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PRODUCTIVE PERFORMANCE AND CARCASS CHARACTERISTICS OF CAPTIVE GRASSCUTTERS (*THRYONOMYS SWINDERIANUS*) FED CONCENTRATE DIETS CONTAINING VARYING LEVELS OF GUINEA GRASS

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PRODUCTIVE PERFORMANCE AND CARCASS CHARACTERISTICS OF CAPTIVE GRASSCUTTERS (*THRYONOMYS SWINDERIANUS*) FED CONCENTRATE DIETS CONTAINING VARYING LEVELS OF GUINEA GRASS

by

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DECLARATION

I, John Kormla Nyameasem, hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

An experiment was conducted at the Department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi, to evaluate the productive performance and carcass characteristics of three groups of growing grasscutters with mean weight of 1174±8.58 g fed home-made concentrate diets. The objective was to assess the feeding values of the diets. The diets were labelled diet 1, diet 2 and diet 3 and respectively contained 0, 7.5 and 15% guinea grass, *Panicum maximum*. The completely randomized design was used in the experiment. Both final body weight and daily weight gain of the grasscutters were significantly higher ($P<0.05$) for animals fed diets 1 and 2. The mean final body weights were 2357±9.01 g, 2177±3.06 g and 1817±10.08 g for animals on diet 1, diet 2 and diet 3, respectively. The corresponding mean daily weight gains were 13.08±0.07, 11.04±0.08 and 7.11±0.13 g/day. The daily dry matter intake of 66.20±0.08, 58.80±0.11 and 53.84±0.93 g/day for animals on diet 1, diet 2 and diet 3, respectively, were statistically similar ($P>0.05$) for the treatment groups. Economics of gain analysis showed that it was cheaper and more profitable to produce a kg live-weight of grasscutter with diets 1 and 2 than diet 3. The means for cold (commercial) carcass weight, which were 1430±6.56, 1287±5.57 and 1060±7.55 g for animals on diets 1, 2 and 3, respectively, also differed ($P<0.05$) between diet 1 and diet 3 fed animals. Diet 1 (0% grass diet) and diet 2 (7.5% grass diet) supported high growth rate and carcass weight and from the economic point of view they were the most efficiently used as they produced the cheapest per unit carcass. It was, therefore, concluded that both the 0% grass diet and 7.5% grass diet could be used as complete diets to rear growing grasscutters in captivity.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS

KNUST: Kwame Nkrumah University of Science and Technology

HCN: Hydrocyanic Acid

EEC: European Economic Community

PKM: Palm Kernel Meal

CBUD: Centre for Biodiversity Utilization and Development

CNS: Central Nervous System

TDN: Total Digestible Nutrient

NDF: Neutral Detergent Fibre

ADF: Acid Detergent Fibre

ADG: Average Daily Gain

FCE: Feed Conversion Efficiency

FCR: Feed Conversion Ratio

GIT: Gastro Intestinal Tract

ANOVA: Analysis of Variance

CP: Crude Protein

SEM: Standard Error of Means

GH¢: Ghana Cedis

USDA: United States Department of Agriculture

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CHAPTER ONE

1.0 INTRODUCTION

There has been, for quite some time, a continuous call for the improvement of the nutritional status of the citizens of many third world countries like Ghana through substantial increase in the intake of protein of animal origin to curb the chronic animal protein malnutrition (Ocloo 1993; FAO 1994). The grasscutter is known to contribute towards the alleviation of protein shortages in some parts of Africa (Baptist and Mensah 1986; Ntiamoah-Baidu 1998).

The grasscutter or cane rat (*Thryonomys swinderianus*) is a wild hystricomorph rodent hunted particularly in West Africa for its meat (Baptist and Mensah 1986; National Research Council 1991; Ntiamoah-Baidu 1998). It is known to have an excellent taste, high nutritional value (Asibey and Eyeson 1975) and meat yield (Clottey, 1981) compared to many livestock species. Apart from its relatively high protein content (18.1%), the cholesterol content is low (48.5-53.4 mg/100 g fresh mass) compared to values for beef (69-72 mg/100 g fresh mass) and goat (75 mg/100 g fresh mass) (van Zyl *et al* 1999b; USDA 2007).

The meat of the grasscutter, said to resemble that of piglets, is greatly appreciated and highly favoured both in West and Central Africa (Baptist and Mensah, 1986; Adjanohoun 1988; National Research Council, 1991; Stier *et al*, 1991; Yeboah and Adamu, 1995) and South Africa (van Zyl *et al*, 1999b). Grasscutter meat is perhaps the most expensive of the preferred meats in West Africa (National Research Council 1991; Asibey and Addo 2000). Consumer acceptance trials indicate that grasscutter meat is accepted by urbanized South Africans in terms of appearance, taste and general acceptability. Consumer preference for grasscutter

meat was found to be 49.7% compared to 28.9% and 21.5% for beef and chevon, respectively (van Zyl *et al* 1999b).

The economic determinants for producing small unconventional livestock are associated with the biological efficiency of these animals. The grasscutter can digest almost any form of edible greenstuff, ranging from coarse grasses to roughages and household scraps (Ewer 1969; Asibey 1974; Müller-Heye 1984). Apart from not competing with humans for food, these animals are easy to house and manage, and can thus be incorporated into mixed production systems to expand the available food resource base.

Grasscutter farming has a major potential for poverty alleviation among the rural and peri-urban poor (Adu *et al* 2005). The economic potential of grasscutter meat is high within the West African region and has an extensive market due to its high demand. About 40,000 tons of grasscutter meat per year is consumed in West Africa of which only 0.2% is provided by domesticated grasscutters (Mensah and Okeyo 2005). The prices of live grasscutters and grasscutter meat in Benin, Cote d'Ivoire and Gabon are 2 to 4 times higher than that of beef, small ruminants and poultry (Mensah 1991; Jori *et al* 1995).

The high demand for grasscutter meat coupled with the economic benefit that accrues from its sale is encouraging aggressive hunting for the animal. In hunting for the grasscutter, some people use fire to flush them out of their burrows during the dry season, which practice invariably results in wild fires. The consequences of this are the destruction of forests and farmlands as well as the gradual decimation of the wild grasscutter populations (Falconer 1992; Addo 1997; Ntiamoah-Baidu 1998). Also, some people use poisonous chemicals with baits to kill them, which practice puts the

consumer at a great risk. Rearing the grasscutter in captivity has been suggested as the solution to this obvious environmental and health problem.

Efficiently producing grasscutters in captivity demands that adequate nutrition is provided to ensure high productivity. There is a growing interest in the raising of grasscutters in backyards among urban dwellers, but their major problem is the unavailability of feed. They have to buy cut grass which may not be readily available (especially in the dry season). Adu *et al* (1999) and Awotwi *et al* (2007) noted that most grasscutter farmers in Ghana feed their grasscutters with Guinea grass (*Panicum maximum*) and Elephant grass (*Pennisetum purpureum*) during the wet season and cassava during the dry season. However, it has long been known that freshly cut Elephant or Guinea grass usually contains less than 10% crude protein (Annor *et al*, 2008). Adu and Wallace (2003) indicated that the nutrient concentration of these grasses does not meet the growth and reproductive requirement of 15-18% crude protein (Schrage and Yewadan, 1999; Mensah and Okeyo, 2005) of the grasscutter.

The problem becomes aggravated in the dry season when the feed materials become unavailable. Some feed materials could be found in riverine areas which may be far from the farmer. Besides, there is very little attempt to formulate feed which could be used as a supplement or main diet for grasscutters. This has resulted in numerous feeding problems during the dry season and even in the rainy season, especially in the urban centres (Awotwi *et al* 2007 ; Annor and Djang-Fordjour 2007). There is also the need to improve the growth rate and feed conversion efficiencies of the grasscutter.

The search for good quality feed for captive grasscutters all year round necessitated the present investigation where the feeding values of three diets

formulated from locally available feedstuffs and containing 0, 7.5 or 15% guinea grass were assessed on the basis of the productive performance and carcass characteristics of growing grasscutters fed the diets. The availability of formulated feed would promote grasscutter production in urban centres where grass (natural food of grassscutter) is not readily available. It would also reduce (if not eliminate) the drudgery associated with grass-feeding in grasscutter production. Besides, feeding problems during the dry season would be minimized.

The main objective of the study was to assess the feeding value of three diets formulated from locally available feedstuffs and containing 0, 7.5 or 15% *Panicum maximum*. The specific objectives were to:

(a) determine the chemical composition of the major feedstuffs used for the experimental diets and the formulated experimental diets.

(b) assess the apparent digestibility of nutrients in the 0, 7.5 and 15% guinea grass diets fed to growing grasscutters.

(c) evaluate the growth performance and carcass characteristics of grasscutters fed diets containing guinea grass.

(d) assess the economics of production when varying levels of guinea grass are added to the grasscutter diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.1 The Grasscutter

The grasscutter is a hystricomorph rodent widely distributed in the African sub-region and exploited in most areas as a source of animal protein (Vos 1978; Asibey 1974; National Research Council 1991; Addo 2002). According to Schrage and Yewadan (1999), the shape of its subspinous hair and the size of its masseter muscle make it a member of the Hystricomorpha suborder of rodents, which includes the superfamily *Thryonomyoidea*. The grasscutter is known to belong to the family *Thryonomyidae* which has only one known genus, Thryonomys, subdivided into two species *T. Swinderianus* (Temminck, 1827), or giant grasscutter, and *T. Gregorianus* (Thomas, 1894), or small grasscutter.

Schrage and Yewadan (1999) described the grasscutter as heavy and compact, and as the largest African rodent after the porcupine (*Hystrix cristata*). The body length of a full-grown grasscutter is reported to be between 42 and 58 cm, and its tail measures between 22 and 25 cm and the standing height ranges from 23 to 30 cm. The average adult weight is said to be 3 kg for females and 4.5 kg for males (Mensah and Okeyo 2005). The head of the adult female grasscutter is known to be slightly elongated but more rounded in the male, both ending with a short snout. The nostrils are pink and hairless and form two oblique slits. The head, with two round black eyes and two almost delicate ears set behind, sits on a very short neck. The limbs are short and the digits have tough, powerful claws. It has very delicate tail which is scaly and grey or black in appearance, tapering towards the tip. The grasscutter has a typical rodent's dental formula of two pairs of incisors, no canine, two pairs of premolars and six pairs of molars. The incisors are tinged orange, very

strong and slightly convex, with three longitudinal grooves running down the upper incisors.

The grasscutter is found in the Guinean Savannah of Sub-Saharan Africa (Mensah and Baptist 1986; Schrage and Yewadan 1999; Adeniji 2008), particularly in areas with annual rainfall of over 750 mm and annual temperature of between 22 and 27°C, characterised by tall grasses. It also lives on the edges of wetlands and marshes, open woodland and rocky ground (Schrage and Yewadan 1999). They are also found in cultivated forest regions and in sugar cane plantations and fields where arable crops such as maize, groundnut and cassava are grown, thus farmers regard them as pests (CBUD 2005).

2.1.2 Nutrient Requirements of the Grasscutter

Knowledge in feeding standards for the grasscutter remains rudimentary and the feeding strategies used have been demonstrated to be inadequate for growth and reproduction (Adu *et al,* 2000; Adu and Wallace, 2003). The diet of the grasscutter in the wild along with results from detailed observation of conditions and performance have been compared with the needs of other animal species (particularly the rabbit) to predict the nutrient requirements for the grasscutter in captivity (Schrage and Yewadan, 1999). Schrage and Yewadan (1999) have suggested feed formulae based on the nutrient requirements of other rodents and rabbit which have yielded good results, considerably reducing cases of illness and boosting weight gain in grasscutters. They have recommended average rates of 15-18% crude protein; 10-18% crude fibre; 3-4.5% fat; 0.2–0.7% calcium; 0.35–0.9% phosphorus and gross energy of 3,702–4,086 Kcal/kg of dry matter in grasscutter feeds.

Mensah and Okeyo (2005) reported 12-18.5% crude protein, 2.5-4.5% crude lipid, 25-45% crude fibre, 2.5-4.5% ash, 45-65% nitrogen free extract and 25-35% acid detergent fibre as the nutrient requirement for an adult grasscutter. Lameed and Ogundijo (2006) fed pelleted concentrates containing 18%, 20%, 22% and 24% crude protein to grasscutters to assess their reproductive performance. Protein inclusion rate of 24% was recommended as best for reproductive performance in grasscutters. Table 2.1 shows the nutrient requirement of herbivores in captivity as suggested by Pond *et al.* 1995.

Table 2.1: The Nutrient Requirement of Herbivores in Captivity.

Constituent	Concentrate (g/kg)	Supplement (g/kg)
Crude protein	170 (min.)	230 (min.)
Acid detergent fibre	130 – 170	100 -140
Ether extract	30 (min.)	30 (min.)
Ash	80 (min.)	120 (max.)
Calcium	6.5 – 10	12 – 15
Phosphorus	6.5 (min.)	9 (min.)

Source: Pond *et al* (1995).

2.1.3 Some Feed Sources for Grasscutter Diets

Some sources of energy available to the grasscutter include grasses (*Saccharum spp., Pennisetum purpureum, Panicum maximum, etc)*; tubers (cassava, sweet potato, etc.) and cereals (such as rice, maize, sorghum and millet) and their by-products (such as wheat bran, brewer's spent grain, pito mash, etc.). Energy source constitutes between 45 and 60% of finished feeds for monogastric animals, and at present maize constitutes the bulk of the energy source used in compounding

concentrate rations (Tewe and Egbunike, 1988). The high digestible energy (15.2 MJ/kg) content of maize makes it a source of energy for grasscutters. The consequent high demand by both humans and some domestic livestock species coupled with both official and unofficial exports have led to situations where prices become very high, resulting in high cost of producing monogastric animals which depend entirely on concentrate feeds. This has necessitated research and use of alternate cereal and other energy feed ingredients (Okai and Boateng, 2007). Alternate energy sources which are used to a lesser extent include sorghum, millet, wheat, barley, oats (and their by-products), cassava chips and molasses. The chemical composition of cassava varies according to the variety, age of plant and processing technology. A comparison of ground yellow corn with cassava root meal is given below (Table 2.1). It should be noted that the protein, vitamins and mineral contents of the root product are nutritionally insignificant.

Table 2.2: Comparison of nutrient composition of cassava root meal and ground corn.

Constituent	Cassava Root Meal %	Ground Maize %
Moisture	12.1	13.5
Crude Protein	2.5	8.5
Ether extract	0.3	3.8
Crude Fibre	3.5	2.0
Ash	1.8	1.1
NFE	79.8	71.1
Calcium	0.18	0.03
Phosphorus	0.09	0.27
Lysine	0.042	0.25
Methionine and Cystine	0.019	0.26
Threonine	0.055	0.35
Tryptophan	0.011	0.05

Source: Rural Agricultural Development Authority, Kingston (2006)

Cassava root meal compares favourably with maize and sorghum as a source of energy for most animals (Smith 2006). It is essentially a carbohydrate source. It contains very little protein which is of poor quality. The fresh product, however, contains a cyanogenic glucoside (linamarin and lotaustralin) which on hydrolysis yield hydrocyanic acid (HCN), glucose and a ketone or an aldehyde (Pond and Maner 1974; Cereda and Mattos 1996). Hydrocyanic acid is very toxic. In small doses, cyanide is detoxified to thiocyanate (a goitrogen) by means of the enzyme rhodanase, making use of methionine as the sulphur donor. This amino acid therefore becomes a limiting factor in cassava feeds (Delange and Ahluwalia 1988).

The level of hydrocyanic acid in cassava limits the use of cassava and its products for livestock feeding. Drying considerably reduces the HCN level by evaporation through the hydrolytic action of linamarinase; and sun-drying has been demonstrated to be more effective than oven drying (Tewe *et al* 1980). Where the HCN is below 100 ppm, as in cassava flour or chips, cassava can be safely incorporated into rations as is allowed by the European Economic Community (EEC) (Delange and Ahluwalia, 1983). Cassava is deficient in essential fatty acids. Hudson and Ogunsua (1974) reported that fat in cassava tuberous roots contains 1.46% linoleic acid, which is low as compared to 60.8% in maize (Holditch and Williams, 1974).

Eshiet *et al* (1979) fed 0, 15, 30 and 45% cassava root meal, in isocaloric and isonitrogeneous diets, to fryer rabbits and observed that rabbits could tolerate up to 30% cassava root meal diet without adverse effects on feed intake and growth rate. The 45% cassava root meal level, however, gave a poor growth and utilization efficiency. None of the cassava root meal levels influenced the carcass parameters and thiocyanate levels of urine and serum in the rabbits.

Palm Kernel Meal (PKM) is the by-product which is obtained after extracting oil from the palm kernel. Several studies have shown that PKM is a useful feed ingredient. Palm kernel meal has variable composition, especially the oil level, depending on the processing condition. Panigrahi and Powell (1991) found that PKM from Sierra Leone contained 14.2% crude fibre and 9.7 MJ/kg DM (ME) whilst another from Malaysia had 21.0% crude fibre and 8.4 MJ/kg DM (ME). The high crude fibre level would adversely affect the digestibility of nutrients in PKM. Ogbonna *et al* (1988) observed that the digestibility of both dry matter and gross energy decreased with increasing levels of PKM in the diet. Although PKM is often used as a vegetable protein supplement in animal rations it is not as popular as groundnut cake or cotton seed cake. Fetuga *et al* (1973) in detailed studies including chemical assays described PKM as being a good source of methionine and cystine but marginal in lysine. On the contrary, McDonald *et al* (1995) considered methionine to be the first limiting amino acid in PKM. One of the earliest studies with PKM (Temperton and Dudley 1940) indicated that PKM was palatable to laying birds. Later studies (Oyenuga 1968; Babatunde *et al* 1975) have contradicted this observation by showing that PKM is relatively unacceptable to monogastric animals, especially at early ages due to its gritty nature and high crude fibre which reduces digestibility, consequently impairing feed utilization.

In some studies, locally produced PKM has been included (0, 10 and 20%) at the expense of maize, wheat bran or soyabean meal without any detrimental effect. While all growth performance criteria, with the exception of feed intake (higher for PKM diets), were found to be similar for the three treatments, the PKM-containing diets were cheaper. However, carcass back-fat thickness was higher ($P<0.05$) for the pigs fed PKM-containing diets (Okai and Opoku-Mensah 1988). Both feed

conversion efficiency and average body weight gain were depressed as the level of inclusion of PKM in broiler diets increased (Osei and Amo 1987; Onwudike 1986b; Panigrahi and Powell 1991). Calculation on feed costs saved by using PKM relative to cotton seed cake and cereals (Alawa and Omunna 1993) leads to the recommendation that PKM incorporation in the diet of the grasscutter is economically attractive.

Panicum maximum is highly palatable to grasscutters (Schrage and Yewadan 1999) and has 23.5-29.9% DM at harvest (Olubajo 1977; Aken'ova and Mohamed-Saleem 1982; Ifut 1987). Nitrogen content in *Panicum maximum* ranges from 0.8 to 2.0% DM; and CF from 29.5 to 42.2% DM (Akinyemi and Onayinka 1982; Ifut 1987). Annor *et al* (2008) observed that the leaf portion of elephant grass is more nutritious than the stem portion (Table 2.2), which implies that the current practice in Ghana whereby farmers cut off the leaves of the grass and feed only the stem fraction should be discouraged.

Table 2.3: Nutrient Composition of Guinea Grass, g 100 g^{-1} dry weight

Nutrient	Leaf	Whole Plant	Stem
Crude Protein	12.54	9.25	5.57
Crude Fibre	27.33	31.00	33.60
Ether Extract	1.64	1.17	1.23
Ash	10.27	9.28	6.32
NFE	48.22	49.30	53.28
Total Dry Matter, 100 g^{-1} wet weight	38.45	34.30	27.95

Source: Annor et al (2008)

2.1.4. Feeding Behaviour of the Grasscutter

The grasscutter is strictly a monogastric herbivore (Skinner and Smithers, 1990) and very fond of sweet and salty foods (CBUD, 2005). It is known to enjoy gramineous plants with thick succulent stalks, such as sugar cane and *Pennisetum purpureum* (Schrage and Yewadan, 1999). It prefers plants with lots of moisture and soluble carbohydrates (Agbelusi, 1997). Ajayi and Tewe (1980), in their study of the food preferences of *T. swinderianus*, found that the animals showed a preference for elephant grass (*Pennisetum purpureum*) and sweet potato tubers (*Ipomoea batatas*) as against concentrates.

The grasscutter adapts readily to a variety of diets. Adu *et al.* (1999) and CBUD (2005) outlined a number of feed materials consumed by the grasscutter. These include grasses (*Saccharum spp., Pennisetum purpureum, Panicum maximum, etc.)*; leguminous fodder (*Centrosema pubescence, Pueraria phaseoloides,* etc.); the roots and pith of oil and coconut palms; fruits (such as pawpaw, pineapple, and mango); tubers (cassava, sweet potato, etc.) and food crops (such as groundnuts, rice, maize and grain legumes). National Research Council (1991) also reported that elephant grass and sweet potatoes are the grasscutter's favourite foods. Irrespective of the kind of forage, grasscutters (unlike other rodents and rabbit) first eat stalks, the bark of twigs and finally some leaves (Mensah and Okeyo, 2005).

In addition to the consumption of forage, the grasscutter resorts to other nutritional elements (like agricultural by products) which abound within its natural milieu to complete its meal course in order to grow and remain healthy (Abdul-Azeez 2007). *T. swinderianus* cut the grasses and other foods with their incisors, producing a chattering sound that is relatively loud and very distinguishable (Mills 1997).

When water is hot, intake is reduced, and when the outdoor temperature is cold, the animal drinks much more (Baptist and Mensah 1986; Holzer 1986; Holzer *et al*. 1986; Adjanohoun 1988; Mensah *et al* 1986; Mensah 2000). Lack of drinking water has been reported to be partially responsible for digestive disorders leading to enterotoxemia (Schrage and Yewadan 1999). Grasscutters lap up water with their tongue when served in a trough. But when industrial drinkers with nipples are used, grasscutters re-adapt and suck at the drinkers. It is suggested to feed a mixture of several grasses, food crops and leguminous fodder crops or grasses in combination with feed supplement. Vitamin and mineral supplements are recommended particularly for growing animals (Schrage and Yewadan 1999; CBUD 2005).

2.2.0 Feed Intake in Grasscutters

Voluntary feed intake refers to the weight of feed eaten by an animal or group of animals during a given period of time during which they have free access to food (McDonald *et al*, 1988). When a grasscutter starts to eat it is said to do so because it is in a state of hunger. Given free access to food of good quality, individuals of many species may eat from 10 to 15 meals a day. Very often the distribution of meals through a 24-hour period is not uniform with more frequent larger meals being taken during the photo-phase (daylight) in those species which are active during that period. However, the grasscutter is a nocturnal animal and therefore more active during the night (The National Academic Press 1991).

Many theories have been postulated to explain the mechanisms of control of voluntary feed intake by animals. National Research Council (1987) reported that voluntary feed intake is controlled by the central nervous system (CNS). They named two centres in the CNS which have control on feed intake in animals. These are the

feeding centre located in the lateral hypothalamus, and the satiety centre located in the ventromedial nuclei of the hypothalamus. Other centres have been found in the CNS and other parts of the body. For example the hepatic portal vein and some centres in the liver may control feed intake (McDonald *et al* 1995). These centres in the CNS and other parts receive messages before they can register satiety or hunger.

Varied feed intakes have been observed in the grasscutter depending on the diet. Ajayi and Tewe (1980) reported different feed intakes for the grasscutter when various feed items were offered as choice feeds in feeding trials. They indicated that grasscutters showed a high preference for sweet potatoes. Other tubers offered were not taken as often as sweet potato. Also, the grasscutters consumed more grass (132.3±11.0 – 140.4±11.0 g/day DM) than concentrate feed (1.60±0.4 – 3.2±2.4 g/day DM), so they concluded that concentrates were not favoured by the grasscutter. Kenfack *et al* (2007) reported average dry matter intakes of 61.1-68.0 g/day of *extruded and expanded diet* (R_1) and 73.3-92.2 g/day of *not expanded diet* (R_2) in a study to investigate the effects of weaning age and type of diet on the gro wth performance of the grasscutter. Mensah (1993; 1995) reported a daily dry matter consumption of 150–250 g for both male and female grasscutters. Van Zyl *et al* (1999a) also reported dry matter intake of 13.9-72.2 g per day.

2.3.0 Feed Conversion Efficiency

Animals convert only a portion of the feed nutrients they consume into useful products for humans. The ability of animals to convert nutrients in the feed they eat into animal products is referred to as efficiency of food conversion. This depends on their ability to digest nutrients in the feed, their requirements for energy and protein for growth, maintenance and other body functions, the amount of the nutrients lost in

metabolic end products and non-productive work, the type of feed consumed and the composition of the animal products produced (Cambell *et al* 2003). Non-ruminants are known to digest approximately 75-85% of dry matter of feed consumed.

It is very important to note that not all the digestible nutrients in feed consumed by animals are used for productive purposes. Some of the digestible protein is not incorporated into body tissues because of improper balance of amino acids for building body proteins. Extra amino acids are deaminated and used as a source of energy. The end products of protein metabolism such as urea and uric acid eliminated in faeces and urine are lost to the animal for productive purposes. Generally, the higher the protein content of a feed the larger the amount of energy lost through these channels. Some energy is lost in faeces, urine, combustible gases and heat of digestion. The proportion of digestible energy taken into the body used for productive purpose varies with the species, individual and kind of feed.

The efficiency of food conversion in meat-producing animals is usually expressed as the units of body weight gained per units of feed consumed. Inheritance, age and weight, level of feeding and average daily gain are known to affect feed conversion efficiency. Campbell *et al* (2003) indicate that feed conversion in farm mammals is 30-40% heritable. Younger animals require less feed per gain than do older. The main contributing factor to more efficient feed conversion in young animals is the composition of body mass which constitutes weight gain. Also, the amount of food consumed per unit of body weight decreases as the animal becomes older and heavier.

According to Campbell *et al.* (2003), limited feeding, if not too drastic, often results in increased digestibility of the diet and less feed wastage. More so, animals provided with limited amount of feed usually have lower percentages of fat in weight

gain. Fast-growing animals on full-feed usually make more efficient gains than slower-gaining ones on full-feed. This is because faster-growing animals use a smaller percentage of their total feed intake for maintenance, are usually healthier, are growing rather than depositing fat and have more efficient metabolic system, which allows better utilization of food they consume for body weight increases.

The effect on growth of increasing feed intake and consequences for efficiency was discussed by Lawrence and Fowler (1997) using field data on cattle, sheep and pigs. They concluded that, if all other factors remain equal, increases in feed intake would result in a better efficiency of feed utilization. Other factors such as diet quality and its palatability to the animal can also affect feed conversion efficiency.

According to Schrage and Yewadan (1999), food conversion ratio (i.e. feed/gain) is 16:1 for grasscutters fed on a fodder-feed supplement mix and 7.2:1 for those fed with only a concentrate diet with 17.7% crude protein, 10.6% crude fibre and a gross energy of 3,973 Kcal/kg of dry matter. They identified feed as the single most important environmental factor in the grasscutter's weight gain. Kenfack *et al*, (2007) observed significant differences in feed conversion ratio when they fed grasscutters with *extruded and expanded diet* (5.37±0.46 and 4.95±0.35 respectively for early and late weaning) but *not expanded diet* (6.45±0.90 and 6.39±1.10).

2.4.0 Grasscutters and Formulated Diets

In close confinement, it is obligatory for the grasscutter breeder to provide better nutrition as required for the animal's growth, good health and reproduction. Researchers have used formulated diets as supplements for grasscutters in captivity and have registered varying feed intakes and growth responses (Kenfack *et al*, 2006;

Yewadan, 2000; van Zyl *et al* 1999a; Nguema and Edderai, 2000). Schrage and Yewadan (1999) outlined ingredients (including wheat bran, soya cakes, maize grains, grain legume pods, brewers' grains, oyster shells and multi-vitamins) and their possible proportions in formulating rations for grasscutters. Jori and Chardonnet (2001), in their review on the status of grasscutter farming in Gabon, indicated that the improvement of diet complements has allowed a substantial improvement in the growth and the yearly weight gain of grasscutters. According to them, average weight improved from 8 to 13 grammes per day depending on the type of supplement given. Full grown males (3500 g) were ready for marketing at the age of 8 months (Nguema and Edderai, 2000). When the supplementary feed is also served, the grasscutter attempts to pick out the maize grains or other choice ingredients which it cherishes most. It nearly empties the feed trough, in this way; a lot of the other feed elements in the composition is lost and cannot be recovered by the animals except in the hutch.

2.5.0 Digestion in the Grasscutter

Schrage and Yewadan (1999) and van Zyl *et al* (2005) described into detail the digestive system of the grasscutter. According to Tondji and Agbessi (1992), the digestive tract of the grasscutter is analogous in many ways to that of the horse. The similarity between the two species lies firstly in size of the large intestine, particularly the caecum, in relation to the other viscera of the digestive tract and secondly in the functional importance of the caecum. As in the horse, the grasscutter's large intestine is the largest organ of the digestive tract; its caecum in particular occupies two-thirds of its left flank from the stomach to the entrance of the pelvic cavity (Schrage and Yewadan 1999). The caecum/large intestine serves as a

fermentation vat and facilitates the digestion of fibre.

Grasscutters are related to guinea-pigs (*Cabia porcellus*), both being hystricomorph rodents and monogastric hindgut fermentors (Ewer 1969; Sakaguchi and Nabata 1992). Fermentation of food occurs mainly in the caecum and the animals are coprophagous (Ewer 1969; Holzer *et al* 1986). Pond *et al* (1995) also indicated that there is a substantial amount of hindgut fermentation in non-ruminant herbivores. The sources of fermentable substrates in the large bowel and caecum include any carbohydrate escaping or arriving from the upper tract. In addition to dietary sources, secretions of saliva and mucus add mucopolysaccharides as fermentation substrate (van Soest 1982).

Sakaguchi *et al* (1987) found that the extent of fibre digestion in four caecum fermentors (guinea pig, rabbit, rat and hamster) fed a common diet was related more closely to the turnover time of large particles in the caecum than to the mean retention time in the whole digestive tract. The guinea-pig was more efficient in fibre digestion than the rabbit, rat and hamster and retained digesta in the caecum and proximal colon the longest (Sakaguchi *et al* 1987). It was also found that guinea-pigs digest organic matter and crude fibre in alfalfa and alfalfa grain diets as efficiently as horses and ponies (Slade and Hintz 1969), indicating that the size of an animal does not affect the efficiency of digestion. This is in contrast to the belief that small mammals are limited by their gut capacity and, having higher energy demands per body mass, should not be able to subsist on high fibre diets to the extent that large mammals do (Foley and Cork 1992).

Van Zyl *et al* (1999a) observed that cane rats have the potential to digest large quantities of fibre in their diet. This probably enables these animals to survive the dry seasons when only dry grass is available. Cane rats on high fibre diets were

reported to have digested larger quantities of fibre with a comparable efficiency as cane rats on low fibre diets, probably due to changes in the gut capacity, for example, enlargement of the caecum and proximal colon, of these animals. It was stated that gut capacity (e.g. in microtine rodents) may enlarge when the animals are faced with high fibre diets, which tend to increase their capacity to digest fibre (Foley and Cork 1992).

Guinea-pigs and cane rats digested fibre more efficiently than rabbits (van Zyl *et al* 1999a), probably as fermentation of fibre in the cane rat and guinea-pig occurs in the caecum and proximal colon where digesta is retained the longest (Sakaguchi *et al* 1987). This is in contrast to the rabbit, where larger particles were retained in the stomach, while small particles and liquid were retained in the caecum, with a fast transit time of digesta in the caecum (Sakaguchi *et al* 1987). Sakaguchi *et al* (1987) concluded that the caecum of the rabbit does not play a significant role in the digestion of fibre and this may explain why the rabbit was not as efficient in fibre digestion as guinea pigs and cane rats.

According to McDonald *et al* (1995), extensive microbial activity occurs in the caecum of monogastric herbivores. The organisms of the lower tract of non-ruminants are very similar to rumen organisms and have similar nutritive requirements (McDonald *et al* 1995). The slow rate of passage and abundant nutrient sources encourage the prolific growth of bacteria. A complex population of acrobic and obligate anaerobic bacteria, including lactobacilli, streptococci, coliforms, bacteriodes, clostridia and yeast have been identified (Holdeman *et al* 1976; McDonald *et al* 1995). The microbes are known to metabolize a wide range of nitrogen and carbohydrate sources from both dietary and endogenous residues, resulting in the formation of a number of products, including indole, skatole, phenol,

hydrogen sulphide, amines, ammonia and volatile fatty acids (acetic, butyric and propionic). More volatile acids are produced from the finer particles as they have a larger surface area for attack by bacteria. The volatile fatty acids produced in the caecum are absorbed. Proteins and non-protein sources of nitrogen (such as urea from the bloodstream) are reformed into microbial proteins. These undergo proteolysis to amino acids and are absorbed. Water-soluble vitamins are synthesized and inorganic minerals are reabsorbed.

The large caecum in these species enables them to more effectively degrade fibrous materials in forage (Tisch 2006). However, hind-gut fermentation is less effective than rumen digestion, because digesta is not held for sufficient time and because many of the products of digestion are not absorbed (McDonald *et al* 1995). Grasscutters overcome this problem by practising coprophagy.

2.6.0 Coprophagy in the grasscutter

Pond *et al* (1995) have indicated that when animals depend heavily on caecal fermentation, there is often an association with coprophagy. Cecotrophy or coprophagy refers to the consumption of the soft faecal pellets (caecal pellets, cecotropes or "night faeces") directly from the anus (Tisch 2006). This practice is sometimes referred to as pseudorumination because it allows the animal to benefit in the same way as a ruminant animal does from microbial activity in the digestive tract.

Grasscutters, like rabbits, practice coprophagy. Grasscutters recycle approximately 10% of their droppings every day (Holzer *et al* 1986). This activity generally takes place very early in the morning, between 5 and 7 am. They use their incisors to take the faeces directly from the anus. Unlike the rabbit, the grasscutter

does not differentiate between rich and ordinary droppings (Schrage and Yewadan 1999).

No specific research has been conducted into the implications of coprophagy for the physiology of the grasscutter's digestion. Nevertheless, caecal pellets make up 7-12% of the rabbit's total dry matter intake. Rabbits on high forage diets will usually consume all of their caecal pellets; and those fed diets low in fibre and excessively rich in energy and protein will not consume all their caecal pellets (Tisch 2006). According to Pond *et al* (1995), cecotrophy supplies the animal with B vitamins and essential amino acids, permits further digestion of fibre and other nutrients by a second passage through the digestive tract. In addition to the intake of nutrients, it may be associated with the need to renew the intestinal flora.

2.7.0 Digestibility of Nutrients

In common usage, digestibility is taken to mean the disappearance of food from the GIT (includes digestion and absorption). It refers to the portion of feed which is acted upon by microbes and digestive enzymes and absorbed. Pond *et al* (1995) and McDonald *et al* (1995) have indicated that digestibility is variable; the same feedstuff given to the same animal at different times is not digested to the same extent. They enumerated several factors, including level of feed intake, digestive disturbances, frequency of feeding, feed processing and associated interactive effects of feedstuff, that cause differences in digestibility in animals. Campbell *et al* (2003) also list temperature, rate of passage through the digestive tract, level of feeding, physical form of the feed and composition of the diet as factors that affect digestibility. Experiments with dairy cattle have shown that increases in temperatures up to 32.2°C are accompanied by corresponding increases in apparent digestibility of

feeds (Campbell *et al* 2003). This has been ascribed to reduced feed intake which allows food to remain in the digestive tract for a longer period of time.

According to Rahjhan (2001), the large variations in the ability of animals to utilize different diets could be attributed to the anatomical and physiological differences in their digestive tracts; and the digestibility of roughages in non-ruminants (and pseudo-ruminants) is lower than in ruminants. Consequently, the Total Digestible Nutrient (TDN) values of the feeds for these animals are lower. Therefore, they cannot be satisfactorily raised on the forage diets alone.

Van Zyl *et al* (1999a) observed that digestibility coefficients of the cane rats for neutral-detergent fibre and protein seem to be intermediate to high when compared to reported values for the porcupine, guinea-pig, degu and rabbit. They reported digestion values of 52.9-88.3%, 50.4-87.2%, 48.3-91.2%, 36.3-80.4% and 44.9-82.7% for dry matter, energy, crude protein, NDF and ADF, respectively, in grasscutters, depending on the fibre levels. Digestibility of nutrients was found to decline with increasing levels of fibre.

2.7.1 Determination of Digestibility

Digestibility values provide information on the actual value of ingested nutrients, because undigested feed is not properly utilized in the body. A digestion trial involves a record of the nutrients consumed and of the amounts voided in the faeces. Modern methods use metabolism cages which ensures that the faeces collected is not contaminated with urine (Maynard and Loosli 1969; McDonald *et al* 1995). The food is mixed thoroughly and given to the animals for at least a week before the collection of faeces begins, in order to accustom the animals to the diet and to clear from the tract residues of previous foods. The use of an easily

distinguishable substance called marker, such as carmine, ferric oxide, soot, chromic oxide, gives a satisfactory result in Omnivora and Carnivora species. For herbivores, the ration is fed in constant daily amounts for an extended period. This experimental period is usually 5-14 days long, with longer periods being desirable as they give greater accuracy, by minimizing the effect of periodic fluctuations in faecal output.

In all digestibility trials, it is highly desirable that meals should be given at the same time each day and that the amount of food eaten should not vary from day to day. Faecal samples from each experimental animal are collected daily, weighed and kept in an air-tight polythene bag and stored in a refrigerator at 4°C. At the end of the trial individual samples are bulked and portions taken for chemical analysis. Apparent digestibility is estimated as nutrient consumed minus nutrient voided in faeces over nutrient consumed (McDonald *et al* 1995).

2.7.2 The effect of fibre on digestibility of nutrients and Performance

Van Zyl *et al* (1999a) reported that high fibre levels in the diet of the cane rat would decrease the digestibility of dry matter, protein and fat in these animals. It was found that dry matter and protein digestibility decreased with an increasing percentage of cell walls in the diet of pigs and rats (Keys *et al* 1970). The effects of adding 5%, 10%, or 15% acid detergent fibre to a nonfibrous basal diet were examined in a comparative feeding study with Polynesian rats (*Rattus exulans*) and laboratory rats by Garrison *et al* (1978). They observed a significant decline in digestibility coefficients for dry matter, crude protein, and gross energy in both species as fibre content increased.

Reduced digestion of nutrients (e.g. protein and fat) as a result of increased fibre may be ascribed to various factors. It was reported for ostriches (also

monogastric hindgut fermentors) that fibre increases the passage rate of food in the stomach and intestine, while components of digesta are retarded in the caecum during microbial fermentation (Swart *et al* 1993). The period of vertebrate enzyme action on the proteins and fats in the food is thus shortened. In other hystricomorph rodents such as degus, *Octodon degu*, turnover rates, feeding rates and the volume of digesta increased on a 57% NDF diet compared to a 35% NDF diet (Bozinovic 1995). Sakaguchi and Ohmura (1992) stated that the retention time of digesta increases with body size for species from the same taxonomic class having similar food habits. Two other reasons why high fibre levels decrease digestion of nutrients in cane rats are that fibre protects constituents of food from the attack by digestive or microbial enzymes (Bondi 1987) and the water-binding capacity of fibre reduces the diffusion rates of digestion products to the mucosal surfaces, which tends to lower digestibility and absorption of these products (Dierick *et al* 1989).

The fibre level in the diet of animals would, therefore, affect the performance of the animals. Van Zyl *et al* (1999a) observed that high fibre levels in the diet influenced the performance of cane rats as animals on the high fibre diet exhibited lower growth rates (body weight gain) than animals on the low fibre diet during their feeding trial. Kornegay (1978) and Dierick *et al* (1989) also reported this where the growth performance of pigs decreased when the fibre content of the diet was increased.

2.8.0 Growth in Grasscutters

Growth can be defined as a correlated increase in the mass of the body in definite intervals of time, in a way characteristic of the species. It is the normal process of increase in size produced by the accumulation of tissues that are similar in

composition to that of the original tissue or organ (Gillespie 1998). Subject to individual variability, there is a characteristic rate of growth for each species and a characteristic adult size and development (Maynard and Loosli 1969). Lawrence and Fowler (1997) observed that the growth cycle of each organ and tissue does not occur in synchrony. Generally, the shape of the animal and the proportions of the tissues and parts alter considerably during growth in response to the current and future physiological needs. The sequence of growth has been described as: 1. nervous tissue; 2. bone; 3. muscle and 4. fat. The skeleton develops earlier in postnatal growth period; the growth curve for bone shows that there is significantly less bone growth after the animal is weaned (Gillespie 1998).

McDonald *et al* (1995) indicated that the simplest manifestation of growth in farm animals is their increase in size and weight. Growth involves an increase in the structural tissues such as muscles and bone and also in the organs. This does not include that which results from fat deposition in the reserves and accumulation of water. This growth is characterised primarily by an increase in protein, mineral matter and water (Gillespie 1998). This growth is readily appreciated and can be subjected to quantification either by weighing or by linear measurement (Lawrence and Fowler 1997).

As animals grow they do not simply increase in size and weight but also develop. That is, the various parts of the animal grow at different rates so that the proportion of the animal changes as it matures. Gillespie (1998) identifies genetic potential, nutrition, sex and environment as the major factors that affect the growth rate of animals after they are weaned. It is considered that the maximum size and development are fixed by heredity. Nutrition is an essential factor determining whether this maximum will be reached, and an optimum nutritional regime is one

which enables the organism to take full advantage of its heredity (Maynard and Loosli 1969; Gillespie 1998).

According to McDonald *et al* (1995), features of the animal's environment, particularly nutrition cause its growth to depart from the sigmoid curve. Gillespie (1998) explains that the general shape of the growth curve in animals is modelled by two opposing forces, a growth accelerating factor and a growth retarding force. He said the growth rate at any given time depends on the magnitude of each of these opposing forces. The growth accelerating force is present in body cells or in the individual cells constituting a population of single-celled individuals. The growth-retarding force is found in the environment surrounding the cells or the individuals in a population. This force involves exhaustion of the supply of essential nutrients, the accumulation of waste products, which results in toxic environment and/or space limitation.

Periods of food scarcity (cold or dry season) may retard growth or even cause the animal to lose weight. Periods of food abundance will allow the animal to grow rapidly. Generally, animals kept under intensive husbandry will follow the normal growth curve. However, inadequate nutrition delays peak muscle growth and slows the rate of fat deposition, whereas proper nutrition hastens the occurrence of peak muscle growth and rates of fat deposition. The mature size of farm animals is related to the rate and the efficiency of gain from birth to market weight, although other factors are also involved (Gillespie 1998).

2.8.1 Measurement of growth

Lawrence and Fowler (1997) outlined a number of techniques for measuring different aspects of growth in live and slaughtered farm animals, including weight,

linear and circumference measurements. According to Gillespie (1998), average daily gain and weight per day of age are two measures used to determine the growth rate of animals – average daily gain for slaughter animals and weight per day of age for breeding animals. Average daily weight gain (ADG) is calculated as total weight gain divided by the duration of the experiment. Other measurements used to determine the value of an animal are often related to its ultimate use. Loin eye area and back fat thickness are often used as measures of growth in pigs produced primarily for slaughter.

Pond *et al* (1995) indicated that growth, as measured by increase in body weight (Maynard and Loosli 1969), is at its most rapid rate early in life, declines gradually until puberty, followed by an even slower rate until maturity. Schrage and Yewadan (1999) observed a similar growth pattern in grasscutters. Daily weight gain is highest between the 8th and 14th month of age and decreases thereafter. Growth rate decreases as the biological stimulus to grow is lessened, because young animals cannot continue to eat as much per unit of metabolic size (Pond *et al* 1995).

The growth of the grasscutter is very slow. Whereas the breeding rabbit reaches 3 kg at the age of 12 weeks, the same weight is not obtained in the grasscutter before 40 weeks (Alogninouwa *et al* 1999). The male and female grasscutters attain the weight of 2.5-4.5 kg and 2-3 kg, respectively, by the 12th month of age (Mensah 1993; 1995).

Ikpeze and Ebenebe (2004), in their study to investigate the productive performance of grasscutters reared under floor housing, open cage and closed cage housing systems, reported average daily weight gains in favour of the floor (8.75 g/d) over the open-cage (7.27 g/d) and the closed-cage (7.22 g/d) housing systems. Mensah and Okeyo (2005) also reported an average daily gain of between 7 -12

g/day for both male and female grasscutters. Van Zyl *et al.* (1999a) also reported average daily gains of 3.5-11.6 g per day for growing grasscuters fed either low or high fibre diet. Kenfack *et al* (2006) recorded an average daily gain (ADG) of 4.44±0.47 g for early weaned grasscutters fed on extruded expanded diet and 4.97±0.14 g for the lately weaned fed on the extruded and expanded diet. These were significantly (P<0.05) greater as compared to that of grasscutters fed on the non expanded diet (3.50±0.70 and 3.31±0.72 g).

Adu and Wallace (2003) recorded a growth rate of 12.1±1.14 g/day when grasscutters were fed freshly cut *Panicum maximum* without drinking water. This was comparable with values quoted for animals fed supplementary diet with a crude protein content of between 15 – 18%. Again, in an investigation to test the efficacy of different dose levels of albendazole for reducing faecal worm egg count in naturally infected captive grasscutters, Adu *et al* (2005) recorded average daily gains of 2.21±2.32 g to 8.18±2.32 g. The untreated grasscutters grew faster than the treated grasscutters, perhaps due to a possible toxicosis of albendazole in the grasscutters.

2.8.2 Effect of Sex on Growth

Sex has been found to influence growth rate in farm animals. In an experiment to compare the growth of first-cross Border Leicester x Merino ram, cryptorchid and wether lambs, Lee (1986) observed that the growth rate of wether lambs (221 g/day) was less (P< 0.01) than that of rams and cryptorchids (308 and 280 g/day, respectively, P = 0.076). Earlier studies by Martin and Stob (1978) showed similar trend when growth and carcass traits of Holstein steers, bulls, and bulls implanted with diethylstilbestrol were compared. Growth rate was highest for implanted bulls (1.30 kg/day), followed by bulls (1.19 kg/day), and steers (1.08

kg/day). In the case of the pig the superiority of the boar over the castrated male in the weight range 20-100 kg is well established, and is generally in the order of 0.10-0.12 (Lawrence and Fowler 1997) but may depend on whether *ad libitum* or restricted feeding is practised, because the castrated male has a greater appetite than the boar (Fowler *et al* 1981). In an attempt to analyze the effect of castration on growth performance of the grasscutter, Alogninouwa *et al* (1999) found growth rate of castrated grasscutters to be lower than that of intact males, but higher than that of the females in the study. The weight gain was positively correlated with the blood thyroxine concentration and negatively correlated with blood cortisol concentration.

Testosterone is an extremely potent growth stimulant contributing to the superior growth rates of entire males, compared with castrated males, in cattle, sheep, pigs and poultry. This is because testosterone stimulates muscle growth. According to Lawrence and Fowler (1997), the gonadal steroid hormones are particularly important in stimulating the increased growth which is apparent in all animals at puberty and as anabolic agents they increase the efficiency of utilization of nitrogen from diets. Heitzman (1981) have proposed that gonadal steroids influence muscle growth by a direct effect on protein synthesis and/or degradation, mediated by a direct entry into the muscle cells. They indirectly influence muscle growth by facilitating the secretion of other hormones, which in turn exert anabolic effect in the muscle.

2.8.3 Growth and Nutrition Interaction

From nutrition standpoint, growth requires a large intake of energy-producing nutrients, protein and adequate supply of the various vitamins and minerals concerned. A minute amount of lipid material goes into the structure of each cell, but

this does not represent a specific dietary requirement with the exception of the essential fatty acids in view of the synthesis of lipids from carbohydrate (Maynard and Loosli 1969). Nutrition is known to affect the proportions and sizes of parts on body weight (Lawrence and Fowler 1997). According to McDonald *et al* (1995), animal growth and nutrition interact with one another in the sense that each can influence the other. The growth pattern of an animal determines its nutrient requirements. Conversely, by altering its nutrition, an animal's growth pattern can be modified. Another aspect of the interaction is that the growth pattern of animals determines the composition of the product of growth, meat, and so affects the consumer of the meat (man).

The aims of controlling animal growth with nutrition are to use the nutritional resources to achieve a rate of growth, and to produce a carcass that meets the requirements of the consumer. The growth rate of growth of an animal is controlled by its nutrient intake, especially by its energy intake (Maynard and Loosli 1969; McDonald *et al* 1995). A rapid rate of growth is desirable because it minimizes the overhead cost of maintenance per unit meat produced (McDonald *et al* 1995). The total requirement for a given nutrient during growth must include amount needed for maintenance as well as the amount needed for the new tissue formed. Nutrient requirement per unit of body weight or metabolic size are greatest for very young animals. The needs taper off gradually as the growth rate declines and as the animal approaches maturity (Pond *et al* 1995).

Protein is laid in the body of an animal during growth. According to Rahjhan (2003), the amount of protein laid down depends upon the amount of protein given, biological value of protein and energy available for synthesis of protein. The energetic efficiency with which the feed is used for growth of protein mass in the

animal is more than for fat synthesis. However, laying of protein mass and fat deposition take place simultaneously.

2.8.3.1 Importance of Nutrients in the Growth of Grasscutters

Energy is probably the most important nutritional consideration in grasscutter nutrition. Animals require energy to grow and to keep the body functioning. Energy is required for mechanical work of essential muscular activity, for chemical work such as the movement of dissolved substances against concentration gradients and for synthesis of expended body constituents such as enzymes and hormones. In the fed animal, the primary demand for energy is meeting this requirement for body maintenance and so preventing the catabolism of the animal's tissues.

The most important nutritional factor affecting the efficiency of a well balanced ration is its energy component. Eshiet *et al* (1980) indicate that energy supply in the diets of rabbits is critical for maximum utilisation of nutrients. Energy supplied by food in excess of that needed for maintenance is used for the various forms of production such as growth. McDonald *et al* (1995) indicated that a growing animal will store energy principally in the protein of its new tissues. Carbohydrates and fats are the primary sources of energy in the diet. Besides being a source of energy, carbohydrates are building blocks for other nutrients. The excess energy in a diet is deposited as fat, which provides insulation and protection for the body.

Fattening livestock requires a large amount of energy nutrients. McDonald *et al*. (1995) identified linoleic, linolenic and arachidonic as essential fatty acids for normal growth in animals. Rations fed to farm animals normally contain enough of these fatty acids to meet their physiological needs (Gillespie 1998). Energy not used

for other needs is deposited as fat within the body tissues. The deposition of fat in the tissues makes the meat tender and juicy and gives it a better flavour.

Protein is the second limiting nutrient in most rations. It is the principal building block of most tissues. Proteins are complex organic compounds formed as a result of polymerisation of simple monomers of amino acids bound together by peptide bonds to form complex compounds of high molecular weight. McDonald *et al* (1990) indicated that the life of the cell and all its phases of activities are intimately connected with protein and amino acids. The biological value of protein can be ascertained by how effectively its amino acid content satisfies the requirement of the animal. The most essential amino acids required by animals include methionine, lysine, tryptophan, cysteine, arginine, leucine, isoleucine, phenylalanine and tyrosine. It must be noted that no one ingredient contains all the nutrients in high proportions as such several ingredients are needed in a mixed ration to supply the needed nutrients required by animals. Adu and Wallace (2003) speculated that the grasscutter may have a requirement for species-specific nutrients probably vitamin C and/or arginine much like the guinea pig for body synthetic reactions.

If dietary energy is not adequate to meet demands, it can be supplied by the breakdown of body fat and muscle. However, there is no way for the body to compensate for prolonged low levels of dietary protein. Therefore, diets deficient in energy, protein or both can result in a protein deficiency and a loss of body condition. Without adequate amounts of protein in the diet, daily feed consumption drops off, feed passage rates decrease and overall digestive efficiency declines. There is specific protein to energy ratio for optimum growth and feed efficiency of animals. No ratio has been reported for grasscutters; however, as the energy content of the

feed increases, the protein content must equally increase to maintain a balanced ratio for optimum growth since the two are closely linked (Matterson *et al* 1955).

Water is the least expensive nutrient in the diet and should always be available to livestock. It makes up about 50 to 70 per cent of body weight. A mature grasscutter drinks between 25 and 150 ml of water a day (Mensah 1995), depending on the temperature and humidity. Animals will lose their appetite, dehydrate and can possibly die if enough water is not available. Water quality is also an important consideration - for example, high sodium and sulphate levels can affect water intake.

Minerals and vitamins, though needed in small quantities by animals, are very vital in the proper functioning of the body enzymes, biochemical activities, health status and reproductive performance of grasscutters. Minerals are loosely classified as macro or micro minerals depending on the relative amounts needed or present in the body. Macro minerals include calcium, phosphorus, magnesium, potassium, sulphur, sodium and chloride. Cobalt, copper, iodine, iron, manganese, molybdenum, selenium and zinc are considered micro or trace minerals. Rations that contain a high percentage of forage usually supply adequate amounts of calcium but may be low in phosphorus. However, rations high in grain contain adequate phosphorus but may be deficient in calcium and other minerals. Micro or trace mineral deficiencies are associated with soil type and are usually geographically related.

Abnormal levels of some minerals such as iron and cobalt do not usually cause a problem with reproduction. Calcium, phosphorus, magnesium and vitamin D are known to be essential for skeletal growth in animals. Calcium and phosphorus ratio in the diet of animals must be considered since abnormal ratios may be as harmful as the deficiency of either element in the diet. Vitamin D facilitates the utilization of calcium and phosphorus in the animal.

Iodine is known to play essential roles in the synthesis of triiodothyronine and tetraiodothyronine (thyroxine) produced in the thyroid gland. The element also occurs in the gland as monoiodotyrosine and diiodotyrosine which are intermediates in the biosynthesis of the hormones from the amino acid tyrosine. The thyroid hormones accelerate reactions in most organs and tissues in the body, thus increasing the basal metabolic rate, accelerating growth and increasing the oxygen consumption of the animal.

Minerals and vitamins are obtained from the feed given to animals. When in short supply, supplementation must be made from the feed or synthetic sources. Oyster shell meal, bone meal and dicalcium phosphate are some sources of calcium and phosphorus in grasscutter diets. Vitamin/mineral premix is a synthetic vitamin-mineral complex that provides most of the vitamins and trace minerals in the diet of farm animals. The grasscutter is known to obtain water soluble-vitamins through coprophagy, synthesized by microbes in the caecum (McDonald *et al* 1995).

Fibre level in the diet has been found to affect growth rate in grasscutters. Van Zyl *et al* (1999a) investigated the extent to which a 45% increase in the fibre component of diets influenced growth rates of cane rats and the digestibility of nutrients and energy in two feeding trials. Higher fibre levels in the diet reduced the digestibility of dry matter, protein and fat, while animals digested fibre components (neutral-detergent fibre, acid detergent fibre, hemicellulose and cellulose) with a comparable efficiency to those maintained on a low fibre diet.

2.9.0 Carcass Traits and Composition of the Grasscutter

Several parameters are used to determine the carcass traits of farm animals. Some of these parameters include dressing percentage, carcass length, meat colour

and flavour, weight of head, weight of internal organs, etc. Robertson-Bulluck (1962) and Talbot *et al* (1965) suggested the use of the relationship between gross weights, dressed carcass and visceral weights in assessing meat production of African wildlife. It appears that the grasscutter compares favourably with a number of domesticated species on these criteria.

The relationship of chilled carcass to live weight is referred to as the dressing percentage of the animal. Young animals have a lower dressing percentage than older animals because, as the animal becomes older and gains in weight, the proportion of the viscera to the rest of the body decreases. Gillespie (1998) identifies factors that affect dressing percentage in animals as: amount of gut fill, weight of animal, degree of muscling, weight of the hide and degree of fatness. The live weight and dressing out percentage of the cane rat (Ajayi and Tewe 1980) exceed those of the giant rat and the domestic rabbit *(Oryctolagus cuniculus)*. Ajayi and Tewe (1980) reported a dressing percentage of 63.8±2.43 and flesh to bone ratio of 3.5:1 for grasscutter carcass. Jori *et al* (1995) also reported a dressing percentage of 64% for both male and female grasscutters. These values were higher than values of 52.79-57.79 (Omojola and Adesehinwa 2006) and 46.9-48.9% (Ghosh and Mandal 2008) for rabbits.

Previous report by Hamm (1982) and Claus *et al* (1984) showed that post-mortem handling of meat carcasses affect to a larger extent the quality traits of meat. The dressing method employed, such as singeing, which is a method widely practised in the home for processing of stocks like goats, sheep, grasscutter and rabbits is a source of variability of the meat quality. Omole *et al* (2005) investigated the effect of scalding and flaming methods of processing on physico-chemical and organoleptic properties of the grasscutter meat. The result shows that flaming method

of processing of grasscutter improved the taste, flavour and general acceptability better than scalding method. The two methods of processing had no effect on the weight of the organ and the dressing percentage, also the chemical composition of the meat was not influenced by the two processing methods hence recommended the use of either of the two methods of processing the fur. The carcass analysis as affected by scalding and flaming is shown in Table 2.3 below.

Table 2.4: Carcass analysis as affected by scalding and flaming.

Variables	Scalding	Flaming
Live weight (kg)	2.65 ± 0.12	2.64 ± 0.11
Defurred weight (kg)	2.55 ± 0.09	2.53 ± 0.10
Carcass weight (kg)	2.03 ± 0.11	2.03 ± 0.11
Dressing %	76.98 ± 3.28	76.96 ± 3.31
Head (kg)	0.24 ± 0.015	0.24 ± 0.013
Kidney (kg)	0.02 ± 0.001	0.02 ± 0.001
Lung (kg)	0.039 ± 0.001	0.038 ± 0.001
Liver (kg)	0.077 ± 0.023	0.077 ± 0.023
Heart (kg)	0.023 ± 0.005	0.023 ± 0.004

The proximate composition of the cane rat carcass shows that there is less fat on the giant rat as reported by Ajayi and Tewe (1980), Schrage and Yewadan (1999) and Omole *et al* (2005). Data obtained from Kramlich *et al* (1973) also indicate that beef, raw lamb and pork have higher fat contents than the cane rat. The protein content of the grasscutter (18.8 – 19.58%) exceeds that of the giant rat and most other domestic livestock except for poultry in which it is slightly higher. These reported values seemed lower than figures of between 19.43% and 21.95% for rabbits (Omojola and Adesehinwa, 2006). It has been established that the age of an

animal has a considerable effect on the protein and fat contents (Pond and Maner, 1974). According to Oseni and Adejuwon (2006), an annual productivity index of 4.64 would mean that a farmer raising 4 grasscutter does would have about 27.84 kg meat annually or 0.5 kg of meat per week based on a mature slaughter weight of 2.50 kg and a dressing percentage of 60%.

Ajayi and Tewe (1980) also reported weights of various body components of the grasscutter expressed as percentages of live weight. The values are shown in *Table 2.5*.

Table 2.5: Weights of various body components expressed as percentages of live weight

Organ	Mean value (± S.E.)
Head	10.5±11.7
Tail	1.4±0.13
Skin	10.2 ± 1.2
Heart	0.5 ±0.015
Lung	1.05±0.3
Stomach	0.75 ±0.025
Duodenum	0.79 ±0.019
Small intestine	0.63 ±0.014
Caecum	1.10±0.02
Large intestine	2.19 ±0.12

Source: Ajayi and Tewe (1980)

2.10.0 Cost of Production

Benefits of greater cane rat farming include a means of increasing and diversifying income sources, extra animal protein for the family and as an avenue for meaningful engagement or hobby. Many factors determine the feasibility of raising a species in captivity, including the species' biological parameters, such as

productivity and vulnerability to disease, and the cost-effectiveness of farming it (Miranda *et al,* 2005). If wildlife is "free for the taking", hunting is generally easier, faster, and cheaper than farming wildlife (Gumal *et al*, 1998). Grasscutter farming is only likely to be widely embraced, therefore, if production costs and efforts are lower than hunting (Ntiamoah-Baidu, 1997; Wilkie and Carpenter, 1999). According to Oseni and Adejuwon (2006), production constraints in grasscutter farming included high kid mortality (especially during the rainy season), labour requirements for forage harvesting and feeding and initial start-up capital.

The aim of pen feeding is to transform feed into meat of a required quality as efficiently as possible. The best measure we have of this in the live animal is food conversion efficiency (FCE), i.e. kg of feed per kg live weight gain. It is important to emphasize the efficiency of feed use, because, food constitutes the highest of the variable costs. So, together with the slaughter price of the animal, feed has the major influence on the profitability of the farm. This cost needs to be compensated for, as much as possible, with high performance to optimize margins and minimize any 'stand-still' time.

Fitzgerald (2007) indicated that it is vital that the value of weight gain covers the feed cost and other costs as well as leaving a margin to cover the farmer's labour input. Recent price rises in concentrates has made *ad lib* concentrate feeding less competitive than grass supplemented with a moderate amount of meal. However, the cost side is only half of the production equation. The weight gain and its value is the other side. Weight gain is under the control of the farmer while the value is set by market forces. Although rising meal prices have affected margins, *ad lib* concentrate diets can still be competitive if high performance is attained. *Ad lib* concentrate diets, therefore, require a high performance. Grasscutters are not the most prolific of rodent

species but the high demand, attractive market price and the small amount of investment required make grasscutter production a suitable minilivestock activity for income generation in many parts of West and Central Africa.

2.11.0 Inferences from the Literature Review

- The grasscutter is a monogastric herbivore but is known to adapt readily to different diets. It is also found to consume some amount of concentrates. The grasscutter is a hingut fermentor, thus the caecum plays a vital role in fibre digestion. Coprophagy in the grasscutter ensures that the products of digestion in the caecum become available to the animal.
- No systematic work has been done on the nutrient requirement of the grasscutter, however, crude protein and energy levels of 15-18% and 9-10 MJ/kg of feed, respectively, have been recommended for grasscutters in captivity. The grasscutter is known to consume about 150-250 g dry matter of forages and about 14-72 g of concentrates per day.
- The grasscutter is a slow grower, but good nutrition has proven to improve its growth rate. Increased levels of fibre in the diet of grasscutter were found to decrease digestibility of nutrients and reduce performance in the animal.
- The dressing percentage of an adult grasscutter has been reported to be around 64%, which is higher than that of the rabbit. Method of processing the fur has no effect on carcass characteristics.
- For people to embrace grasscutter production, the cost of production must be cheaper than hunting. Feed cost, which constitutes the highest variable cost, must be reduced and performance of the grasscutter improved through good nutrition in order to maximize profitability of the grasscutter industry.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1.0 Location and Duration of the Research

The experiment was conducted at the animal house of the Animal Science Department, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Kumasi is located in the southern central part of Ghana. It lies between Latitude 06°43'N and Longitude 01°36'W. It is in the transitional zone (semi-deciduous forest zone). It has hot-humid climate with mean annual temperature of 26.3°C (minimum monthly temperature of 20°C–28°C between December and January and maximum monthly temperature of 34°C between February and March). The rainfall is bimodal. The main rainy season occurs between March and July, with a short dry spell in August. The minor rains occur from September to October. The dry season begins in November and ends in February. The annual mean rainfall is about 1,250 mm. The mean annual Relative Humidity is 75%.

3.2.0 Experimental Animals and Management

A total of eighteen young male grasscutters of a mean (±SD) body weight of 1174±8.58 g were selected from the grasscutter stock of the Animal Science Department. The grasscutters were put into groups of similar mean body weight and were allotted to cages of equal space, each cage housing one of them, in a completely randomized design. An animal in a cage constituted a replicate. Each cage, measuring 50 cm x 50 cm x 40 cm, was equipped with similar concrete feeding and watering troughs. Feed and water were provided *ad libitum*.

3.2.1 Health, Sanitation and Management

The cages were scrubbed with a detergent and disinfected with CAMEL Antiseptic (PZ Cussons Ltd., Accra) before the experiment. The CAMEL antiseptic contained the active ingredient dichlo-meta-xylenol (2% w/w) and was mixed with water in the ratio 30 ml to 4.5 litres of water. The grasscutters were dipped with a 0.5% solution of bromocyclen (Finetech Industry Limited, Hubei) to control ectoparasites at the start of the experiment. They were also given 5% Banminth 48 (pyrantel tartrate) powder (Phibro Animal Health, Inc., New Jersey) applied at the rate of 500 mg per kg body weight, through their feeds, to control endoparasites.

3.3.0 Experimental Diets and Feeding

3.3.1 Processing of Feed Ingredients and Chemical Analyses

The palm kernel cake used for the experiment was sun-dried to a moisture content of 12-14%. The *Panicum maximum* was cut into pieces of about 2 cm long and sun-dried to a moisture content of 10-12%. The dried grass was milled using a hammer mill with 3 mm sieve. The ingredients, including maize, were milled into meal using a hammer mill at the Animal Science Department. The meals for the respective ingredients were stored in jute sacks until needed for the feed formulations. About 50 g of each ingredient was collected and kept in black polythene bags stored in a cool dry environment and later analyzed for their chemical contents.

The major ingredients (i.e. soyabean meal, maize, *Panicum maximum*, cassava flour, wheat bran and palm kernel cake) used in formulating the experimental diets were initially subjected to proximate analysis using the procedures of the Association of Official Analytical Chemists (1990). Samples of

the experimental diets were also subjected to proximate analysis. Acid detergent fibre (ADF) and neutral detergent fibre (NDF) (Goering and Van Soest, 1970) were estimated for the experimental diets. The procedures for Calcium and Phosphorus analyses of the experimental diets followed those of Fick *et al* (1979). Faecal Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were determined to estimate the fibre digestibility of the diets. The metabolizable energy (ME, kcal/kg) values were estimated using the methods of Pauzenga (1985) (see appendix 2). The chemical analyses were done at the laboratories of the Department of Animal Science of the Faculty of Agriculture and that of the Department of Biochemistry of the Faculty of Science, all of the Kwame Nkrumah University of Science and Technology (KNUST).

3.3.3 Diet formulation, Compounding and Feeding

There were three experimental diets, designated Diet 1, Diet 2 and Diet 3. The three diets were formulated to contain similar crude protein, calcium, phosphorus and energy levels. The grasscutters were given water and feed *ad libitum*. The feeding trial lasted for thirteen (13) weeks. The daily rations were measured and fed to the animals between 8.00 am and 9.30 am each day, according to the treatments. The leftover feed, including spilled feed, were collected and weighed the following day. Spilled wet feeds were sun-dried before weighing. Feeds mixed with excreta were sieved to separate them from the contaminant before weighing was done. BRAUN (Docbel Industries, New Delhi) Top-pan scale (1kg x 5g) was used for weighing the feeds.

Details of the diets, their unit cost and calculated chemical compositions are presented in *Table 3.1* below.

Table 3.1: Percentage Dry Matter Composition and calculated nutrient composition of treatment diets

Ingredients	Inclusion level (g/kg dry mass)		
	Diet 1	Diet 2	Diet 3
Panicum maximum	0.00	75.0	150.0
Palm kernel meal	182.5	182.5	182.5
Cassava root meal	100.0	100.0	100.0
Soybean meal	200.4	222.8	229.9
Maize	249.6	222.2	140.1
Wheat bran	250.0	180.0	180.0
Dicalcium phosphate	10.0	10.0	10.0
Common salt	5.0	5.0	5.0
[1]Vitamin/mineral premix	2.5	2.5	2.5
Total	1000.0	1000.0	1000.0
Calculated Nutrient Composition			
Crude protein	195.0	195.0	195.0
Crude fibre	95.1	116.2	143.7
Ether extract	29.6	26.6	24.2
Ash	43.6	45.3	49.4
Methionine + cystine	5.8	6.0	6.1
Lysine	9.1	9.8	10.4
Tryptophan	2.6	2.7	2.8
Threonine	6.4	6.9	7.1
M.E. (MJ/kg)	13.0	12.6	12.1

[1]Vitamin/min. premix composition = Vit. A (800 IU), Vit. D (3000 IU), Vit. E (8 IU), Vit. K (2 mg), Vit. B1 (1 mg), Vit. B2 (2.5 mg), Vit. B12 (5 mg), Niacin (10 mg), Panthothenic acid (5 mg), Antioxidant (6 mg), Folic acid (0.5 mg), Choline (150 mg), Iron (20 mg), Manganese (80 mg), Zinc (50 mg), Cobalt (0.225 mg), Iodine (2 mg) and Selenium (0.1 mg)

3.5.0 Parameters Measured

The performance of the animals was monitored in terms of feed consumption, weight gain and feed conversion ratio for the 13-week period. Economics of production and some carcass characteristics were also determined.

3.5.1 Feed Intake

Feed intake was calculated as the difference between feed offered and feed left over. The cumulative daily feed intake for the whole experimental period was calculated to obtain total feed intake. Average daily intake was calculated as the total intake divided by the number of days of the experiment (i.e. 91 days). Average Total Dry Matter Intake and Average Daily Dry Matter intake were also calculated.

3.5.2 Apparent Digestibility

The apparent trial followed the thirteen-week feeding trial. Three (3) male grasscutters from each treatment group were selected, and each was placed in a metabolism cage for the apparent digestibility. Each animal was given a known amount of the treatment diet; and after allowing a forty-eight (48) hour preliminary period for the digestive tract of the animal to be freed of any indigestible material coming from the feed consumed prior to the start of the feeding. When the collection of the faeces was begun it lasted for seven (7) days.

All the faeces voided were collected by tying a mosquito wire netting under each cage. Faecal samples from each experimental animal were collected daily, weighed and kept in an air-tight polythene bag and stored in a refrigerator at 4°C. At the end of the seven days individual samples were bulked and portions taken for chemical analysis. Digestibility coefficients for dry matter, crude protein, acid

detergent fibre (ADF) and neutral detergent fibre (NDF) were determined (see appendix 1 for the relation).

3.5.3 Weight gain

The animals were weighed at the start and the end of the experiment to obtain their initial weights and final weights. Total weight gain was determined for the various treatments by calculating the difference between the final average weights at the end of the experiment and the initial average weights. Average daily weight gain (ADG) was calculated as total weight gain divided by 91 days (i.e. duration of the experiment).

3.5.4 Feed conversion ratio (FCR)

Feed conversion ratio was determined as the ratio of total dry matter intake over the total weight gain.

3.5.5 Economics of production

Economics of production was estimated based on the feed cost per kg gain. Feed cost per kg of each of the experimental diets was estimated based on the prices of the ingredients at the time of the trial. Harvesting and transportation costs constituted the cost of grass. Feed cost was calculated as the product of cost per kg diet and total feed intake. Also, feed cost per kg gain was calculated for individual dietary treatments as a product of the feed cost per kg diet and feed conversion efficiency.

3.5.6 Carcass parameters

Three grasscutters were randomly selected and slaughtered at the end of the feeding trial for carcass analysis. Prior to slaughtering, the grasscutters were fasted for 24 hours but had access to water. After slaughter, carcasses were defurred by scalding, eviscerated, weighed and chilled at 4°C for about 24 hours. Carcass parameters measured included live-weight at slaughter, dressed weights (hot and cold), weight of dressed head, weight of giblet and carcass length. Weight of loin, thighs, shoulders and thorax were also measured. Others included the weight of gastro-intestinal (GI) tract (whole and empty), kidneys, lungs, heart, spleen, undressed head and tail.

The dressing percentage was obtained from the dressed weight (cold) expressed as a percentage of the weight at slaughter. After splitting the carcass into two, the distance between the first rib and the anterior edge of the pubis symphysis gave the carcass length. The absolute weight of the GIT was determined when full and after the contents had been removed (empty). The organs were then expressed as a percentage of the live weights. The weight of the shoulders, thighs, loin, and thorax were also expressed as a percentage of the dressed weight.

3.6.0 Statistical Analysis

Data on body weight, feed intake, nutrients digestibility and carcass characteristics were subjected to ANOVA using a computer statistical package called Costat (Cohort Software, 2005). The Duncan's Multiple Range Test was used to separate significant mean differences between treatments at the 5% significance level. The results from the analysis are shown in chapter four.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1.0 Chemical composition of the feed ingredients and experimental diets

Table 4.1: Proximate composition of some feed ingredients (DM Basis)

Ingredient	Dry matter (%)	Crude protein (%)	Ether extract (%)	Ash (%)	Crude fibre (%)	Nitrogen free extract (%)	M.E[1] (MJ/kg)
Wheat bran	86.2	16.7	4.5	5.3	12.4	61.2	13.2
Maize	86.9	8.9	4.1	1.4	2.6	83.1	15.1
Palm kernel meal	85.5	20.9	10.0	6.1	22.4	49.7	10.9
Soyabean meal	87.4	44.8	1.9	6.0	6.1	41.3	13.7
Panicum maximum	88.4	5.5	1.2	6.2	39.0	48.3	8.4
Cassava root meal	87.1	3.3	0.3	1.9	4.5	90.0	14.0

[1] *Metabolizable energy was estimated using the formula of Pauzenga (1985).*

The proximate composition of the major ingredients used in formulating the experimental diets is shown in Table 4.1. Values obtained were found to be similar to values reported in previous studies. However, crude protein (CP) level in *Panicum maximum* was found to be lower than earlier reported values of 8.9-9.6% (Orsar and Agbelusi 2006; Odedire and Babayemi, 2008; Annor *et al* 2008). Age is known to influence nitrogen concentration in plants. Mature plants tend to have lower nitrogen concentration than younger ones. The lower CP level recorded for *P. maximum* in this study may be attributable to the fact that the grasses were harvested at 12th week of regrowth, a stage known to have reduced nitrogen concentration (Grof and Harding 1970). Previous researchers used *Panicum maximum* harvested at much

younger stage. The ash level obtained for *P. maximum* falls within the range of 3–12 % published by Bogdan (1977) and Gillespie (1998).

Table 4.2: Chemical Composition of Experimental Diets (DM Basis)

Constituent	Mean (g/kg dry mass)		
	Diet 1	Diet 2	Diet 3
Dry Matter	894.9	883.6	887.4
Crude Protein	192.4	192.3	192.0
Ether Extract	16.6	28.2	15.6
Crude Fibre	76.8	93.9	116.5
Ash	91.5	88.2	88.7
Nitrogen Free Extract	622.7	597.4	587.2
Acid Detergent Fibre	162.8	171.5	253.7
Neutral Detergent Fibre	428.5	516.0	544.6
Calcium	29.5	27.2	31.6
Phosphorus	13.6	14.7	13.7
[2]ME (MJ/kg)	12.78	12.80	12.22

[2]Metabolizable energy was estimated using the formula of Pauzenga (1985)

Table 4.2 above shows the chemical composition of the experimental diets. The difference in fibre content between diet 1 and diet 3 was 9% in acid detergent fibre and 12% in neutral detergent fibre. Crude protein levels remained 19% in all the three experimental diets.

The chemical composition of the diets compared favourably with the recommended diets found in the literature. The level of acid detergent fibre in Diet 3 (15% grass diet) was found to be higher than the 13 – 17% level recommended by Pond *et al.*(1995), but the neutral detergent fibre levels in all the diets were within

the range of 42–64% recommended by Mensah and Okeyo (2005) for adult grasscutters. The diets contained similar crude protein levels of 19.24%, 19.23% and 19.20% for diets 1, 2 and 3, respectively. These levels were higher than the minimum of 17% suggested by Pond *et al* (1995) for herbivores in captivity.

Calcium and phosphorus levels were similar for the experimental diets. Calcium and phosphorus levels (Table 4.2) were found to fall within the ranges of 2.72-3.16% and 1.36-1.47%, respectively. These values were found to be higher than values of 0.2-0.7% and 0.35-0.9% suggested by Pond *et al* (1995) and Schrage and Yewadan (1999). However, the 1-2:1 calcium to phosphorus ratio recommended by McDonald *et al* (1995) was met.

The fibre component (NDF and ADF) differed in the diets. Diet 3 (15% *P. maximum)* was found to be higher in both acid detergent fibre (ADF) and neutral detergent fibre (NDF) with levels of 25.37% and 54.46%, respectively. Diet 2 (7.5% *P. maximum)* was next with levels of 17.15% and 51.60% of ADF and NDF, respectively. Diet 1 (no *P. maximum*) had lowest values of ADF (16.28%) and NDF (42.85%). ADF level in diet 3 was found to be higher than the 13-17% levels recommended by Pond *et al* (1995). The NDF levels were within the range of 42-64% recommended by Mensah and Okeyo (2005) for grasscutters. The higher ADF and NDF levels in diet 3 may be due to the higher inclusion rate of *P. maximum* which was found to contain the highest fibre component (Table 4.1).

The energy content of diet 3 was slightly lower compared to the levels in diets 1 and 2. All the same, the metabolisable (ME) levels (12.22-12.80 MJ/kg) of the three experimental diets were high enough to support at least a moderate growth rate as was seen in the present study. The energy content of the three experimental diets compared favourably with the 9.3-13.9 MJ/kg suggested by Mensah and Okeyo

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(2005) for grasscutters. The inclusion of maize and cassava meal, which are known to have high energy values, could have contributed to the high energy content of the diets. The chemical contents of the diets, therefore, appeared adequate to support a reasonable productive performance. This was illustrated in the present study as all the experimental animals gained weight over the 13 week period.

4.2.0 Apparent Nutrient Digestibility of Experimental Diets

The apparent nutrient digestibility values of the experimental diets are shown in *Table 4.3* and *Figure 4.1* below.

Table 4.3: Apparent Digestibility of diets fed to *T. swinderianus* (Mean)

Parameters	Mean (g/100 g dry mass)			
	Diet 1	Diet 2	Diet 3	SEM
Total faecal output (DM), g	97.4^{b}	98.5^{b}	138.3^{a}	1.11
Digestible DM/metabolic wt, g/kg $W^{0.75}$	457.0	457.2	437.9	12.57
Apparent Digestibility				
Dry Matter	78.7^{a}	77.3^{a}	64.6^{b}	0.52
Crude Protein	88.1^{a}	86.3^{a}	77.5^{b}	0.32
Neutral Detergent Fibre	68.9^{a}	70.5^{a}	56.0^{b}	0.68
Acid Detergent Fibre	63.6^{a}	59.0^{ab}	55.0^{b}	0.77
Hemicellulose	75.1^{b}	78.8^{a}	62.0^{c}	0.66

SEM= Standard Error of Means
a, b, c= means in same horizontal row with different superscript are significantly different (P<0.05).

Significant differences (P<0.05) were observed in the apparent digestibility of dry matter, crud e protein and fibre components (NDF, ADF and hemicellulose) between treatments. Apparent digestibility of dry matter, crude protein and NDF was similar (P>0.05) for diets 1 and 2 but significantly (P<0.05) lower for diet 3. ADF

was significantly ($P<0.05$) different between diets 1 and 3 only, however, hemicellulose digestibility differed significantly ($P<0.05$) between treatment groups. The digestible dry matter intake per metabolic weight ($W^{0.75}$) was similar ($P>0.05$) for the three diets. The apparent digestibility values obtained in this study agree with values obtained by Van Zyl *et al* (1999a). They used acid detergent fibre (16.6-33.6%) and neutral detergent fibre (29.8-55.3%) levels comparable to what were used in the present study and reported values of 52.9-88.3%, 48.3-91.2%, 44.9-82.7%, 36.3-80.4% and 30.7-73.8% for dry matter, crude protein, ADF, NDF and hemicellulose, respectively. Their values were influenced by fibre levels as is being suggested in the present study. The present results are, however, superior to the 66-68% dry matter digestibility and 57-59% crude protein digestibility reported by Obi *et al.* (2008) for grasscutters.

Crude protein digestibility was highest in all the three experimental diets and ADF digestibility was lower in the three diets. Apparent digestibility of dry matter, crude protein and ADF were highest for diet 1, followed by diet 2 and diet 3 in that order, except for NDF and hemicellulose, which were highest for diet 2 and lowest for diet 3. This trend is attributable to the increasing levels of fibre (specifically ADF) in the diets. For example, apparent digestibility values for dry matter were 78.7% for diet 1, a lower fibre diet (16.28% ADF), as compared with 77.3% and 64.6% for diets 2 (17.15% ADF) and 3 (25.37% ADF), respectively (Table 4.2). Van Zyl *et al* (1999a) observed a similar trend where higher fibre levels in the diet reduced the digestibility of dry matter, protein and fat.

The digestibility of a food is closely related to its chemical composition. The fibre fractions of food have the greatest influence on its digestibility and both the amount and chemical composition of the fibre is important (McDonald *et al*, 1995).

The digestibility of cell walls depends on the degree of lignification, i.e. the lignin content of acid detergent fibre (ADF). ADF is inversely related to the diet's digestibility (McDonald *et al* 1995; Gillespie 1998). Graded proportions of *Panicum maximum* in the experimental diets perhaps caused the differences in apparent digestibility of dry matter, NDF and ADF, with the 15% inclusion rate giving the lowest digestibility values for diet 3.

It was found that dry matter and protein digestibility decreased with an increasing percentage of cell wall content in the diet of pigs and rats (Keys *et al* 1970). ADF intake was found to correlate negatively with dry matter ($r = -0.5014 \pm 0.33$) and crude protein ($r = -0.5931 \pm 0.30$) digestibility. These relationships were, however, not significant ($P>0.05$) (*see appendix 4, pp. 82*).

Reduced digestion of nutrients (e.g. protein and fat) as a result of increased fibre may be ascribed to various factors. It was reported for ostriches (also monogastric hindgut fermentors) that fibre increases the passage rate of food in the stomach and intestine, while components of digesta are retarded in the caecum during microbial fermentation (Swart *et al* 1993). The period of vertebrate enzyme action on the proteins and fats in the food is thus shortened. In other hystricomorph rodents such as degus, *Octodon degu*, turnover rates, feeding rates and the volume of digesta increased on a 57% NDF diet compared to a 35% NDF diet (Bozinovic 1995). Turnover rates were, however, not measured in the present study. Two other reasons why high fibre levels decrease digestion of nutrients in cane rats are that fibre protects constituents of food from the attack by digestive or microbial enzymes (Bondi 1987) and the water-binding capacity of fibre reduces the diffusion rates of digestion products to the mucosal surfaces, which tends to lower digestibility and absorption of these products (Dierick *et al* 1989).

4.3.0 Performance of grasscutters fed the formulated diets

The performance of the grasscutters fed the formulated diets with graded levels of *P. maximum* (0%, 7.5% and 15%) is summarized in *Table 4.4* below.

Table 4.4: Performance of grasscutters fed the experimental diets.

Parameters	Dietary treatments			
	Diet 1	Diet 2	Diet 3	SEM
Initial live weight, *g*	1167	1172	1170	45.77
Final body weight, *g*	2357^{a}	2177^{a}	1817^{b}	65.97
Total body weight gain, *g*	1190^{a}	1005^{a}	646^{b}	55.92
Average daily gain, *g/day*	13.08^{a}	11.04^{a}	7.11^{b}	0.61
Average total feed intake, *g*	6805	6122	5726	234.28
Average daily feed intake, *g/day*	73.18	65.83	61.57	2.52
Average daily dry matter intake, *g/day*	66.20	58.80	53.84	2.30
Feed conversion ratio	5.23^{b}	5.67^{b}	8.12^{a}	0.37
Cost/kg of feed, *GH¢*	0.2427	0.2483	0.2333	-
Feed cost/kg live weight gain, *GH¢*	1.2700^{b}	1.4079^{b}	1.8952^{a}	0.09

SEM= Standard Error of Means
a, b, = means in same horizontal row with different superscript are significantly different (P<0.05).

4.3.2 Weight gain

Grasscutters with an initial body weight of 1174±8.58 g had different final body weights of 2357±9.01g, 2177±3.06 g and 1817±10.08 g for diet 1, diet 2 and diet 3, respectively. These differences were found to be significant (P<0.05) between animals fed diet 3 and those fed diets 1 and 2 (Table 4.4). Total gain and average daily gain also followed the same trend, obviously due to differences in the final weights. Total body weight gain and average daily gains observed were found to be significantly (P<0.01) lower for diet 3 fed grasscutters.

The average daily gain values observed compared favourably with values reported in previous studies. Ikpeze and Ebenebe (2004), in their study to investigate the productive performance of grasscutters under different housing systems reported daily weight gains of 7.22-8.75 g/day. Mensah and Okeyo (2005) also reported an average daily gain of between 7-12 g/day for both male and female grasscutters. Adu and Wallace (2003) recorded a growth rate of 12.1±1.14 g/day when grasscutters were fed freshly cut *P. maximum* without drinking water. Kenfack *et al* (2006), however, reported lower values of 3.31-4.97 g/day when grasscutters were fed extruded and expanded diet and non-expanded diet. Annor *et al* (2008) also reported lower daily gains of 2.68-7.44 g/day when grasscutters were fed fresh guinea grass (whole plant, leaves or stem). Adu and Wallace (2003) have indicated the nutrient levels in Guinea grass are often far below the requirements of the grasscutter for growth. Grasscutters fed on *Panicum maximum* would, therefore, have inferior growth rate when compared with the nutrient levels such as contained in the experimental diets used in the current study.

4.3.1 Feed consumption

Numerical differences were observed for total feed intake, average daily feed intake and average daily dry matter intake (*Table 4.4*) between the treatments. For example, diet 1 which did not contain *P. maximum* had the highest total feed consumption, daily feed intake and daily dry matter intake. Feed intakes did not differ between treatments (P>0.05). The current daily dry matter intakes were lower than the 89-124 g (Annor *et al.* 2008) and 61-65 g (Obi *et al.* 2008) reported earlier. But this may be due to the fact that the earlier researchers fed forages. Generally, grasscutters consume more grass and tubers than concentrate diets. Varied feed intakes have been observed in the grasscutter depending on the diet. Ajayi and Tewe

(1980) reported different feed intakes for grasscutters when various feed items were offered in choice feeding trials. They observed that the grasscutters consumed more grass (132.3±11.0 – 140.4±11.0 g/day DM) than concentrate feed (1.60±0.4 – 3.2±2.4 g/day DM), so they concluded that concentrates were not favoured by the grasscutter. Several factors are known to affect feed intake in farm animals, including palatability, nature of the diet and the live body weight of the animal and the energy content of the feed. The high energy level in the diets and the dusty nature of the diets might have discouraged higher feed intake, thus being responsible for the generally low feed intakes observed in this study.

According to McDonald (1995), diets that are digested rapidly, and are also of high digestibility promote high intakes. The faster the rate of digestion, the more rapidly is the digestive tract emptied, and the more space is available for the next meal. The chemical component of foods that determine their rate of digestion is ADF level in the diet. There is a negative relationship between the ADF content of feeds and the rate at which they are digested. Therefore, foods that differ in ADF (or cell wall content) will promote different intakes. This may explain the differences observed in feed intakes between the experimental animals.

4.3.3 Effect of diet on feed conversion ratio

Feed conversion ratios recorded in this study (Table 4.4) were significantly ($P<0.05$) lower for diet 3-fed animals. Grasscutters fed Diet 1 which contained no *P. maximum* had the highest dry matter intake (66.2 g/day) and feed conversion efficiency. This translated into higher daily weight gain (13.08 g/day). Grasscutters fed diet 2 (7.5% grass diet) recorded relatively lower feed intake and feed conversion efficiency and weight gain. The growth performance of diet 2–fed grasscutters was

found to be statistically similar to diet 1 fed grasscutters. Diet 3 which contained 15% guinea grass had the lowest dry matter intake and tended to depress growth rate (7.11 g/day) and also deteriorated feed conversion efficiency.

In general, better feed conversion efficiency appeared to be associated with faster weight gain (r = -0.88±0.12) (*see appendix 4, pp 82*). The results observed in this study were similar to values obtained by Kenfack *et al* (2007) when they fed grasscutters with *extruded and expanded diet* (5.37±0.46 and 4.95±0.35 respectively for early and late weaning) and *not expanded diet* (6.45±0.90 and 6.39±1.10), but better than the 7.2 reported by Schrage and Yewadan (1999). The growth rate of an animal is dependent on many factors among which are the adequacy of its diet (nutrient density), digestibility of the diet and the quantity of feed the animal consumes. This is true for grasscutters. A highly digestible diet supports a more rapid rate of growth than a less digestible diet as may be the case of diet 3 (Table 4.2).

The fibre content of a diet is known to have a remarkable effect on nutrient digestibility (McDonald *et al*, 1995). It is also known to influence feed intake. According to Orsar and Agbelusi (2006) monogastric herbivores are less endowed to use fibrous diets and therefore, avoid very high fibrous diets. The inferior apparent digestibility recorded for diet 3 (15% grass diet) may be due to the high fibre content of the present diet (Table 4.2) as also found by Van Zyl *et al.* (1999) and Gang *et al.* (2006).

Several investigators (Graham *et al* 1986; Graham and Aman 1987; Olesen *et al* 2001; Fanimo *et al* 2003) have reported that addition of fibre to the diet can lead to a lower apparent digestibility of starch, fat, crude protein and peptides, and also withhold them from absorption (Green 2000; Fernandez 2003). Kakala (1981) also observed that high crude fibre content depressed digestibility of dry matter and

energy. Moreover, the water-binding capacity of fibre has been reported to reduce diffusion of the products of digestion towards mucosal surface (Dierrick *et al* 1989). Thus the lower growth rate observed for grasscutters on the diet containing the highest proportion of guinea grass might be caused by the reduced amount of protein, energy and other nutrients available for growth, particularly when true growth is considered as deposition of protein.

Van Zyl *et al* (1999a) observed a similar trend in grasscutters where higher fibre levels in the diet reduced the digestibility of dry matter, protein and fat. They also observed in one of the trials that grasscutters fed a high fibre diet exhibited significantly lower growth rates than animals fed a low fibre diet. Chiou *et al* (1998) observed a significant ($P<0.05$) decrease in the digestibility of crude protein, gross energy and dry matter content in the diet of rabbits due to dietary lignin. They also reported a significant ($P<0.05$) decrease in caecal concentration of volatile fatty acids. The poor performance of grasscutters fed diet 3 could be attributed to the relatively lower dry matter, NDF and ADF digestibility which might have resulted in lower available nutrients for growth.

4.3.4 Cost of Production

The costs per kg of diets (*Table 4.4*) as at the time of the experiment were GH¢ 0.2427, GH¢ 0.2483 and GH¢ 0.2333 for diets 1, 2 and 3, respectively. Diet 3 was relatively cheaper than diets 1 and 2, probably due to the high inclusion rate of guinea grass which is one of the cheapest ingredients in the diet. Feed cost per kg live weight gain was statistically similar ($P>0.05$) for diets 1 and 2 but significantly ($P<0.05$) higher for diet 3, with diet 1 recording the lowest cost (GH¢1.27 per kg

diet), followed by diet 2 (GH¢1.41 per kg diet) and diet 3 (GH¢1.90 per kg diet) recording the highest cost.

The decline in feed cost as the amount of maize in the diet was reduced by replacement with guinea grass, was due solely to the huge price disparities between maize and the grass. On the other hand, feed cost per kg liveweight did not follow the trend observed for the cost of feed (per kg). Grasscutters on 0% grass diet and 7.5% grass diet recorded better economy of gain than those fed the 15% grass diet. The appreciable growth rates of grasscutters on the 0% grass diet and 7.5% grass diet might have accounted for the superior economy of gain observed. The lower growth rates as well as the poor feed conversion efficiencies, might have contributed to the poor economy of gain of grasscutters fed 15% grass diet. It could, therefore, be concluded that it was cheaper and more profitable to produce a grasscutter with diet 1 and diet 2 than with diet 3.

4.4.0 Effect of Diet on Carcass Characteristics

The various carcass characteristics and measurements of the grasscutters fed the experimental diets are shown in Tables 4.5.1, 4.5.2 and 4.5.3. The mean values observed for grasscutters fed diet 1 and diet 3 were found to be significantly ($P<0.05$) different with respect to weight at slaughter, dressed carcass weights as well as head and total edible parts. Carcass length also showed significantly ($P<0.05$) lower mean values for diet 3 (25.6 cm) as compared to values for diet 1 (27.8 cm) and diet 2 (27.3 cm). Slaughter weight, hot carcass weight, cold carcass weight and carcass length followed the same trend in the present study. Grasscutters on 0% grass diet and 7.5% grass diets had higher values than grasscutters on 15% grass diet.

Table 4.5.1: Effect of the Experimental Diets on Carcass Characteristics (Mean)

Parameters	Dietary Treatments			
	Diet 1	Diet 2	Diet 3	SEM
Live weight at slaughter, *g*	2425^{a}	2223^{ab}	1850^{b}	76.83
Dressed carcass (hot), *g*	1468^{a}	1320^{ab}	1087^{b}	54.02
Dressed carcass (chilled), *g*	1430^{a}	1287^{ab}	1060^{b}	53.30
Drip loss, *g*	38.3^{a}	33.7^{a}	26.3^{b}	0.79
Giblet (liver, heart and kidney), *g*	76.6	70.0	67.7	3.53
Dressed head, *g*	220^{a}	210^{a}	184^{b}	3.04
Dressed tail, *g*	27.3^{a}	25.7^{ab}	20.7^{b}	0.92
GI tract (empty), *g*	178	168	150	5.48
[2]Total Edible parts, *g*	1905^{a}	1735^{ab}	1462^{b}	62.92
Carcass yield, %	58.6	57.8	57.3	0.41
Total Edible parts, %	78.5	78.0	79.1	0.47
Drip Loss, %	2.62	2.56	2.44	0.06
Carcass length, cm	27.8^{a}	27.3^{a}	25.6^{b}	0.29

SEM= Standard Error of Means
a, b, = means in same horizontal row with different superscript are significantly different (P<0.05).
[2]Total Edible parts = dressed carcass + head + GI tract (empty) + tail

Attah *et al* (2006) reported similarly that hot carcass weight and cold carcass weight increased significantly as slaughter weight increased. Dressing yield, in terms of dressed carcass (chilled) and total edible parts were highest for diet 1 (58.9, and 78.5%, respectively), followed by diet 2 (57.8, and 78.0%, respectively) and diet 3 (57.3, and 79.1%, respectively). These were, however, statistically (P>0.05) similar. The dressing percentages obtained in this study are slightly lower than the 64% previously reported by Ajayi and Tewe (1980) and Jori *et al* (1995), but are comparable to the 50-55% reported by Annor *et al* (2008).

Table 4.5.2: Primal cut-up parts of the carcass of grasscutters fed the experimental diets

Traits	Dietary Treatments (mean)			
	Diet 1	Diet 2	Diet 3	SEM
Carcass weight (cold), *g*	1430[a] (100)	1287[ab] (100)	1060[b] (100)	53.30
Cut-up Parts				
Shoulders, *g*	212.0 (14.8±0.07)	203.0 (15.8±0.14)	192.0 (18.0±1.17)	10.25
Loin, *g*	216.0 (15.0±0.70)	205.0 (16.0±0.10)	159.0 (14.9±0.93)	10.57
Thorax, *g*	396.0[a] (27.4±2.91)	333.0[ab] (25.9±0.02)	247.0[b] (23.4±0.95)	19.92
Thighs, *g*	594.0[a] (41.9±3.65)	533.0[ab] (41.4±0.18)	454.0[b] (42.9±0.92)	15.50
Cutting loss, *g*	12.3 (0.86±0.03)	12.0 (0.93±0.11)	9.3 (0.90±0.19)	0.50

SEM= Standard Error of Means
a, b, = means in same horizontal row with different superscript are significantly different (P<0.05).
Figures in parenthesis indicate percentage (±SD) of part to dressed carcass(cold) weight.
SD= Standard Deviation of Means

Dressing percentage is reported to be influenced by several factors including amount of gut fill, slaughter weight, slaughter age, degree of muscling, degree of fatness and nutrition of the animal (Gillespie 1998; Kedebe *et al* 2008). The differences (not significant) in the relative weight of gut to live-weight at slaughter (*Table 4.5.3*) between treatment diets could be responsible for the slight differences in dressing percentage. Animals on diet 3 had a relatively high gut (full) composition in relation to live-weight at slaughter. Since viscera weight is not considered in the determination of dressing percentage, higher percentage composition of viscera would reduce dressing percentage. According to Osei and Twumasi (1989) poorly digested feed results in poor tissue deposition and this may explain why grasscutters on the 15% grass diet had inferior carcass characteristics. Annor *et al.* (2008) made a

similar observation that grasscutters fed diets with high fibre content obtained low dressing percentage.

Table 4.5.2 shows the primal cut-up parts of grasscutters fed the experimental diets. The trends were similar for all parts, i.e. higher values for grasscutters on the 0% grass diet and 7.5% grass diet than the 15% grass diet. Differences observed in the weights of the thighs and loin were found to be significantly ($P<0.05$) different between diets 1 and 3 animals. The primal cuts were found to favour grasscutters fed diet 1 than the others. Percentage composition was higher for thighs (41.9, 41.4 and 42.9%), followed by thorax (27.4, 25.9 and 23.4%) for diets 1, 2 and 3, respectively. As reported by Attah *et al.* (2006), the weight of the primal cuts followed the same pattern as weight at slaughter. Cutting losses of 0.86, 0.93 and 0.90% for diets 1, 2 and 3, respectively (Table 4.5.2), observed in the current study are similar to values of 0.76 – 1.31% observed by Ghosh and Mandal (2008) in broiler rabbits, and much lower than the 6.04% reported by Salroo *et al* (1989) for the Soviet Chinchilla rabbit.

The differences observed in carcass characteristics between the treatments may be attributed to the differences in live-weight at slaughter. In all the parameters measured, diet 1 turned to produce better carcass traits, followed by diet 2 and the poorest was diet 3. The relatively higher apparent digestibility of diets 1 and 2 might have resulted in increased availability of nutrients for body building. Good nutrition will, therefore, make more carcass available to the market as demonstrated in the present study.

The effects of the formulated diets on organ weights are shown in Table 4.5.3. The differences between traits were statistically ($P>0.05$) similar. Heart, liver, lung and kidneys were heavier for animals on diet 1, followed by diet 2 and diet 3, probably due to the significant ($P<0.05$) differences in live-weight at slaughter. The

percentage weighting of gut (full and empty) shows an increasing numerical trend from diet 1 to diet 3 (*Table 4.5.3*). It seemed grasscutters on the more fibrous diet (diet 3) had a higher gut proportion of body weights, followed by diet 2 and diet 1. Ajayi and Tewe (1980) reported similar percentages (see *Table 2.3*).

Table 4.5.3: The effect of the experimental diets on organ weights of the grasscutters (Mean).

Organ	Dietary Treatments (mean)			
	Diet 1	Diet 2	Diet 3	SEM
GI tract (full), *g*	348.3 (14.38±0.28)	419.3 (18.95±5.90)	363.3 (19.68±0.55)	25.22
GI tract (empty), *g*	178.0 (7.36±0.36)	168.0 (7.55±0.17)	150.0 (8.18±1.28)	5.48
Heart, *g*	12.8 (0.53±0.03)	12.0 (0.54±0.03)	11.0 (0.59±0.07)	0.56
Liver, *g*	53.8 (2.21±0.14)	48.0 (2.16±0.18)	47.0 (2.52±0.24)	2.84
Spleen, *g*	2.23 (0.09±0.00)	2.67 (0.12±0.02)	2.33 (0.13±0.03)	0.13
Lung with trachea, *g*	18.33^{a} (0.76±0.12)	14.67^{ab} (0.66±0.05)	11.0^{b} (0.59±0.08)	0.98
Kidney, *g*	10.0 (0.41±0.02)	10.0 (0.45±0.05)	9.67 (0.53±0.04)	0.34

SEM= Standard Error of Means
a, b, = means in same horizontal row with different superscript are significantly different (P<0.05).
Figures in parenthesis indicate percentage (±SD) of organ to live weight at slaughter.
SD= Standard Deviation of Means

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

The present study was conducted to assess the feeding value of three concentrate diets, containing 0, 7.5 or 15% guinea grass fed to growing captive grasscutters. The chemical composition of the diets showed that the diets were adequate as they supported growth in the grasscutters. The differences in the diets had no effect on feed consumption in the captive grasscutters. It was observed that grasscutters tend to develop heavier guts when fed highly fibrous diets. Grasscutters fed diets 1 and 2, which contained 0% and 7.5% guinea grass, respectively, were found to be more efficient as they produced the cheapest per unit carcass. Diet 3 (15% grass diet), though cheaper, showed the least economy of gain and produced the poorest carcass traits, indicating that concentrate feeds containing high levels of NDF (more than 55%) and ADF levels beyond 17% may not be able to support rapid growth in the captive grasscutter. It is evident from the present study that good nutrition will make more grasscutter meat available to the market.

Diets 1 and 2 can, therefore, be used as sole feeds for growing captive grasscutters. Diet 2 is, particularly, recommended to grasscutter farmers living within the middle belt zone of Ghana (where grass abounds) for feeding grasscutters, especially during the dry season. To confirm the results of the present study, it is recommended that the study be repeated with a greater number of grasscutter weanlings.

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APPENDICES

Appendix 1: Formula for determining Apparent Digestibility of Nutrients

$$\textit{Apparent digestibility} = \frac{\text{Nutrient Consumed} - \text{Nutrient in Faeces}}{\text{Nutrient Consumed}}$$

Appendix 2: Pauzenga's formula for determining Metabolizable Energy (M.E)

ME (kcal/kg) = (37 x CP%) + (81.8 x EE%) + (35.5 x NFE%).

Where CP= crude protein, EE= fat and NFE= nitrogen free extract

Appendix 3: Formula for estimating quantity of digestible nutrients

Digestible Nutrient (g/kg dry matter) =

Digestibility coefficient of nutrient x weight of nutrient (g/kg dry matter)

Appendix 4: Correlation relationships between some parameters

Parameters	Correlation coefficient (r)	Standard Error
Dry matter digestibility and ADF intake	-0.50^{ns}	0.33
Crude protein digestibility and ADF intake	-0.59^{ns}	0.30
Feed intake and NDF intake	0.44^{ns}	0.34
Daily gain and FCE	-0.88*	0.12
Head and Final weight	0.93*	0.14
Head and Carcass weight	0.89*	0.17

*ns = not significant (P>0.05); * = significant (P<0.01)*

Appendix 5: Digestibility Trial- ANOVA for Total DM Intake

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	7207.84	3603.92	15.3123	.0044 **
Error	6	1412.17	235.36		
Total	8	8620.01			

Coefficient of Variation = 3.58%

Appendix 6: Digestibility Trial - ANOVA for Total Faecal (DM) Output

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	3253.96	1626.98	146.12	.0000 **
Error	6	66.81	11.13		
Total	8	3320.76			

Coefficient of Variation = 3.00%

Appendix 7: Digestibility Trial - ANOVA for DM Digestibility

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	365.80	182.90	76.1355	.0001 **
Error	6	14.41	2.40		
Total	8	380.22			

Coefficient of Variation = 2.11%

Appendix 8: Digestibility Trial - ANOVA for CP Digestibility

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	193.06	96.53	107.2820	.0000 **
Error	6	5.40	0.90		
Total	8	198.46			

Coefficient of Variation = 1.13%

Appendix 9: Digestibility Trial - ANOVA for ADF Digestibility

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	110.30	55.15	10.3589	.0113 *
Error	6	31.94	5.32		
Total	8	142.24			

Coefficient of Variation = 3.90%

Appendix 10: Digestibility Trial - ANOVA for NDF Digestibility

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	380.87	190.43	45.6630	.0002 **
Error	6	25.02	4.17		
Total	8	405.89			

Coefficient of Variation = 3.14%

Appendix 11: Digestibility Trial - ANOVA for Hemicellulose Digestibility

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	468.42	234.21	83.0633	.0000 **
Error	6	16.92	2.82		
Total	8	485.34			

Coefficient of Variation = 2.33%

Appendix 12: Digestibility Trial – ANOVA for Digestible DM / Metabolic Weight

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	735.42	367.71	0.2584	.7804 ns
Error	6	8536.69	1422.78		
Total	8	9272.11			

Coefficient of Variation = 8.37%

Appendix 13: ANOVA for Initial Live Weight

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	77.78	38.89	0.0010	.9990 ns
Error	15	565617	37708		
Total	17	565694			

Coefficient of Variation = 16.60%

Appendix 14: ANOVA for Final Weight

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	907200	453600	5.7906	.0137 *
Error	15	1175000	78333		
Total	17	2082200			

Coefficient of Variation = 13.22%

Appendix 15: ANOVA for Total weight gain

Source	d.f	SS	MS	F	P
Main Effects					
Treatment	2	915677.78	457838.89	8.1342	.0040 **
Error	15	844283.33	56285.56		
Total	17	1759961.11			

Coefficient of Variation = 25.05%

Appendix 16: ANOVA for Average Daily Gain

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	110.6114	55.3057	8.1437	.0040 **
Error	15	101.8678	6.7912		
Total	17	212.4793			

Coefficient of Variation = 25.04%

Appendix 17: ANOVA for Total Feed Intake

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatments	2	3577059.11	1788529.6	1.8103	.1976 ns
Error	15	14819486.67	987965.78		
Total	17	18396545.78			

Coefficient of Variation = 15.99%

Appendix 18: ANOVA for Average Daily Feed Intake

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatments	2	413.6511	206.8255	1.8111	.1974 ns
Error	15	1712.9661	114.1977		
Total	17	2126.6172			

Coefficient of Variation = 15.98%

Appendix 19: ANOVA for Average Dry Matter Intake

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	463.4383	231.71917	2.4378	.1211 ns
Error	15	1425.7923	95.0528		
Total	17	1889.230628			

Coefficient of Variation =16.35%

Appendix 20: ANOVA for Feed Conversion Efficiency

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	29.1676	14.5838	5.9976	.0122 *
Error	15	36.4739	2.4316		
Total	17	65.6416			

Coefficient of Variation = 24.58%

Appendix 21: ANOVA for Feed Cost per kg Gain

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	1.2947	0.6474	4.6300	.0272 *
Error	15	2.0973	0.1398		
Total	17	3.3920			

Coefficient of Variation = 24.53

Appendix 22: ANOVA for Live weight at slaughter

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	510672	255336	4.8068	.0567 *
Error	6	318717	53119		
Total	8	829389			

Coefficient of Variation = 10.64%

Appendix 23: ANOVA for Dressed Carcass Weight (hot)

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	222173.56	111086.78	4.2303	.0714 *
Error	6	157560	26260		
Total	8	379733.5556			

Coefficient of Variation = 12.54%

Appendix 24: ANOVA for Dressed Carcass Weight (cold)

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	208425	104212	4.0759	.0762 *
Error	6	153407	25568		
Total	8	361832			

Coefficient of Variation = 12.70%

Appendix 25: ANOVA for Drip loss

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	219.56	109.78	19.3725	.0024 **
Error	6	34 5.67			
Total	8	253.56			

Coefficient of Variation = 7.26%

Appendix 26: ANOVA for Giblet

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	129.8467	64.9233	0.5779	.5895 ns
Error	6	674.0733	112.3456		
Total	8	803.92			

Coefficient of Variation = 14.84%

Appendix 27: ANOVA for Dressed head weight

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	2072	1036	12.4819	.0073 **
Error	6	498	83		
Total	8	2570			

Coefficient of Variation = 4.45%

Appendix 28: ANOVA for Dressed tail

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	72.22	36.11	4.7101	.0589 *
Error	6	46	7.67		
Total	8	118.22			

Coefficient of Variation = 11.28%

Appendix 29: ANOVA for Total Edible Parts

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	299160.	149580	4.1978	.0724 *
Error	6	213795	35633		
Total	8	512955.32			

Coefficient of Variation = 11.10%

Appendix 30: ANOVA for Carcass Length

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	8.50889	4.2544	5.6226	.0421 *
Error	6	4.54	0.7567		
Total	8	13.0489			

Coefficient of Variation = 3.23%

Appendix 31: ANOVA for Carcass Yield

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	3.9283	1.9641	1.3018	.3392 ns
Error	6	9.0529	1.5088		
Total	8	12.98122			

Coefficient of Variation = 2.12%

Appendix 32: ANOVA for Drip loss %

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	0.0520	0.0260	0.8534	.4719 ns
Error	6	0.1829	0.0305		
Total	8	0.2349			

Coefficient of Variation = 6.87%

Appendix 33: ANOVA for Total Edible Parts %

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	1.9693	0.9846	0.4883	.6361 ns
Error	6	12.0975	2.0163		
Total	8	14.0668			

Coefficient of Variation = 1.81%

Appendix 34: ANOVA for Shoulders

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	602	301	0.3184	.7389 ns
Error	6	5672	945		
Total	8	6274			

Coefficient of Variation = 15.22%

Appendix 35: ANOVA for Loin

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	5509.56	2754.78	2.7380	.1429 ns
Error	6	6036.67	1006.11		
Total	8	11546.22			

Coefficient of Variation = 16.40

Appendix 36: ANOVA for Thorax

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	33738.67	16869.33	4.7241	.0586 *
Error	6	21425.33	3570.89		
Total	8	55164			

Coefficient of Variation = 18.37%

Appendix 37: ANOVA for Thighs

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	29720.67	14860.33	6.8706	.0281 *
Error	6	12977.33	2162.89		
Total	8	42698			

Coefficient of Variation = 8.82%

Appendix 38: ANOVA for Cutting loss

Source	d.f	Type I SS	MS	F	P
Main Effects					
Treatment	2	16.22	8.11	3.65	.0918 ns
Error	6	13.33	2.22		
Total	8	29.56			

Coefficient of Variation = 13.283572%

Appendix 39: ANOVA for GI Tract (Full)

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	8402	4201	0.7339	.5186 ns
Error	6	34344	5724		
Total	8	42746			

Coefficient of Variation = 20.07%

Appendix 40: ANOVA for GI Tract (Empty)

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	1208	604	2.2370	.1880 ns
Error	6	1620	270		
Total	8	2828			

Coefficient of Variation = 9.94%

Appendix 41: ANOVA for Heart

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	4.88	2.4400	0.8541	.4716 ns
Error	6	17.14	2.8567		
Total	8	22.02			

Coefficient of Variation = 14.16%

Appendix 42: ANOVA for Liver

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	81.7222	40.8611	0.5621	.5974 ns
Error	6	436.1667	72.6944		
Total	8	517.8889			

Coefficient of Variation = 17.19%

Appendix 43: ANOVA for Spleen

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	0.3089	0.1544	0.9653	.4331 ns
Error	6	0.96	0.16		
Total	8	1.2689			

Coefficient of Variation = 16.59%

Appendix 44: ANOVA for Lung

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	80.6667	40.3333	4.7143	.0588 *
Error	6	51.3333	8.5556		
Total	8	132			

Coefficient of Variation = 19.94%

Appendix 45: ANOVA for Kidneys

Source	d.f	Type 1 SS	MS	F	P
Main Effects					
Treatment	2	0.2222	0.1111	0.1081	.8992 ns
Error	6	6.1667	1.0278		
Total	8	6.3889			

Coefficient of Variation = 10.25%

ns means *not significant (P>0.05);* * means *significant (P<0.05);* ** means *significant (P<0.01); SS* means *Sum of Squares; MS* means *Mean Squares; d.f* means *degrees of freedom*