta + 60% growers mash cooked without salt.

CHAPTER FIVE

DISCUSSION

5.1 FEED CONSUMPTION AND WEIGHT GAIN

The results showed that 40% level of inclusion of rumen ingesta to growers mash was quite acceptable.

The average feed intake of 65.6g/d (RIGM) was similar to the 67.0g daily intake for rabbits fed cowpea haulm diets (Aduku et al, 1986b). These workers also reported daily intakes of 48.7g and 78.2g for rabbits fed wheat bran and peanut haulm diets respectively. The daily feed intakes of 65.6g/day also agreed with 66g/day for sewage sludge and poultry waste respectively fed to rabbits by Ekpenyong and Biobaku (1986). The daily feed intake was however lower than 79± 12g daily intake reported by Aduku et al (1989) for maize consumption and 102g/day on perennial peanut diet (Gomez de Varela et al, 1983), and higher than the level of 56.9g/day reported by Evans et al (1983), on oat diets. Feed consumption was significantly higher ($P<0.05$) with GM than RIGM. Since RIGM was higher in crude fibre (22.4%), the rabbits were expected to consume more RIGM to compensate for their energy requirements (Schlolaut, 1987). In this study, the rabbits consumed more growers mash probably because it was more palatable.

The weight gain for GM (16.7g/day) was higher than the 12g/day reported by Ekpenyong (1984), with weanling rabbits

fed broiler starter mash and 9.5g/day for growers mash for 28 days at Ibadan. The weight gain of 10.6g/day for RIGM was therefore encouraging in the light of the 12g/day reported above. These values are lower than 19.3g/day, 18.6g/day and 18.1g/day on peanut, sunflower and palm kernel meal diets respectively, reported by Aduku et al (1988). The daily weight gain of 10.6g/day (RIGM) compared favourably with results obtained by Ekpenyong and Biobaku (1986) for sewage sludge (10.49g/day) and poultry waste (11.20g/day).

Comparatively lower values of weight gain were obtained in this study because the diets were not pelleted. According to Harris et al (1983), weight gain of rabbits on pelleted feeds (44g/day) is significantly better than weight gain of those on unpelleted feed (29.3g/day). Weight gain towards the end of the experiment (Weeks 6 and 7) was higher for RIGM (20.5g) than GM (7.9g). This may indicate that RIGM may result in higher weight gain in older rabbits.

The efficiency of feed conversion (EFC) was found to be 6.2 for RIGM and 5.4 for GM. EFC is indicative of the economic level of the feed. It would therefore seem that RIGM is more economical than GM. It will no doubt cost less to produce 1kg of dried rumen ingesta diet than GM or pelleted feed for rabbits. It is possible that the higher EFC of RIGM may be attributed to some growth factors such as vitamin B_{12} (Schendel and Johnson, 1954; Trakulchang and Balloun, 1975). The supplementation of rabbit diets with

rumen contents may have some additional benefits, such as the enrichment of such diets with B-vitamins but according to Jovanovic and Cuperlovic (1977), such aspects are not yet sufficiently investigated. Although RIGM had higher level of fibre (22.4%) than GM (17.7%), this high level of fibre did not cause significant decrease in weight gain. This is probably because coprophagy allows recycling of cecotrophs for further digestion of fibre and contributed bacterial protein to the animals. This is further supported by Barnes et al (1963) who found that coprophagy contributes 12-25% to growth rate of rabbits and by Harris et al (1983) who found that weight gain was the same for rabbits on diets which were high or low in crude fibre. The biological value to rats, of rumen microbial proteins was found to be relatively high (Bergen et al, 1968). The possible explanation for the poorer utilization of RIGM may be due to a high level of crude fibre in rumen contents.

The fact that no mortality was recorded in feeding RIGM and also that the resultant weight gain compared favourably with that of GM shows that rumen ingesta used at 40% level of inclusion met the growth requirements of the rabbits. Rumen ingesta may therefore be used as feed supplement in rabbit diets thereby eliminating the need for costly protein supplements.

5.2 PROXIMATE COMPOSITION OF THE FEEDS

Rumen ingesta with high crude fibre (27.2%), crude protein (17.5%) and fat (4.2%) was successfully incorporated into

poultry growers mash ration and fed to weaned rabbits at the level of 40% incorporation. The resultant diet (RIGM) which contained crude fibre (22.4%), crude protein (18.0%) and fat (3.0%) was readily consumed by the rabbits. The composition of the rumen ingesta used in this study differed from that of the rumen contents used by Jovanovic and Cuperlovic (1977) which was composed of 30.3% crude fibre, 21.8% crude protein, 6.1% fat and 11.5% ash. The levels of protein and ether extract of RIGM did not differ significantly from the levels in GM.

The crude fibre level of 22.4% (RIGM) is considered high. In rabbits, crude fibre beyond 20% may cause caecal impaction (Cheeke, 1983). However, dietary fibre is useful in preventing enteritis and fur chewing (Cheeke, 1983). Cases of caecal impaction were not observed in this study. Fibre is also indispensable for the adequate filling of the digestive tract and maintenance of normal peristaltic conditions. The crude fibre level of RIGM was higher than that of wheat bran (10.8%) and close to the 30% level of sun dried alfalfa (Harris et al, 1983). Peanut and cowpea haulms, 23.82% and 20.8% respectively have been successfully fed to rabbits as supplements (Aduku et al, 1986). The level of crude fibre in RI was lower than 30 - 40% determined by Antogniovanni et al (1973) and 30.3% determined by Jovanovic and Cuperlovic (1977).

The high level of crude protein content of the rumen ingesta (17.5%) may be due to a high dietary crude protein content

(Jansen et al, 1977). The level of crude protein recommended for growing rabbits is 16% (NRC, 1977).
A rabbit, by the role of its caecum and practice of cecotropy is capable of utilizing dietary crude protein efficiently (Robinson et al, 1981). Protein requirements of rabbits are 15-16% for growth (Lebas, 1980; Lang, 1981; Harris et al, 1982; Omole, 1982). The 18% crude protein level of RIGM in this study agrees with the level of 18.08% used by Martina and Damian (1983), who found that crude protein could be decreased to 16.32% without affecting weight gain.

The low fat level (3.0%) of RIGM may have increased the palatability of the diet in accordance with the observation of Finzi and Verita (1976), that low fat levels increase palatability but higher levels may reduce it. The level of fat in RI (4.2%) was lower than the value of 6.1% determined by Jovanovic and Cuperlovic (1977) but was within the range of between 2 and 6% determined by Antongiovanni et al (1973).

It seems logical that all the differences between the levels of crude fibre, crude protein and fat for the rumen ingesta used for this study and levels reported by others may be dependent on the quality of feed consumed by the cattle before slaughter. The dry matter of RIGM was 89.4% indicating a low moisture content. This is an advantage in terms of the keeping quality.

5.3 NECROPSY, PARASITOLOGY AND MICROBIOLOGY

Investigation into the cause of death of all the rabbits

that consumed 100% rumen ingesta did not implicate any protozoan parasite such as coccidia. There was no enteritis as would have been expected especially since the rabbits were weaned shortly before the experiment. The rabbits however looked cachectic before death as they lost weight and even went off feed. From the faecal samples examined, only few coccidia cocysts, paramphistomum and taenia eggs were recovered. Taenia eggs (oncospheres) are fairly resistant to adverse conditions and the rabbit is an intermediate host of the tapeworm of dogs. The predominant bacteria recovered both aerobically and anaerobically were Escherichia coli (E. coli), Aerobacter aerogenes and Citrobacter diversus, isolated from visceral organs of the dead rabbits and also from the feed sample. Jawetz et al (1989) reported that Citrobacter and many of the other enteric bacteria are members of the normal intestinal flora. E. coli has often been observed in outbreaks of enteritis in rabbits and is usually considered as being a secondary condition (Weisbroth et al, 1974). Citrobacter diversus, the most prominent bacteria isolated may not have caused the death of the rabbits since it is not strictly pathogenic. It is, however, noted that Citrobacter may become pathogenic only when they reach tissues outside the intestinal tract causing inflammation at these sites (Jawetz et al, 1989). Citrobacter diversus may have therefore contributed to the rabbits' inappetence before death.

Enteritis was not observed, perhaps, because rumen ingesta

contained no grains but high fibre. According to Cheeke and Patton (1978), diets high in grain and low in fibre promote an increased incidence of enteritis. Citrobacter may have tended to overgrow other bacteria. It appears that the death of the rabbits was not caused by the bacteria isoloated. With little evidence of coccidiosis and helminthiasis no evidence of enteritis, starvation may have been the cause of death.

5.4 CARCASS CHARACTERISTICS AND QUALITY:

The average slaughter weights of the rabbits used in this study: 1153.0g and 1441.0g for RIGM and GM respectively were lower than 2129g reported by Chen et al (1978) for New Zealand white (NZW) rabbits fed on pelleted feed and slaughtered at 12 weeks. Templeton (1968), reported that an average fryer weight of 1.5 - 2.0g had carcass yield of 56.3%. The average slaughter weight for the rabbits in this study at 12 weeks of age was higher than 1061.6 ± 37.3g reported by Taylor et al (1989) but lower than 2120g reported by Ghodrati and Coppings (1988), for 9 week old NZW rabbits and similar reports by Chen et al (1978); Holmes et al (1984); Rao et al (1977, 1978, 1979).

5.4.1 Dressing Percentage:

The dressing percentage in this study: 68.0% (RIGM) and 69.8% (GM) was higher than those reported by the following workers: Rao et al (1978) (45.6% - 50.3%), Templeton (1968) (56.3%), Hinner (1962) (50.7% - 58.5%) and USDA (1973)

(56%). Several factors affect dressing percentage. It has been reported that low dressing percentage may result if feed was not removed prior to slaughter (Coppings et al (1988). In this study, the rabbits were skinned and both the head and legs were not left on the carcass yet the dressing percentage was high.

Together, the thigh and loin added up to 41.5% (GM) and 38.6% (RIGM) of the dressed carcass. These values are lower than the values of 57.6%, 51.0 - 57.3% and 57.6% reported by Makayawo and Coppings (1985), Rao et al (1978) and Taylor et al (1989) respectively. The least weight was recorded for the back (13.8%, RIGM; 13.5%, GM). This was not un-expected since few major muscle groups are associated with the rib cage. This observation agrees with Makayawo and Coppings (1985) as well as the observation that the light frail nature of the shoulders may have contributed to the equally low weight of the shoulders, next to the backs.

Feeding regime significantly influenced relative organ weights. Total values for the liver, kidneys and heart (3.7% RIGM and 4.3% GM) were close to results obtained by Khafagi (1971), 4.24 - 4.33%. Gauss et al (1977) reported that dressed carcass weight had no significant effect on the proportion of retail cuts and quality of meat. Carcass yield is a major variable in determining the profitability of meat processing operations.

5.4.2 Cooking Loss:

The thigh and loin lost more weight during cooking than did the shoulders and backs for both feeding systems. This does not completely agree with the report of Taylor et al (1989), that the hindlegs and racks lost more weight during cooking (42.6g and 40.8g respectively) than did the loin and forelegs (34.9g and 13.7g respectively). Considering the thickness of the thigh, the cooking loss recorded for the thigh in this study was not expected since the majority of cooking loss is evaporative water loss in the rabbit (Paul, 1964) and the thigh being the largest and thickest cut, would have less surface area per unit weight for water loss to take place. Coppings and Ekhator (1990), observed that the difference in cooking loss between the loin and hindlegs was probably because the hind legs are larger and thicker cuts of the rabbit carcass. It may however be speculated that the cooking end point temperature utilized in this study was too high, resulting in increased cooking loss. Holmes et al (1984) used microwaves to cook the rabbit thigh meat and in their study, lower cooking temperature resulted in lower cooking loss.

Total cooking loss in this study was affected by feeding regime and losses were higher ($P<0.05$) for RIGM. This may be due to the higher moisture content of RIGM meat (72.1) than that of GM meat (70.5). This result agrees with the observations of McCurdy et al (1981), Kropf et al (1975) and Foster et al (1979), that feeding regime affected

cooking loss. Researchers have reported higher cooking losses from higher energy feeding regimes (Malphrus et al, 1962) and no relation between level of nutrition and total cooking loss (Jacobson and Fenton, 1956; Meyer et al, 1960).

5.4.3. Carcass Quality

The protein, fat and water content of meat from the two feeding regimes (19.8%, RIGM; 20.4% GM), (7.7%, RIGM; 8.0%, GM) and (72.1%, RIGM; 70.5%, GM) respectively, compare favourably with protein (18.6 - 19.4%), fat (7.9 - 10.9%) and water (68.5 - 72.0%) obtained by Rao et al (1978). The value for water was higher than 67.9% reported by USDA (1973) but agreed with 72.8% reported by Whiting and Jenkins (1978). Water value has been reported to decrease with age (Rao et al, 1978). While the fat value was higher than the value of 4g/100g reported by Aduku and Olukosi (1990), the protein value was comparable to 22g/100g reported by the same workers.

According to Rao et al (1978), protein quality of rabbit meat is not influenced by age while the fat content increased with age. Information on carcass quality and composition of rabbit meat is limited in contrast to that available for other meats (Ziegler, 1968). The protein value, 19.8% (RIGM) compares favourably with 20.0% reported in USDA (1963) for chicken and is higher than the values for veal (18.8%), beaf (16.3%) and pork (11.9%). The value for fat (7.7%, RIGM) is indeed very much lower than the values

reported for various meats: chicken (11.0%), veal (14.0%), beef (28.0%) and pork (45.0%). Meat from rabbits fed on rumen ingesta as supplemental feed may be said therefore to have very good nutritional value, being comparatively high in protein and low in fat. This assumption agreed with the observation of Sunki et al (1978).

5.5 SENSORY EVALUATION

Sensory analysis results portray rabbit meat from this feeding regime as acceptable.

The fact that the highest score for meat from either feeding regime was recorded for the thigh established the thigh as a 'choice cut' in line with the observations of Gauss et al (1977) that the thigh and loin are the so called "high priced" cuts of rabbit carcass.

All the sensory properties were scored during each session. Theoretically, it is preferable to score only one property at any tasting session but several of these properties are so closely interrelated that it is often necessary to estimate them at the same time. Beynen et al (1989), observed that a pinkish rather than intensely red carcass obtained high scores. A score of 7.4 (moderately attractive) in this study for colour is considered high. The meat was pinkish and the surface was not browned as is usually observed when cooking with wood fire. Colour and other aspects of appearance influence food appreciation and quality especially by the consumer (Amerine et al 1965).

Flavour and juiciness may have been affected by cooking procedure as observed by Mc Curdy et al (1981), that low temperature reduces flavour and juiciness. The entire sensory measurements may have been affected by other factors such as individual differences among the judges in perception and intelligence. This is particularly supported by Tyler (1956), who distinguished between objective and subjective judges, active and passive judges and also, confident and cautious judges.

CHAPTER SIX
CONCLUSION

From this study, it is shown that rabbits cannot survive on feed compounded solely with rumen ingesta. At 40% substitution however, reasonable growth rate (0.82) and weight gain (10.6g/day), comparable with those achieved by feeding 100% growers mash (growth rate = 1.30; weight gain = 16.7g/day) were recorded. It was not possible to relate the 100% mortality recorded for the rabbits that consumed RI to any specific cause such as bacteria.

The meat resulting from the two feeding regimes showed no significant difference with regard to the proximate factors (protein, fat and water). Feeding regime had significant influence on relative organ weights. Total cooking loss for the carcass was affected by feeding regime and losses were higher ($P<0.05$) for RIGM. Sensory panelists were able to differentiate between meat from rabbits fed RIGM and meat from rabbits fed GM for the sensory properties of colour, taste, juiciness, flavour, tenderness and chewiness. These differences were, however, not significant and meat from the two feeding regimes scored well in overall acceptability. Meat resulting from feeding RIGM is acceptable for human consumption.

As shown by these results, rumen ingesta can be incorporated into rabbit feed at 40% incorporation with resultant weight gain. Rabbit keepers may now be encouraged to collect rumen ingesta from the abattoirs and slaughter houses thus

ridding the premises of heaps of rumen ingesta. This achieves disposal efforts and improves on the environmental sanitation aspect of waste management. Because of the vast quantities of rumen ingesta which are produced and mostly discarded at slaughter houses and abattoirs, their efficient utilization in rabbit feeding could have an important economic effect. This by-product may even be given a monetary value and may supply more proteins for rabbit feeding. The encouragement of Nigerians to produce and consume rabbit meat will no doubt be one of the ways of solving the inadequate per capita consumption of animal protein in Nigeria. Feeding rabbits with rumen ingesta at 40% incorporation with poultry growers mash will be an economical way of achieving the above objective. For the determination of the optimum level of incorporation and the economical implications, further investigations involving feeding trials with weaned rabbits are needed.

Appendix 1: METEOROLOGICAL DATA FOR KADUNA, 1991

MONTH	MEAN MAX ^{o}C	MEAN MIN ^{o}C	TOTAL RAIN(mm)	MEAN RELETIVE HUMIDITY	MEAN EVAPORATION (mm)	MEAN WIND RUN (KM/DAY)
JANUARY	31.6	16.5	0.0	24.0	13.8	159.72
FEBRUARY	35.9	20.0	0.0	29.0	11.7	59.97
MARCH	36.0	22.0	3.6	32.0	13.4	62.55
APRIL	34.9	23.5	32.0	60.0	8.1	-
MAY	31.0	21.9	222.5	74.0	3.6	146.26
JUNE	30.8	21.2	226.4	79.0	3.5	159.67
JULY	28.4	20.6	185.8	83.0	2.8	153.10
AUGUST	27.9	20.3	548.8	87.0	2.1	134.44
SEPTEMBER	31.1	20.4	130.5	81.0	2.9	126.36
OCTOBER	32.0	19.9	61.8	75.0	3.9	106.32
NOVEMBER	33.0	15.9	0.0	43.0	10.8	174.50
DECEMBER	30.3	14.9	0.0	37.0	11.8	237.41

Source: Form met. 143/3. Department of Meteorological Services, Kaduna.

Appendix 2: INITIAL AND WEEKLY WEIGHTS OF THREE GROUPS OF RABBITS.

GROUP	RABBIT NO	INITIAL WEIGHT(g)	WEEKLY WEIGHT (g) WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7
A	1*	628	675	685	**				
	2	630	660	**					
	3	630	700	750	**				
	4*	626	624	620	**				
	5	627	620	600	**				
	6	630	635	625	**				
	7	620	600	596	**				
	8*	635	640	647	**				
	9	620	615	**					
	10	626	624	626	**				
B	11*	630	673	728	791	866	950	1023	1124
	12	632	682	740	823	905	999	1086	1182
	13	629	690	763	850	941	987	1060	1158
	14	633	696	747	820	895	978	1074	1175
	15	628	681	713	776	860	958	1049	1154
	16*	630	686	745	806	886	977	1060	1154
	17	632	687	728	781	850	930	1021	1144
	18	634	691	763	842	894	981	1039	1132
	19	634	697	763	838	913	999	1053	1154
	20*	629	684	743	811	883	956	1041	1131
C	21	625	707	807	900	1020	1145	1273	1408
	22*	636	726	771	891	1016	1144	1275	1414
	23*	630	715	775	870	979	1094	1219	1362
	24	628	711	801	926	1056	1177	1306	1437
	25	626	691	781	886	1011	1149	1286	1434
	26	625	695	795	899	1030	1168	1309	1452
	27*	634	719	819	934	1062	1192	1324	1460
	28*	628	698	796	916	1056	1188	1326	1469
	29	630	730	850	985	1121	1261	1379	1509
	30	629	740	836	964	1084	1217	1355	1498

* = Female ** = Dead

Appendix 3: DAILY FEED CONSUMPTION DATA OF RABBITS FED 100% RUMEN INGESTA (RI)

DATE	FEEDING	RABBIT NO.									
		1	2	3	4	5	6	7	8	9	10
WEEK 1											
22/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	un-consumed (g)	85	75	70	80	80	65	70	80	75	75
	Consumed	15	25	30	20	20	35	30	20	25	25
23/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	83	96	75	70	91	82	82	70	85	70
	Consumed (g)	17	4	25	30	9	18	18	30	15	30
24/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	86	92	75	75	81	84	80	75	92	81
	Consumed (g)	14	8	25	25	19	16	20	25	8	19
25/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	72	78	62	33	80	75	65	68	60	50
	Consumed (g)	28	22	38	67	20	25	35	32	40	50
26/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	60	73	55	76	70	60	64	60	80	60
	Consumed (g)	40	27	45	34	30	40	36	40	20	40
27/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	28	33	60	40	30	25	35	40	30	30
	Consumed (g)	72	67	40	60	70	75	65	60	70	70
28/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	80	50	70	60	65	75	45	60	65	80
	Consumed (g)	20	50	30	40	35	25	55	40	35	20

DATE	FEEDING	RABBIT NO.									
		1	2	3	4	5	6	7	8	9	10
WEEK 2											
29/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	16	54	80	70	70	75	75	70	80	80
	Consumed (g)	84	46	20	30	30	25	25	30	20	20
30/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	60	100	50	30	40	45	65	50	35	40
	Consumed (g)	40	0	50	70	60	55	35	50	65	60
1/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	70	100	60	40	30	40	50	35	38	54
	Consumed (g)	30	0	40	60	70	60	50	65	62	46
2/5/91	Given (g)	100	*	100	100	100	100	100	100	100	100
	Un-consumed (g)	40		55	70	50	50	38	35	45	56
	Consumed (g)	60		45	30	50	50	62	65	55	44
3/5/91	Given (g)	100		100	100	100	100	100	100	100	100
	Un-consumed (g)	80		50	20	20	38	36	40	70	65
	Consumed (g)	20		50	80	80	62	64	60	30	35
4/5/91	Given (g)	100		100	100	100	100	100	100	100	100
	Un-consumed (g)	8		62	26	40	60	42	12	100	25
	Consumed (g)	92		38	74	60	40	58	88	*	75
5/5/91	Given (g)	100		100	100	100	100	100	100		100
	Un-consumed (g)	88		40	60	35	70	100	30		40
	Consumed (g)	12		60	40	65	30	0	70		60

* = Died

DATE	FEEDING	RABBIT NO.							
		1	3	4	5	6	7	8	10
week 3									
6/5/91	Given (g)	100	100	100	100	100	*	100	100
	Un-consumed (g)	80	15	70	75	80		38	40
	Consumed (g)	20	85	30	25	20		62	60
7/5/91	Given (g)	100	100	100	100	100		100	100
	Un-consumed (g)	100	30	100	68	20		24	25
	Consumed (g)	*	70	*	32	80		76	75
8/5/91	Given (g)		100		100	100		100	100
	Un-consumed (g)		40		45	48		50	60
	Consumed (g)		60		55	52		50	40
9/5/91	Given (g)		100		100	100		100	100
	Un-consumed (g)		100		75	70		35	100
	Consumed (g)		0		25	30*		65	0
10/5/91	Given (g)		*		100			100	*
	Un-consumed (g)				80			40	
	Consumed (g)		20		60				
11/5/91	Given (g)				100			100	
	Un-consumed (g)				18			60	
	Consumed (g)				82*			40*	

Appendix 4: DAILY FEED CONSUMPTION DATA OF RABBITS FED 40% RUMEN INGESTA + 60% GROWERS MASH (RIGM).

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
WEEK 1											
22/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	78	83	68	65	74	43	48	39	75	38
	Consumed (g)	22	17	32	35	26	57	52	61	25	62
23/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	83	62	35	38	54	58	45	48	43	50
	Consumed (g)	17	38	65	62	46	42	55	52	57	50
24/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	54	38	42	45	43	39	38	43	42	42
	Consumed (g)	46	62	58	55	47	61	62	57	58	58
25/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	65	63	72	39	38	43	48	37	39	36
	Consumed (g)	35	37	28	61	62	57	52	63	61	64
26/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	39	45	48	56	68	37	36	35	39	32
	Consumed (g)	61	55	52	44	32	63	64	65	61	68
27/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	46	37	39	43	45	42	40	38	36	24
	Consumed (g)	54	63	61	57	55	58	60	62	64	76
28/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	45	70	75	36	38	42	39	36	34	36
	Consumed (g)	55	30	25	64	62	58	61	64	66	64

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
WEEK 2											
29/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	52	33	34	38	42	43	39	36	38	35
	Consumed (g)	48	67	66	62	58	57	61	64	62	65
30/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	45	24	28	31	33	42	48	26	25	28
	Consumed (g)	55	76	72	69	67	58	52	74	75	72
1/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	46	33	38	60	45	48	36	39	37	31
	Consumed (g)	54	67	62	40	55	52	64	61	63	69
2/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	37	23	35	28	29	31	34	34	38	32
	Consumed (g)	63	77	65	72	71	69	66	66	62	68
3/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	56	31	52	54	58	31	33	52	30	32
	Consumed (g)	44	69	48	46	42	69	67	48	70	68
4/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	54	50	58	46	52	40	43	48	42	40
	Consumed (g)	46	50	42	54	48	60	57	52	58	60
5/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	32	18	35	38	43	30	40	48	31	30
	Consumed (g)	68	82	65	62	57	70	60	52	69	70

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
WEEK 3											
6/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	38	35	23	28	45	48	23	25	28	29
	Consumed (g)	62	65	77	72	55	52	77	75	72	71
7/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	23	38	43	45	48	39	36	35	30	32
	Consumed (g)	77	62	57	55	52	61	64	65	70	68
8/5/92	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	38	48	45	52	50	58	53	48	45	49
	Consumed (g)	62	52	55	48	50	42	47	52	55	51
9/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	42	48	39	37	36	45	48	50	52	51
	Consumed (g)	58	52	61	63	64	55	52	50	48	49
10/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	53	26	23	25	36	56	43	40	52	41
	Consumed (g)	47	74	77	75	64	44	57	60	48	59
11/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	40	41	48	49	39	38	56	53	43	42
	Consumed (g)	60	59	52	51	61	62	44	47	57	58
12/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	38	58	60	53	48	45	40	31	30	33
	Consumed (g)	62	42	40	47	52	55	60	69	70	67

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
WEEK 4											
13/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	31	52	61	38	33	38	40	42	48	45
	Consumed (g)	69	48	39	62	67	62	60	58	52	55
14/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	43	49	52	58	53	53	52	49	48	41
	Consumed (g)	47	51	48	42	47	47	48	51	52	59
15/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	38	53	55	54	35	38	48	43	45	40
	Consumed (g)	62	47	45	46	65	62	52	57	55	60
16/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	35	37	31	32	42	45	48	43	41	31
	Consumed (g)	65	63	69	68	58	55	52	57	59	69
17/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	48	43	45	38	39	45	46	45	43	41
	Consumed (g)	52	57	55	62	61	55	54	55	57	59
18/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	23	25	38	33	26	29	31	30	20	23
	onsumed (g)	77	75	62	67	74	71	69	70	80	77
19/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	25	36	38	35	28	27	14	37	36	35
	Consumed (g)	75	64	62	65	72	77	86	63	64	65

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
WEEK 5:											
20/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	38	49	43	48	52	37	36	30	33	30
	Consumed (g)	62	51	57	52	48	63	64	70	67	70
21/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	35	43	47	39	36	38	23	29	26	31
	Consumed (g)	65	57	53	61	64	62	77	71	74	69
22/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	40	48	43	39	38	36	35	27	29	23
	Consumed (g)	60	52	57	61	62	64	65	73	71	77
23/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	26	29	20	23	15	19	27	28	32	30
	Consumed (g)	74	71	80	77	85	81	73	72	68	70
24/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	52	53	37	35	43	48	52	16	21	23
	Consumed (g)	48	47	63	65	57	52	48	84	79	77
25/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed	58	38	33	52	48	49	40	33	38	31
	Consumed (g)	42	62	67	48	52	51	60	67	62	69
26/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	29	23	28	27	26	42	53	32	20	28
	Consumed (g)	71	77	72	73	74	58	47	68	80	72

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
WEEK 6											
27/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	28	25	26	33	35	38	28	29	31	29
	Consumed (g)	72	75	74	67	65	62	72	71	69	71
28/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	27	31	35	28	23	25	29	32	31	30
	Consumed (g)	73	69	65	72	77	75	71	68	69	70
29/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	22	28	23	29	20	26	31	35	37	26
	Consumed (g)	78	72	77	71	80	74	69	65	63	74
30/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	25	23	30	25	36	29	28	23	25	24
	Consumed (g)	75	77	70	75	64	71	72	77	75	76
31/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	20	23	21	26	27	29	31	32	23	21
	Consumed (g)	80	77	79	74	73	71	69	68	77	79
1/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	23	21	26	32	21	20	38	25	24	23
	Consumed (g)	77	79	74	68	79	80	62	75	76	77
2/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	20	21	24	26	26	23	31	33	21	20
	Consumed (g)	80	79	76	74	74	77	69	67	79	80

DATE	FEEDING	RABBIT NO.									
		11	12	13	14	15	16	17	18	19	20
Week 7:											
3/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	19	27	28	23	19	26	25	18	21	20
	Consumed (g)	81	73	72	77	81	74	75	82	79	80
4/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	21	29	23	25	23	24	18	21	22	24
	Consumed (g)	79	71	77	75	77	76	82	79	78	76
5/691	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	19	18	24	20	21	25	24	19	21	22
	Consumed (g)	81	82	76	80	79	75	76	81	79	78
6/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	23	27	26	19	25	21	22	22	18	20
	Consumed (g)	77	77	74	81	75	79	78	78	82	80
7/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	21	19	21	23	19	20	22	18	21	21
	Consumed (g)	79	81	79	77	81	80	78	82	79	79
8/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	18	21	20	19	21	18	20	22	20	23
	Consumed (g)	82	79	80	81	79	82	80	78	80	77
9/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	19	22	21	18	19	18	21	23	24	20
	Consumed (g)	81	78	79	82	81	82	79	77	76	80

Appendix 5: DAILY FEED CONSUMPTION DATA OF RABBITS FED 100% GROWERS MASH (GM)

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK 1											
22/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	55	20	60	60	30	40	48	36	50	50
	Consumed (g)	45	80	40	40	70	60	52	64	50	50
23/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	44	44	15	25	24	20	40	15	35	30
	Consumed (g)	56	56	85	75	76	80	60	85	65	70
24/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	30	40	35	45	12	60	20	25	35	40
	Consumed (g)	70	60	65	55	88	40	80	75	65	60
25/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	50	20	15	14	12	30	45	12	20	25
	Consumed (g)	50	80	85	86	88	70	55	88	80	75
26/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	15	12	30	45	10	20	35	18	20
	Consumed (g)	90	85	88	70	55	90	80	65	82	80
27/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	8	20	15	25	15	18	12	40	25
	Consumed (g)	90	92	80	85	75	85	82	88	60	75
28/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	10	20	30	8	12	12	18	20	30
	Consumed (g)	88	90	80	70	92	88	88	82	80	70

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK 2:											
29/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	15	10	20	18	32	30	40	8	15	20
	Consumed (g)	85	90	80	82	68	70	60	92	85	80
30/4/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	8	15	8	12	40	16	20	20	24
	Consumed (g)	90	92	85	92	88	60	84	80	80	76
1/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	18	16	40	32	30	28	14	16	10	10
	Un-consumed (g)	82	84	60	68	70	72	86	84	90	90
2/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	8	10	8	12	40	16	20	22	18	15
	Consumed (g)	92	90	92	88	60	84	80	78	82	85
3/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	15	20	24	12	16	18	14	24	30
	Consumed (g)	90	85	80	76	88	84	82	86	76	70
4/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	6	18	15	20	12	10	25	24	18
	Consumed (g)	88	94	82	85	80	88	90	75	76	82
5/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	30	12	16	20	25	24	10	12	10	16
	Consumed (g)	70	88	84	80	75	76	90	88	90	84

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK 1											
6/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	8	16	20	14	30	41	9	16	23	25
	Consumed (g)	92	84	80	86	70	59	91	84	87	75
7/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	27	19	16	14	10	13	13	13	25	26
	Consumed (g)	73	81	84	86	90	87	87	87	75	74
8/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	15	17	14	15	27	8	14	17	34	20
	Consumed (g)	85	83	86	85	73	92	86	83	66	80
9/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	19	16	14	38	35	22	8	6	14	12
	Consumed (g)	81	84	86	62	65	78	92	94	86	88
10/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	17	8	6	32	24	12	16	12	10
	Consumed (g)	88	83	92	94	68	76	88	84	88	90
11/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	14	16	30	35	12	17	12	31	10	17
	Consumed (g)	86	84	70	65	88	83	88	69	90	83
12/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	12	14	16	11	11	10	25	25	31
	Consumed (g)	90	88	86	84	89	89	90	75	75	69

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK 4											
13/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	17	10	9	40	16	18	21	24	10
	Consumed (g)	88	83	90	91	60	84	82	79	76	90
14/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	17	13	10	8	21	18	17	11	10
	Consumed (g)	88	83	87	90	92	79	82	83	89	90
15/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	8	11	15	10	6	8	14	20	24	16
	Consumed (g)	92	89	85	90	94	92	86	80	76	84
16/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	12	13	11	17	25	8	16	14	10
	Consumed (g)	90	88	87	89	83	75	92	84	86	90
17/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	17	16	8	18	6	21	17	14	10	16
	Consumed (g)	83	84	92	82	94	79	83	86	90	84
18/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	16	19	21	22	25	31	16	14	17	21
	Consumed (g)	84	81	79	78	75	69	84	86	83	79
19/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	22	13	19	17	12	10	21	13	16	12
	Consumed (g)	78	87	81	83	88	90	79	87	84	88

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK5											
20/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	6	18	8	12	21	24	18	17	25	24
	Consumed (g)	94	82	92	88	79	76	82	83	75	76
21/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	21	10	12	12	32	16	18	12	14	12
	Consumed (g)	79	90	88	88	68	84	82	88	86	88
22/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	8	10	12	18	16	21	27	12	15
	Consumed (g)	88	92	90	88	82	84	79	83	88	85
23/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	6	8	10	30	14	16	21	24	18
	Consumed (g)	90	94	92	90	70	86	84	79	76	82
24/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	18	8	12	11	25	26	18	21	25	24
	Consumed (g)	82	92	88	89	75	74	82	79	75	76
25/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	8	16	8	7	18	15	17	21	12	18
	Consumed (g)	92	84	92	93	82	85	83	79	88	82
26/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	19	12	10	17	8	12	16	25	14	18
	Consumed (g)	81	88	90	83	92	88	84	75	86	82

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK 6:											
27/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	8	15	17	10	9	16	41	12	18	20
	Consumed (g)	92	85	83	90	91	84	59	88	82	80
28/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	12	12	16	8	9	10	14	12	17	12
	consumed (g)	88	88	84	92	91	90	86	88	83	88
29/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	10	10	15	11	17	21	16	17	21	16
	Consumed (g)	90	90	85	89	83	79	84	83	79	84
30/5/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	8	6	13	10	12	11	8	9	12	14
	Consumed (g)	91	94	87	90	88	89	92	91	88	86
1/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	7	15	5	17	18	8	13	7	5	16
	Consumed (g)	93	85	95	83	82	92	87	93	95	84
2/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	4	17	18	40	5	7	13	21	9	7
	Consumed (g)	96	83	82	60	95	93	87	79	91	93

DATE	FEEDING	RABBIT NO.									
		21	22	23	24	25	26	27	28	29	30
WEEK 7:											
3/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	0	6	18	7	15	13	9	18	3	6
	Consumed (g)	100	94	82	93	85	87	91	88	97	94
4/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	2	14	13	8	1	9	8	12	15	3
	Consumed (g)	98	86	87	92	99	91	92	88	85	97
5/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	5	12	10	13	5	15	5	3	2	7
	Consumed (g)	95	88	90	87	95	85	95	97	98	93
6/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	3	8	16	4	8	18	13	5	9	6
	Consumed (g)	97	92	84	86	92	82	87	95	91	94
7/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	2	13	18	0	15	9	6	0	5	4
	Consumed (g)	98	87	82	100	85	81	84	100	95	96
8/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	1	5	7	12	3	7	1	13	9	12
	Consumed (g)	99	95	93	88	97	93	99	87	91	88
9/6/91	Given (g)	100	100	100	100	100	100	100	100	100	100
	Un-consumed (g)	3	7	10	8	5	16	0	5	7	6
	Consumed (g)	97	93	90	92	95	84	100	95	93	94

Appendix 6: WEEKLY WEIGHT GAINS (g) FOR THREE GROUPS OF RABBITS

		W E E K S							
GROUP	RABBIT NO.	1	2	3	4	5	6	7	TOTAL (g)
A.	1	47	10	-	-	-	-	-	-
	2	30	-	-	-	-	-	-	-
	3	70	50	-	-	-	-	-	-
	4	-2	-4	-	-	-	-	-	-
	5	-7	-20	-	-	-	-	-	-
	6	5	-10	-	-	-	-	-	-
	7	-20	-4	-	-	-	-	-	-
	8	5	7	-	-	-	-	-	-
	9	-5	-	-	-	-	-	-	-
	10	-2	2	-	-	-	-	-	-
B.	11	43	55	63	75	84	73	101	494
	12	50	58	73	82	94	87	96	550
	13	61	73	87	91	46	73	98	537
	14	63	51	73	75	83	96	101	542
	15	53	32	63	84	98	91	105	526
	16	56	59	61	80	91	83	94	524
	17	55	41	53	69	80	91	123	512
	18	61	72	79	52	87	58	93	502
	19	63	66	75	75	80	60	101	520
	20	55	59	68	72	73	85	90	502
C.	21	82	100	93	120	125	128	135	783
	22	90	45	120	125	128	131	139	778
	23	85	60	95	109	115	125	143	732
	24	83	90	125	130	121	129	131	809
	25	65	90	105	125	138	137	148	808
	26	70	100	104	131	138	141	143	827
	27	85	100	115	128	130	132	136	826
	28	70	98	120	140	132	138	143	841
	29	100	128	135	136	140	118	130	879
	30	111	96	128	120	133	138	148	869

Appendix 7: MEAN WEEKLY FEED CONSUMPTION (g) OF RABBITS ON TWO FEEDING REGIMES.

WEEK	GROUP B*	GROUP C**
1	368.2	509.9
2	432.9	571.0
3	409.4	574.9
4	421.2	591.8
5	456.5	588.1
6	514.4	609.4
7	549.8	632.1

* Fed on 40% Rumen Ingesta + 60% Growers Mash (RIGM).

** Fed on Growers Mash (GM).

Appendix 8: MEAN WEEKLY WEIGHT GAIN (g) OF RABBITS ON TWO FEEDING REGIMES

WEEK	GROUP B*	GROUP C**
1	56.0	84.1
2	56.6	90.7
3	69.5	114.0
4	75.5	126.4
5	81.6	130.0
6	79.7	131.7
7	100.2	139.6

* Fed on 40% Rumen ingesta + 60% Growers Mash (RIGM).

** Fed on Growers Mash (GM).

Appendix 9: RANDOMISED 3 - DIGIT CODED NUMBERS

	GMS		GMS-		RIGMS		RIGMS-	
Cuts	Code	Judges No	Code	Judges No	Code	Judges No	Code	Judges No
SHOULDERS	313	1	417	2	632	3	741	4
	308	5	760	6	815	7	939	8
	462	2	982	3	483	4	516	5
	493	6	532	7	935	8	264	1
	986	3	684	4	713	5	356	6
	972	7	136	8	111	1	873	2
	765	4	546	5	287	6	414	7
	778	8	222	1	337	2	644	3
BACKS	306	1	418	2	633	3	931	4
	463	5	761	6	816	7	742	8
	494	2	983	3	484	4	517	5
	987	6	533	7	936	8	265	1
	971	3	685	4	714	5	357	6
	764	7	137	8	112	1	874	2
	779	4	547	5	288	6	415	7
	314	8	223	1	338	2	645	3
LOINS	301	1	419	2	634	3	932	4
	461	5	762	6	817	7	818	8
	495	2	984	3	485	4	488	5
	988	6	534	7	937	8	933	1
	970	3	686	4	715	5	718	6
	766	7	138	8	113	1	116	2
	775	4	548	5	289	6	286	7
	310	8	224	1	339	2	646	3
THIGH	305	1	416	2	635	3	934	4
	465	5	763	6	819	7	813	8
	496	2	985	3	486	4	487	5
	989	6	535	7	938	8	939	1
	973	3	687	4	716	5	717	6
	767	7	139	8	114	1	115	2
	776	4	548	5	283	6	285	7
	311	8	225	1	335	2	647	3

GMS = Meat from rabbits fed Growers Mash and cooked with salt.
GMS- = Meat from rabbits fed Growers Mash and cooked without salt.
RIGMS = Meat from rabbits fed 40% Rumen ingesta + 60% Growers Mash and cooked with salt.
RIGMS- = Meat from rabbits fed 40% Rumen ingesta + 60% Growers Mash and cooked without salt.

Appendix 10: QUESTIONNAIRE FOR SENSORY PANEL

Sir/Madam,

You are kindly requested to respond to the questions below to enable a researcher select judges to evaluate the effects of two feeding regimes on various aspects of sensory properties of different cuts of rabbit meat.

Please mark 'X' against the appropriate answer.

RESPONDENT'S NAME_____DATE_____

1. EXPERIENCE: My experience in food tasting is :

   Much Little Nil

2. AVAILABILITY: If called upon to participate, I:

   Shall Quickly respond May be readily available

3. AGE: I am:

   Below 20 years 20-25 years 26-30 years

   31 - 35 years 36 - 40 years 41 - 45 years

   46 - 50 years Above 50 years

4. SEX: Male Female

5. HEALTH: Physically fatigued Not physically fatigued

   Susceptible to mouth infections Yes No

   Susceptible to Sinus infections Yes No

   Frequent head colds Yes No

   Allergic to rabbit meat Yes No

   Asthmatic Yes No

6. PREFERENCE: I like Dislike rabbit meat

7. SMOKING HABIT:
   Smoke heavily Occassionally Don't smoke

8. FOOD PREJUDICES: Much Little None

9. OCCUPATION: Please state:_____

10. ECONOMIC OR SOCIAL LEVEL: Junior Class Middle class

Senior Class

11. GEOGRAPHIC AREA OF ORIGIN: North East West

12. How often do you eat rabbit meat? Several times a week

Few times a week Few times a year Never

Thank you for your response.

Please return completed Questionnaire to :

The Principal
College of Agriculture and Animal Science,
Mando Road,
PMB 2134,
Kaduna.

Appendix 11: TEN - POINT HEDONIC SCALE

Judge's Name_____ Date_____

You are presented with cooked portions from different cuts of rabbit meat from two different feeding regimes. Please taste each sample and evaluate it for the quality factor listed below, using the appropriate scale.

QUALITY FACTOR	SCORING SCALE										SAMPLE CODES
	10	9	8	7	6	5	4	3	2	1	
Colour		Very attractive		Moderately attractive			Slightly un-attrac-tive		Very unattrac-tive		
Taste	10	9 very good	8	7 Good	6	5 Fair	4	3 Poor	2	1 very Poor	
Juiciness	10	9 Very Juicy	8	7 Moderately Juicy	6	5	4 Slightly Dry	3	2 Very Dry	1	
Flavour	10	9 Highly Acceptable	8	7 Slightly Acceptable	6	5	4 Slightly Un-accep-table	3	2 Very Un-accep-table	1	
Tenderness	10	9 Very tender	8	7 Moderately tender	6	5	4 Slightly tough	3	2 Very tough	1	
Chewiness	10	9 Very full	8	7 Moderately full	6	5	4 Slightly light	3	2 Very light	1	
Overall acceptability	10	9 Very good	8	7 Good	6	5 Fair	4	3 Poor	2	1 Very poor	

Appendix 12 ANOVA FOR TOTAL AND WEEKLY FEED CONSUMPTION OF TWO GROUPS OF RABBITS ON TWO FEEDING REGIMES

Source of Variation	Degree of Freedom	Sum of Squares	Mean Squares	F - Value	Pr > F
Total Feed					
Corrected total	139	1033139.6			
Group	1	610896.5	610896.5	199.7	0.0001
Error	138	422243.1			
Week 1					
Corrected total	19	133875.0			
Group	1	100394.5	100394.5	54.0	0.0001
Error	18	33480.5			
WEEK 2					
Corrrected total	19	114005.0			
Group	1	95358.1	95358.1	92.1	0.0001
Error	18	18646.8			
WEEK 3					
Corrected total	19	144142.6			
Group	1	136951.3	136951.3	342.8	0.0001
Error	18				
WEEK 4					
Corrected total	19	151235.0			
Group	1	145521.8	145521.8	458.5	0.0001
Error	18				
WEEK 5					
Corrected total	19	104270.2			
Group	1	86592.8	86592.8	88.2	0.0001
Error	18	17677.4			
WEE 6					
Corrected total	19	49691.8			
Group	1	45125.0	45125.0	177.9	0.0001
Error	18	4566.8			
WEEK 7					
Corrected total	19	45107.0			
Group	1	33866.5	33866.5	54.2	0.0001
Error	18	11240.5			

Appendix 13: ANOVA FOR TOTAL AND WEEKLY WEIGHT GAIN FOR TWO GROUPS OF RABBITS ON TWO FEEDING REGIMES

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F - Value	Pr > F
Total gain					
Corrected total	139	123497.6			
Group	1	63176.3	63176.3	144.5	0.0001
Error	138	60321.3			
WEEK 1					
Corrected total	139	6093.0			
Group	1	3948.1	3948.1	33.1	0.0001
Error	138	2144.9			
WEEK 2					
Corrected total	139	12068.6			
Group	1	5814.1	5814.1	16.7	0.0007
Error	138	6254.5			
WEEK 3					
Corrected total	139	12397.8			
Group	1	9901.3	9901.3	66.1	0.0001
Error	138	2696.5			
WEEK 4					
Corrected total	139	14639.0			
Group	1	12954.1	12954.1	138.4	0.0001
Error	138	1684.9			
WEEK 5					
Corrected total	139	14183.2			
Group	1	11712.8	11712.8	85.3	0.0001
Error	138				
WEEK 6					
Corrected total	139	15530.2			
Group	1	13520.0	13520.0	121.1	0.0001
Error	138				
WEEK 7					
Corrected total	139	8899.8			
Group	1	7761.8	7761.8	122.8	0.0001
Error	138	1138.0			

Appendix 14 ANOVA FOR PROXIMATE ANALYSIS FACTORS FOR THREE FEEDS.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F - Value	Pr > F
RI[a]					
Total	17	16234.0			
Factors	5	16233.8	3246.8	1000000.0	0.0
Error	12	0.1			
RIGM[b]					
Total	17	15969.5			
Factors	5	15969.1	3193.8	83413.5	0.0001
Error	12	0.5			
GM[c]					
Total	17	15703.8			
Factors	5	15703.4	3140.7	1000000.0	0.0
Error	12	0.3			

a = Rumen Ingesta (100%)

b = 40% Rumen Ingesta + 60% Growers Mash

c = 100% Growers Mash

Appendix 15 ANOVA FOR PROXIMATE ANALYSIS FACTORS FOR MEAT FROM TWO FEEDING REGIMES:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F - Value	Pr > F
Total	23[a]	18773.5			
	23[b]	17547.5			
	47[c]	36321.6			
Factors	2[a]	18772.9	9386.4	1000000.0	0.0
	2[b]	17540.1	8770.0	24308.1	0.0001
Cuts	3[a]	0.1045	0.0349	1.2	0.3351
	3[b]	0.9783	0.3261	0.9	0.4586
	3[c]	0.3156	0.1052	0.0	1.0000
Group	1[c]	0.5852	0.5852	0.0	0.9791
Error	18[a]	0.5	0.0		
	18[b]	6.4941	0.3608		
	43[c]	36320.7	844.7		

a = Group B rabbits (40% Rumen Ingesta + 60% Growers Mash)
b = Group C rabbits (100% Growers Mash).
c = Group B and C rabbits.

Appendix 16: ANOVA ON MEAN VALUES OF SENSORY SCORES ON VARIOUS ORGANOLEPTIC PROPERTIES OF RABBIT MEAT FROM TWO FEEDING REGIMES

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F - Value	Pr > F
Colour					
Model	18	268.6	14.9	8.87	0.0001
Corrected total	511	1097.9			
Replication	3	22.8	7.6	4.53	0.0038
Cut	3	130.3	43.5	25.87	0.0001
Feeding regime	3	103.1	34.4	20.44	0.0001
Cut vs feeding	9	12.1	1.3	0.80	0.6190
Error	493	829.3			
Taste					
Model	18	370.6	20.6	10.17	0.0001
Corrected total	511	1368.7			
Replication	3	12.0	4.0	1.98	0.1163
Cut	3	79.3	26.4	13.06	0.0001
Feeding regime	3	252.9	84.3	41.64	0.0001
Cut vs feeding	9	26.3	2.9	1.45	0.1656
Error	493	998.1			
Juiciness					
Model	18	220.6	12.3	5.93	0.0001
Corrected total	511	1238.8			
Replication	3	33.5	11.2	5.41	0.0011
Cut	3	91.1	30.4	14.70	0.0001
Feeding regime	3	81.1	27.0	13.09	0.0001
Cut vs feeding	9	14.9	1.7	0.80	0.6122
Error	493	1018.2			
Flavour					
Model	18	222.1	12.3	5.78	0.0001
Corrected total	511	1274.7			
Replication	3	4.7	1.6	0.74	0.5314
Cut	3	66.9	22.3	10.45	0.0001
Feeding regime	3	130.1	43.4	20.32	0.0001
Cut vs feeding	9	20.3	2.3	1.06	0.3920
Error	493	1052.6			
Tenderness					
Model	18	281.4	15.6	8.05	0.0001
Corrected total	511	1238.7			
Replication	3	46.8	15.6	8.04	0.0001
Cut	3	95.8	31.6	16.44	0.0001
Feeding regime	3	126.8	42.3	21.76	0.0001
Cut vs feeding	9	12.0	1.3	0.69	0.7188
Error	493	957.3			

Appendix 16 contd.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F - Value	Pr > F
Chewiness					
Model	18	232.6	12.9	6.49	0.0001
Corrected total	511	1214.3			
Replication	3	15.1	5.0	2.54	0.0561
Cut	3	35.7	11.9	5.98	0.0005
Feeding regime	3	157.5	52.5	26.37	0.0001
Cut vs feeding	9	24.2	2.7	1.35	0.2077
Error	493	981.7			
Overall Acceptability					
Model	18	224.9	12.5	6.32	0.0001
Corrected total	511	1198.8			
Replication	3	13.1	4.4	2.21	0.0860
Cut	3	80.6	26.9	13.6	0.0001
Feeding regime	3	108.1	36.0	18.23	0.0001
Cut vs feeding	9	23.1	2.6	1.30	0.2337
Error	493	973.9			

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