KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF AGRICULTURE

DEPARTMENT OF ANIMAL SCIENCE

SHEA NUT CAKE IN SUPPLEMENTAL CONCENTRATE FOR GROWING DJALLONKE RAMS FED A BASAL DIET OF RICE STRAW AND GROUNDNUT HAULMS IN THE DRY SEASON

BY

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COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

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THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSTY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (ANIMAL NUTRITION) DEGREE

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DECLARATION

I, Solomon P. Konlan, hereby declare that this submission is my own research work towards the award of the M.Sc. and that, it contains no materials previously published by another person or material which has been accepted or concurrently being used for the award of any other degree in this University or elsewhere, except where acknowledgment has been duly cited in the text and in the references.

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ABSTRACT

Graded levels of Shea Nut Cake (SNC) was evaluated as part of supplemental concentrate for growing Djallonke rams to determine its effects on the growth performance and the haematological and biochemical profile of the sheep. The experimental sheep were fed with rice straw and groundnut haulms *ad libitum* and supplemented with two concentrate diets with 11.5% or 23.0% shea nut cake. The treatment diets were labeled as T1 (rice straw and groundnut haulms; control diet), T2 (control diet plus concentrate containing 11.5% SNC) and T3 (control diet plus concentrate containing 23.0% SNC). All the animals received 700 g of the control diet which comprised a mixture of 20 mm pieces of rice straw (62.5%) and groundnut haulms (37.5%) daily. In addition T2 and T3 rams received 200 g of the appropriate supplemental diet daily. The experimental animals had a mean initial weight of 12 ± 2.4 kg and were 12 ± 2 months of age. The experimental design was double 3 x 3 Latin square. Thus each treatment diet was assigned to two animals at a time. Each feeding period was made up of four weeks. The first three weeks of each round was the adjustment period and data were collected during the last week of the round. Dry matter intake, weight gain, and blood samples were taken for analysis. The results indicated that total dry matter intake (TDMI) was significantly different ($P<0.05$) among the three treatments in the order T1< T3 < T2. Straw intake (Basal Diet) was significantly ($P<0.05$) lower in T3 than in T1 and T2 animals. Substitution rate increased from 0.15 in T2 to 0.45 in T3 as the SNC inclusion level increased from 11.5% to 23.0% in the treatment diets. The average daily weight gain obtained for the three dietary treatments were 20.88 g/d, 31.86 g/d and 37.74 g/d for T1, T2 and T3 respectively. The haematological values recorded were not significantly different between treatment groups. However, the serum total protein of animals on T3 was significantly ($P<0.01$) higher than that for those on T1 but similar to that of the T2 group. It was concluded that shea nut cake can be included in supplementary diets for Djallonke sheep up to 23.0% without adverse effects on growth performance and the haematological profile and serum metabolites of the sheep.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

Livestock production accounts for 40% of the world's gross agricultural production (MoFA, 2000). This is due to the fact that there is a shift in the dietary habits of people to increased meat consumption, especially among high income earners (Ranjhan, 2001). Subsistence farmers in most rural communities all over the world most of the time keep livestock as an investment and insurance against natural disasters (Devendra and McLeory, 1982). Globally, sheep rearing is predominantly aimed at wool production. However, meat is the major product in many countries (Croston and Pollot, 1994). Sheep have a special function in the followers of Islam and are also used for funeral cerebrations and dowries in Ghana (Koney, 2004; Devendra and McLeory, 1982). The main objective of any livestock enterprise is to convert feedstuffs into animal products at a faster and cheaper rate (Payne, 1990).

Sheep rearing in Ghana is mainly for meat production using the Djallonke and Sahellian Sheep and their cross breeds (Ockling, 1988; MoFA, 2000). The Djallonke, also known as West African Dwarf (WAD) sheep according to Karbo and Bruce (2000) is the predominant sheep in Ghana. Most small scale sheep farmers in Ghana face a lot of challenges in generating income from the stock due to the slow growth rate, unstable weight gains related to seasonal imbalances of feed and reproductive problems (Annor *et al,* 2007). The problems militating against livestock production in general have led to an average importation of 50% livestock and/or its products to satisfy Ghana's domestic requirements (Sabri *et al,* 2001).

In the savanna zone of Ghana, natural forages become scarce in the dry season due to outbreak of bush fires and the small dried fodder left also loses its nutritive value. This makes the animals lose body weight during the period and creates a cyclic body weight gain and weight loss in the rainy and dry seasons respectively (Otchere *et al,* 1986). To break this cycle, animal scientists over the years have identified feed supplementation, which have proved successful particularly with sheep, as a remedy. However, the use of staple cereal grains leads to competition between humans and animals and increases the cost of supplementation making it unprofitable and unsustainable in livestock production (Otchere *et al,* 1986; Croston and Pollot, 1994; Karbo *et* *al,* 2002). Indeed, there is the need to sustain supplementation by exploring cheaper sources for supplementary feed. Ranjhan (2001) stated that crop residues (Straws and Stovers) and agro-industrial by-products along side with grazing and scavenging will remain important sources of feed ingredients for livestock production. Related to this, crop residues such as groundnut haulms, potato and cassava peels and leaves have been recommended as good supplementary feedstuffs that can be used in the dry season to supplement the dry and fibrous fodder (Koney, 2004). Much work has been done with the use of crop residues and some industrial by-products as supplementary feed for sheep in particular and ruminants in general. Among these are; rice straw (Otchere *et al,* 1977; Karbo *et al,* 2002), cotton seed (Dzoagbe, 1998), pigeon pea waste (Agbolosu, 1997) and Soyabean cake (Obese, 1998). These have been certified as feeds for dry season supplementation in Ghana (Karbo *et al,* 2002).

Shea nut cake (SNC) is one of the agro-industrial by-products produced in the processing of shea nut into sheabutter (Asante, 1987). This is abundant in Northern Ghana and is currently being disposed of or being used marginally as fuel (Esien 2003). Okai (1989) estimated that 500,000 tones of SNC are being produced annually in the savanna zone of Ghana. SNC have been reported to contain anti nutritional factors such as theobromine, saponin and tannin which at certain levels lower feed intake, digestibility and absorption in non-ruminants (Morgan *et al.*, 1980; Okai and Bonsi, 1989; Atuahene, *et al* 1998). Some works have been done on the use of SNC as feed for supplementing sheep. These include; the preference study of varying level of SNC utilization by sheep (Esien, 2003) and the growth response of sheep fed SNC-based diet (Issaka, 2006).

The increasing use of unconventional feedstuffs as feed for livestock especially during the dry season and in confinement calls for the evaluation of the effect of these unconventional feedstuffs on the health status of the livestock. Madubuike and Ekenyem (2006) stated that haematology and serum chemistry assay of livestock suggest the physiological disposition to their nutrition. Esonu *et al* (2001) stated that, haematological constituents reflect the physiological responsiveness of the animal to its internal and external environment, which include feed and feeding. Furthermore, some scientists have studied the effects of various feeds on the haematology and serum metabolites of livestock and have concluded that some feed ingredients including unconventional sources affect the animal's physiology.

The objectives of this work were to use graded levels of SNC as part of supplemental concentrate diet for Djallonke rams to examine;

- the growth performance of the rams
- effect of the diet on haematological and serum metabolites of the rams, and
- the effect of the SNC on total tract apparent nutrient digestibility by the Djallonke rams on the diets

CHAPTER TWO LITERATURE REVIEW

2.1 Origin and Importance of the West African Dwarf Sheep

The West African Dwarf (WAD) sheep are widely distributed throughout the West and Central Africa. The breed is believed to have evolved from the ancient Egyptian sheep *ovis longipes palaeoaegypticus* (Yapi-Gnaore *et al.*, 1997). It is small in size but physically and sexually strong. It is stress and disease resistant especially to unfavourable climate and trypanosomiasis. These are attributes considered as adaptive features to reduce heat stress and to overcome the effect of rainfall and humidity of sub-equatorial and equatorial climates (Ryder, 1999). Climate is therefore not likely to have any negative effects on its performance in its natural environment. However, variation in forage supply could influence physical growth and physiological maturation.

Apart from serving as a source of meat and income, the WAD sheep has significant social roles in West Africa. These include religious and funeral ceremonies. Sheep are used as gifts for strengthening human relationship, symbol of appreciation and payment of bride prices. In terms of value, the live animal has more value than its carcass (Charray *et al*, 1992).

2.2 Loss in weight of ruminants during the dry season.

It has been established that ruminants gain weight in the rainy season as there are abundant green natural pasture which is nutritionally rich. They, however, lose weight in the dry season due to low quality fodder which is compounded by its unavailability (Otchere *et al,* 1977). Rose-Innes (1960) reported up to 11% weight lost in cattle and Otchere *et al* (1977) recorded 15% weight lost in sheep at the Accra plains in Ghana during the dry season and attributed it to poor quality and unavailable fodder. This underscores the need for feed supplementation of the ruminant in the dry season to maintain or improve weight gain. Indeed, supplementation often relies on the energy rich grains. This is, however, often scarce and expensive and not economical to use (Karbo *et al*, 2002). The other way out is to investigate agro-industrial byproducts and/or crop residues that are not used by humans and non-ruminants for supplementing ruminants.

2.3 The use of Agro-industrial by-products in feeding sheep

Different agro-industrial by-products and/or crop residues have been used for feeding ruminants over the years; much work has been done with sheep on the use of by-products such as cotton seed (Avornyo *et al.*, 2001). Obese (1998) fed soya bean cake to Djallonke sheep as supplement with other by-products. The treatments were 200 g of cassava peels and 100 g of soya bean cake (T_1), 200 g of cassava peels and 100 g of groundnut haulms (T_2) and no supplement (T_3) as control under on-station trial conditions. The result obtained indicated that the average daily supplementary feed intake did not differ significantly in T1 and T_2. However, T_1 recorded the highest mean weight gain (2.96 kg) while T_3 had the lowest (0.96 kg). The average (± s. d.) daily weight gains were 48 ± 4 g, 32 ± 3 g and 16 ± 3 g for T_1, T_2 and T_3 respectively. On – farm studies of the same treatments showed similar trend but higher values were obtained for the soya bean cake supplemented sheep, with an average daily weight gain (55.56 ± 1.2 g/day) significantly higher ($P<0.05$) than that of the control group of 22.2 ± 1.2 g/day (Obese, 1998). However, the soya bean cake is more costly than other byproducts such as groundnut haulms and cassava peels (Karbo *et al*, 2002). Baiden *et al* (2007) reported that dry matter intake, daily weight gain and FCR were not influenced in sheep and goats when fed with different levels of cassava pulp as a replacement of cassava peels. The treatment diets were; 0%, 15%, and 30% cassava pulp. However, total dry matter intake was significantly higher ($P<0.01$) in sheep than in goats. Table 2.4 shows these results.

Table 2.4 The influence of dietary treatments on daily weight gain, dry matter intake and feed conversion ratio of sheep and goats fed cassava pulp

Item	**0% pulp**		**15% pulp**		**30% pulp**		
	goats	**Sheep**	**Goats**	**sheep**	**Goats**	**sheep**	**SEM**
Initial weight, kg	8.7	16.7	8.7	16.6	8.6	16.6	1.2
Final weight ,kg	11.1	22.5	11.5	21.7	11.2	21.6	1.2
Daily weight gain g/day	38.2^a	91.0^b	46.0^a	81.0^b	42.0^a	79.0^b	6.2
DMI g/day							
Roughage	131_a	241_b	142_a	226_b	137_a	234_b	13.0
Concentrate	229_a	359_b	225_a	405_b	230_a	395_b	22.4

Total	360a	636b	367a	631b	370a	629b	31.1
FCR (Feed:gain)	9.8	6.9	8.2	8.1	9.5	7.9	1.0

DMI = Dry Matter Intake, FCR = Feed Conversion Ratio, SEM= Standard Error of Mean. Means within the same row with different superscripts are significantly different (P>0.01)

The use of other by-products like rice straw (Otchere *et al*, 1977; Karbo *et al*, 2002) and cocoa husk (Otchere *et al*, 1986), cassava and groundnut haulms (Wesseh, 1999) to feed ruminants have been certified as good supplementary feed for ruminants.

As stated in the introduction, another agro-industrial by-product abundant in Northern Ghana that has not been used much is Shea Nut Cake (SNC). This is produced in large quantity by Kassendjan Ltd and Bosebel vegetable oil Company Ltd both in Tamale and women groups or individuals throughout northern Ghana. This is dumped at the processing sites and it is a source of environmental pollution. Traditionally, shea nut cake is used by women as a fuel and source of potassium for traditional soap making (Kariderm, 2006). It can currently be obtained free of charge except for cost of collection.

2.4 Dry matter intake of small ruminants fed forage or straws with supplemental concentrate.

According to Njwe and Olubajo (1992), the intake of forage or straws is depressed by the intake of concentrate supplement. Sheep on grass basal diet are supplemented with protein concentrate such as soya bean meal, the dry matter intake and digestibility increase as a result of increased supply of protein to the rumen microbes (Jamie *et al*, 2009). An increased intake of cell content was recorded when the concentrate levels in goats' diet were increased. Related to the concentrate intake, an increase in the level of groundnut cake and cassava flour in goats ration led to increased live weight gain, the highest gain obtained from animals fed both concentrates (groundnut cake and cassava flour). A combination of 200 g cassava flour and 100 g of groundnut cake and maize straw resulted in an average growth rate of 52 g/day. Another level of 200 g of cassava flour and 150 g of groundnut cake also recorded 62 g/day using fresh guatemala grass as the basal diet. Goats that were put on 0 to 50 g concentrate supplement lost weight due to inadequate energy and protein intake (Njwe and Olubajo, 1992). The mean dry matter intake of growing goats was reported as 334.25 g and 337.00 g when the goats were fed with maize stovers supplemented by different browse leaf meal- based concentrate and cotton seed based concentrate respectively (Ndemanisho *et al*, 2007). In similar studies, Njwe and Godwe (1988) recorded dry matter intake of 590.20 g/d, 699.53 g/d and 701.38 g/d for T1, T2 and T3 dietary treatments respectively for West African Dwarf sheep. The three treatment diets were; T1 (fresh napier grass with no supplement), T2 (fresh napier grass supplemented with undefatted soyabean meal) and T3 (NaOH treated soya bean pods with undefatted soya bean meal). The average liveweight gained were; 41 g/d, 77 g/d and 79 g/d for T1, T2 and T3 respectively.

2.4.1 Substitution effects of concentrate supplemental diet fed to ruminants

Concentrate supplementation increased forage intake initially after which it declined as the concentrate consumed increased in the ruminants' diet due to substitution effect (Nguyem *et al*, 2008), which is more effective in animals on crop residues basal diet (like rice straw) than animals on pasture grass. A decline in rice straw intake from 1.24 kg to 0.48 kg dry matter per day in sheep was reported when the animals were given supplemental concentrate. A linear increase in organic matter digestibility with initial increasing concentrate intake was also recorded. However, NDF digestibility declined with higher levels of concentrate intake (Nguyem *et al*, 2008). Substantial increase in live weight gain is obtained by supplementing ruminants on low digestible forage with energy and protein concentrates (Hennessy *et al*, 1995). According to Ba *et al* (2008) increased intake of concentrates increases live weight gain but there is a limit to how much of this supplement ruminants can consume, any quantity exceeding that would lead to negative effects on digestibility of fibre. For instance cassava powder supplementation depressed the NDF digestibility from 62% to 41% in cattle. Due to high concentration of highly digestible starch in most concentrate supplements, negative associative effects on forage digestion can be expected when fed in significant quantities (Huhtanen, 1991).

Wanapat and Khampa (2007) reported a significant decline in the cellulolytic bacterial population when cassava chips supplement were fed to cattle. Presumably this effect is similar in many formulated concentrates. This decline in cellulolytic bacterial population in the rumen may be responsible for the decline in fibre digestibility. Substitution rate of concentrate described as the quantity of forage or conserved fodder rejected due to the intake of concentrate supplement, according to Nguyem (2008) is given as;

$$\frac{\text{FI in un -supplemented treatment - FI in supplemented treatment}}{\text{CI in supplemented treatment}}$$

Where: FI is Forage Intake and CI is Concentrate intake.

The substitution rates of concentrate for forage in ruminants on grazing pasture or fed *ad libitum* on conserved forages ranges between 0 and 1 kg / kg DM (Stockdale, 2000). Nguyem *et al* (2008) reported a modest substitution rate of 0.3 to 0.5 kg DM reduction in forage intake per kg DM supplement consumed by cattle as the amount of concentrate intake increased up to 2% of the animals' live weight in the ration. Substitution rate increases with decreasing quality of roughage and with increasing level of concentrates supplementation (Dulphy, 1980). Stockdale (2000) stated that the reduced fibre digestibility is the primary cause of substitution.

2.5 The Shea Nut tree *(Vitellara pardoxa gaertn)*

The shea nut tree according to Lovett and Haq (2000) is a multi-purpose tree and highly valued for the oil obtained from the nut. The nut is enclosed in a mesocarp which is eaten as a fruit especially in the farming communities. The tree is common in the semi-arid zone of subSaharan Africa. An inventory in the West Gonja District of the Northern Region of Ghana indicated that the species is found more in fallow lands than in intensively cultivated lands. This was attributed to the general tree logging activities in intensively cultivated lands. However, virgin lands with similar environmental features had fewer shea nut trees. This indicates that farmers do intentionally nurse existing seedlings or plant the sheanut trees during farming periods (Asante, 1987). The survey further showed that, there are higher proportions of large matured trees on farm lands (Lovett and Haq, 2000).

The nuts are mainly collected by women and children (Asante, 1987). Fallen nuts are collected mostly during early hours of the day (05:30 h – 07:30 h GMT) before the start of other farming activities. Matured fruits may also be plucked and buried or kept in air-tight containers for it to ripe after which the fruits are depulped and the nuts boiled and/or sun dried to prevent germination (Esien, 2003). The amount of nuts collected according to Adomako (1985) depends on;

- The population density of the trees
- The population density of the farming community and
- The price incentive of the butter processed or the raw shea nut.

2.5.1 The processing of shea nut to butter and cake

Asante (1987) stated that, two methods of processing shea nut into butter and cake exist. These are traditional and modern industrial methods. The traditional method consists of the following procedure; crushing the nut, roasting, milling, kneading, boiling, stirring, decanting and collecting the oil (Irvine, 1974).

The dry kernels are crushed by placing one or two nuts at a time on a flat stone or concrete floor and hitting hard with a specially made pestle. The crushed nuts are roasted or fried in an oven or pan. This process continuous till it turns brown, splits and shine with oil. The roasted mass is milled manually with a grinding stone or by using corn mill (Asante, 1987). The milled mass is kneaded with cold or warmed water until it becomes thick to work with. More water is then added and the process continuous until fat rises to the surface of the water. The crude fat is skimmed and boiled again. The milled oil floats on the surface and is gradually collected into a calabash or any suitable storage container and stored as shea butter. The remaining residue after skimming the fat and after the last boiling of the crude fat is dried to obtain shea nut cake (Irvine 1974). The traditional method of shea butter extraction yields 25 – 30% shea butter and the cake is generally oily (Dalzich 1955).

Asante (1987) reported that, the industrial shea nut processing yields more oil (shea butter) than the traditional method and thus produces less oily cake. This process also produces two kinds of SNC with varying levels of fat content; 22 – 24% and 10 – 12% for midway cake and final cake respectively (Asante, 1987).

According to Asante (1987), the industrial shea butter extraction process uses the screw press method. This involves preheating of the nut at 90°C by means of steam and passing the nut through a screw press machine for the first stage extraction which removes the fat and leaves the cake with a fat content of 22 – 24%. The cake is heated again and passed through a second stage of fat extraction, leaving the cake with a fat content of 10 – 12%. This cake is disposed of as a by-product, which is referred to as shea nut cake.

2.5.2 Anti-Nutritional factors in shea nut cake

Atuahene (1998) reported the presence of some anti - nutritional factors such as theobromine and saponin in addition to tannin earlier detected by Morgan and Trinder (1980) in the shea nut cake.

a. Saponin; Chemically, saponin consists of an aglycone of either steroidal or triterpenoid in nature and one or more glycosides (sugar chains) and occurs in plants that are consumed by humans and animals (EFSA, 2009). It has been reported to reduce feed intake, inhibit growth rate of swine and poultry and show toxicological effects at higher levels in the diet (Livingston *et al.*, 1977). Saponins cause injury to the digestive mucosa and haemolysis in the blood, when fed to non-ruminants at higher levels. It inhibits smooth muscle activities, slows down digesta flow and causes membranous irritations of mouth and the digestive tract (McDonald *et al*, 1995). In mice and rats, saponins cause local gastro-intestinal toxicity as well as liver and kidney toxicity (EFSA, 2009). It further reduces the activities of digestive enzymes in nonruminants (Livingston *et al.*, 1977; Longstaff and McNab, 1991). These were attributed to the ability of the saponin to bind with protein and form complex bonds. Thus, enzymes of protein origin can form bonds with these components and reduce their activities resulting in abdominal disorders. Contrary to the above, others reported that saponin has the potential as dietary additive at optimum levels in diets favouring high growth rate and better feed efficiency (Yejuman *et al*, 1998), lower serum cholesterol level (Udea and Shigemizu, 1998) and reduces the emission of ammonia in animals' excreta (AL-Bar *et al*, 1993). According to EFSA (2009) ruminants are more tolerant to saponins than monogastric animals, and can tolerate inclusion levels up to a maximum of 20% of high saponin containing feed ingredient (like *Madhuca mongifolia* seed cake) in the diet.

b. Tannin; generally tannin induces negative responses such as astringency, bitterness or unpleasant taste when consumed (Brown, 2008). In poultry small quantities of tannin causes adverse effects. Levels from 0.5 to 2.0 % can cause depression in growth rate and egg production while levels from 3 to 7% can cause death. Similar effects have been found in swine. Hydrolysable tannins are toxic to ruminants when fed at higher levels above 20% (Brown, 2008). Tannin is reported to reduce absorption of minerals such as irons (Garrow and James, 1993). This occurs as a result of formation of complexes with iron which form linkages with proteins during mastication and appears to reduce microbial degradation of protein (Guthrie *et al*, 1995). Barry (1985) reported that, sheep could adapt to tannin rich plants or feed if it is offered as a supplementary diet only up to 25% of the feed offered on dry matter basis. The addition of more proteins or amino acids may alleviate the anti-nutritional effects of tannins. Also, moderate levels of tannins (less than 4%) in forage legumes can lead to beneficial response in ruminants resulting in higher growth rate and milk yield (Brown, 2008).

c. Theobromine; This is colourless and odourless 3, 7- dimethylxanthine with slightly bitter taste, it occurs naturally in *Theobroma cacao* and other related *Theobroma* species (SOPCFC, 2008). It is an alkaloid and lethal to chickens, monogastrics and young ruminants (McDonald *et al*, 1995). Peckham (1984) indicated that, theobromine level of 150 g/kg is toxic for laying hens. It was reported that cocoa shells and oilcakes which contain high amounts of theobromine is acceptable to ruminants up to 0.8 kg/day without adverse effects and recommended the inclusion rate for cocoa residue in ruminants' diets of 2%, equivalent to 0.5 kg/day (SOPCFC, 2008). Tettey (1983) reported theobromine content up to 360 mg per 100 g of SNC. Atuahene (1998)

reported 4.5- 5.7 g/kg theobromine content of shea nut cake. The chemical composition of the shea nut cake according to Atuahene (1998) is shown in Table
2.5.2a and 2.5.2b.

Table 2.5.2a Chemical Composition of shea nut cake

Comp.	**Proximate analysis**					**ibre components**		
	DM	CP	EE	CF	ASH	NDF	ADF	HEM.
g/Kg	915.0	162.4	134.0	95.0	42.0	100.7	92.3	8.4

Source: Atuahene *et al* (1998)

Table 2.5.2b Chemical Composition of shea nut cake

Comp.	**Mineral Elements**									**Others**		
	Cu	P	Mg	Iron	I	K	Zn	Cu	Na	Saponin	Theobromine	ME (MJ/kg)
g/Kg DM	3.73	2.81	1.60	0.42	0.42	0.37	0.30	0.48	0.34	2.97	4.50	7.12

Source: Atuahene *et al* (1998)

2.5.3 Assessment of SNC as feedstuff

Okai and Bonsi (1989) reported a decrease in feed cost when increasing levels (0, 5, 10 and 15%) of SNC were fed to growing gilts. They found that inclusion of SNC significantly (P<0.05) depressed growth rate and feed conversion efficiency but did not affect intake. However, there was a slight decrease (2%) in daily feed intake as the level of SNC increased in the diet. They attributed the fall in intake to an irritation of the digestive tract or an adverse effect of the SNC on the rate of digesta flow.

Weight gains of 0.057, 0.048, 0.050 and 0.035 kg/pig/day were recorded for the various levels of SNC (0%, 5%, 10% and 15% respectively) at the end of ten weeks feeding period (Okai and Bonsi, 1989). The 15% SNC inclusion level recorded the lowest rate of growth and was significantly different (P<0.05) from the rest. Rhule (1995) stated that, SNC can be fed to grower and finisher pigs at a level of 5% and 10% respectively without any adverse effects on daily gain. This was based on results from pigs fed diets containing 0%, 5%, 10%, 15% and 20%

inclusion levels of SNC. The respective average daily gain during the grower phase was, 0.05, 0.04, 0.03 and 0.02 kg/day. That of the finisher phase was 0.05, 0.05, 0.05, 0.04 and 0.04 kg/day respectively. The gain of grower pigs on the control diet (0% SNC) was similar to that of 5% SNC diet but differed from levels above 5% SNC level. SNC therefore has been recommended as a potential feed ingredient for pigs at 5-10% inclusion level.

In poultry, Atuahene (1998) stated that SNC could be incorporated in the diet of growing broilers up to 2.5% without adverse effects on performance. The report added that inclusion level above 2.5% (5% and 7.5%) significantly (P<0.01) decreased weight gain. There was a decreased intake as SNC levels increased and consequently a decrease in weight. This was attributed to the presence of saponin and theobromines in the SNC, as they have been reported to cause reduction in palatability of diets. Mortality recorded was attributed to higher inclusion levels of SNC (Atuahene *et al*, 1998). Olorede and Longe (1999) stated that, pullets could take up to 10% SNC inclusion level in the diet, higher than the 2.5% SNC inclusion level reported by Atuahene (1998). But they agreed that higher inclusion levels of SNC in the diet of poultry birds depress intake and growth rate. Tables 2.5.3.1 and 2.5.3.2 present the findings of Olorede and Longe (1999) when pullets were fed with different levels of Shea Butter Cake (SBC). From Table 2.5.3.1, nutrients retention was lower in diet 3 and consequently depression in growth was recorded (Olorede and Longe, 1999).

Table 2.5.3.1 Growth and nutrient retention of pullet chicks fed graded levels of shea butter cake.

SBC	0	100g/kg	200g/kg	SEM
Diets	1	2	3	
Growth rate	7.12^{a}	6.55^{ab}	5.09^{b}	14.5
Apparent retention (%)				
Dry matter	75.34	74.07	68.78	5.8
Crude protein	74.54	73.24	66.48	6.1
Ether extract	90.3^{a}	94.68^{a}	87.58^{b}	2.0
Crude fibre	26.15^{ab}	42.99^{a}	15.46^{b}	13.7
Ash	34.06	43.26	35.77	12.1

g/chick/day; abc; means in the same row with different superscripts are significantly different (P<0.05). Source: Olorede and Longe (1999).

Table 2.5.3.2 Haematology and serum chemistry of pullet chicks fed graded levels of shea butter cake

SBC g/kg Diets	0 1	100 2	200 3	SEM
PCV%	23.13ab	22.00a	24.00b	1.2
Hb%	7.51	7.29	7.65	0.34
RBC ($x10^6$/L)	3.69a	3.64^{a}	4.6^{b}	0.24
WBC ($x10^3$/L)	21.43a	18/34^{b}	2.15^{ab}	1.8
Total Protein (g/dl)	3.06	2.93	2.98	0.23
Albumin (g/dl)	0.91	0.85	0.90	0.8
Globulin (g/dl)	2.15	2.08	2.10	0.19
Cretinine (mg/dl)	0.4	0.38	0.35	0.03
Urea (mg/dl)	10.18	10.38	10.33	0.36
Cholesterol (mg/dl)	97.13	80.00	88.75	13.75
Serum G.P.T.(I.U./L)	21.00	22.13	17.63	7.4
Serum G.O.P (IU/L)	26.63	25.0	24.25	2.6

a b: means in the same row with different superscripts are significantly different (P<0.05). PCV: packed cell volume; Hb; Haemoglobin, RBC; Red Blood Cells, WBC; White Blood Cells, GPT; Glotamate Pyruvate Treansminase, GOT; Glutamate Oxaloacetate Transaminase. Source: Olorede and Longe (1999).

From Table 2.5.3.2, there was no effect on serum metabolites, blood sugar, total protein, globulin, haematocrite and blood haemoglobin at all the inclusion levels of SBC in the diet. In ruminants, according to Esien (2003), SNC can be incorporated in the diet of sheep up to 50% with wheat or rice bran and will be accepted by the sheep. Salifu (2004) reported that, shea nut cake may be added to the diet of sheep up to 15% without adverse effects on their performance. This was concluded from a study of sheep response to SNC-based diet at 0%, 15% and 30% inclusion levels to form diet 1, 2 and 3 respectively. The results on weight gain were 73.75 g/day, 60.18 g/day and 38.93 g/day for diets, 1, 2 and 3 respectively. There was no significant difference (P<0.05) between diets 1 and 2, but diet 3 differed significantly. Issaka (2006) repeated this work at a different location and had similar trends. It was also reported that the dry matter intake increased at 15% inclusion level and decreased at 30% inclusion level. A feed conversion efficiency of 22.36, 17.24 and 10.7 for diets 1, 2 and 3 respectively (0%, 15% and

30% SNC respectively) were recorded. SNC can therefore be incorporated into the diet of sheep up to 15% to lower cost and maximize profit (Issaka, 2006). It has been reported that SNC inclusion level up to 30% or more depresses feed intake and consequently affect weight gain (Salifu 2004; Issaka 2006). Contrary to this, Annoh (2005) reported no significant difference in feed intake and weight gain among sheep fed three different levels of SNC (0%, 15% and 30% representing diets 1, 2 and 3 respectively) when he added cassava chippings into diet 3, which reduced the concentration of ether extract in the diet. He concluded that SNC can be included in the diet of sheep up to 30% when incorporated with other ingredients that have little or no ether extract such as rice straw and cassava chippings.

The potential growth rate of the Djallonke sheep, can be as high as 80 g/day if the diet is adequately supplemented (Berger, 1983). Ngwa and Tawah (1991) reported that supplementation of Djallonke sheep with an average weight of 22 kg with rice straw, groundnut haulms, cotton seed and cowpea vines, recorded average daily gain of 29.24 g, 48.98 g, 52.4 g and 49.19 g/day respectively. An average daily weight gain between 87.0 - 130 g were reported when hybrid sheep developed from Djallonke and sahalian crosses were fed with cassava peels and pigeon pea waste (Ngwa and Tawa, 1991).

2.6 Digestibility in small ruminants on concentrate supplement fed with fresh forages or straws

According to Aboakye (2004), dry matter digestibility of SNC-based diets decreases at higher levels of SNC inclusion in the diet. In a three graded levels feeding trial with sheep on shea nut cake-based diets with 0%, 15% and 30% SNC for dietary treatment 1, 2 and 3 respectively the result indicated that crude protein digestibility in diet 3 was significantly lower ($P<0.05$) than diets 1 and 2. No significant differences existed in the digestibility of ether extract and crude fibre among the three diets. However, Aboakye (2004) had significantly higher ($P<0.05$) organic matter and Total Digestible Nutrients (TDN) in diet 1 and 2 than in diet 3. The findings revealed that, diet 3 (30% SNC inclusion level) recorded low dry matter intake and low nutrient digestibility. The apparent digestibility of the various nutrients is shown in Table 2.6.1

Table 2.6.1 Apparent digestibility (%) of the various nutrients in shea nut -based diets fed to sheep.

Nutrients		Treatment means		
	D_1	D_2	D_3	SEM
DM	68.64^a	61.54^a	46.3^b	3.80
DP	74.09^a	56.67^b	19.92^c	5.97
EE	57.97^a	59.75^a	64.13^a	5.29
CF	53.83^a	39.97^b	36.00^b	5.75
NFE	78.61^a	73.99^a	48.81^b	4.13
OM	75.32^a	68.75^a	49.79^b	4.00
TDN	74.64^a	70.15^a	52.14^b	4.82

a b; Means with deferent superscripts within the same row are significantly different (P<0.05). SEM; Standard Error of Mean, (Source; Aboakye, 2004).

Jamie *et al* (2009) reported an average dry matter apparent digestibility of 65.2% when lambs were supplemented with different crop residues fed with fresh Bahia grass as basal diets.

When maize stovers were fed to growing goats and supplemented with browse leaf meal - based concentrate and compared with cotton seed cake based concentrate, the feed intake and apparent digestibility values recorded are shown in Table 2.6.2. The digestibility of dry matter, crude protein and energy improved (Ndemanisho *et al*, 2007). Njwe and Olubajo (1992) reported the following average digestibility values in West African Dwarf Goats fed fresh guatemala grass and supplemented with cassava flour or groundnut cake; 69.90, 71.99, 60.61, 77.56, 48.33, 51.04 and 68.49% for dry matter, crude protein, cell wall, cell content, acid detergent fiber, cellulose, and energy respectively for groundnut cake supplementation and 69.90, 69.44, 63.42, 49.15, 57.31, 59.24 and 67.78% respectively, for cassava flour supplementation.

Table 2.6.2 Intake and apparent digestibility of growing goats fed maize stovers and supplemented with different browse leaf meals compared to whole cotton seed.

Parameter	Treatments				
Intake g/d	LBC	ABC	MBC	GBC	CBC	SE

DM	347a	335a	331c	324d	337ab	4.10
OM	316a	312b	305c	297d	316a	0.50
CP	41.1a	39.6b	39.1b	38.3c	39.8a	0.07
NDF	206b	243a	220ab	221ab	172c	9.06
ADF	141a	148a	135ab	136ab	115b	6.04
Digestibility						
DM	0.63	0.62	0.62	0.69	0.68	2.52
OM	0.66	0.65	0.66	0.71	0.71	2.44
CP	0.68b	0.73b	0.71b	0.79	0.79	2.01
NDF	0.62	0.66	0.65	0.66	0.60	3.91
ADF	0.57	0.54	0.53	0.57	0.49	4.42
G R g/d	24.0	22.1a	23.7	25.4	33.1	2.2
FCR	12.8	13.7	12.8	12.1	9.5	1.41

Means with different superscripts within the same row are significantly different (P<0.05).Treatment: LBC; leucaena- based concentrate, ABC; Albizia based –concentrate, MBC; Moringa-based concentrate, GBC; Gliricidia based concentrate.CBC; cotton seed- based concentrat (Source: Ndemanisho *et al* 2007).

According to Lee (2008), forage with dry matter digestibility of 60 to 69% is considered as high quality forage in terms of energy supply. About 70% of the energy in these kinds of forages is degraded in the rumen by microorganisms and 30% escape to small intestines and digested by enzymes for absorption.

For all feedstuffs ruminant animals need about 65 to 68% of the protein to be rumen degradable for adequate rumen functions and the development of microbial protein. If more protein is degraded in the rumen, the animal gets less bypass protein for absorption in the small intestines, and the ruminant is denied of certain essential amino acids that are deficient in rumen degraded protein. Also, much of the rumen degraded protein is absorbed in the form of ammonia and excreted via the urine which is a waste of protein. It is therefore necessary to have bypass protein in every feedstuff fed to ruminants (Lee, 2008). Sewell (1993) stated that supplementation of ruminants with concentrates, for instance corn supplementation to cattle should be limited to 0.5 to 1% of the animal’s body weight.

The digestibility values of West African Dwarf sheep fed T1 (fresh napier grass without supplement), T2 (fresh napier grass supplemented with undefatted soya bean meal) and T3 (NaOH treated soya bean pods with undefatted soya bean meal) are shown in Table 2.6.3.

Generally, the tested diets were fairly digested. The average liveweights gained were 41 g/d, 77 g/d and 79 g/d for T1, T2 and T3 respectively (Njwe and Godwe, 1988).

Table 2.6.3 Percentage digestibility of dry matter and other nutrients by West African Dwarf sheep fed napier grass and NaOH treated soya bean pods supplemented with undefatted soya bean meal.

Nutrient %	Treatments		
	T1	T2	T3
Dry matter	68.89-4.23ab	69.67-1.06a	66.70-36b
Crude protein	74.88-2.72b	83.04-0.43a	79.70-1.09ab
Organic matter	72.53-4.69	73.34-1.229	67.77-2.15
Crude fibre	75.29-3.82a	65.36-3.66b	62.13-1.58b
Ether extract	59.18-5.12b	83.89-2.66a	83.85-2.73a
Nitrogen free extract	70.13-4.78	69.18-1.98ab	60.89-2.51b

Values within the same row with same letter superscript are not significantly different (P> 0.05) Source: (Njwe and godwe, 1988).

2.7 Haematology and serum metabolites of sheep

An analysis of a number of ruminants' blood was done in an animal health care laboratory at Daya, India (Pampori 2003) and the normal ranges and means of ruminants' haematological profile of some selected parameters were reported as shown in Table 2.7.1.

Table 2.7.1 Normal heamatological profile of ruminants

Animal	Parameters							
	Hb %	PCV %	RBC (10^6/C)	WBC (10^3/C)	Glucose mg%	Serum total cholesterol mg%	Plasma Protein g%	Plasma albumin g%	Plasma globulin g%
Cattle	8-14	24-38	5-9	4-10	35-55	50-130	6.74-7.46	3.03-3.55	3.00-3.48
Average	11	32	7	7	45	90	7.1	3.29	3.24
Sheep	8-16	26-36	5-11	4-10	35-74	100-150	6.00-7.90	2.70-3.90	3.50-5.70
Average	12	30	8	8	54.5	125	6.95	3.3	4.6
Goat	8-14	24-36	10-18	4-13	45-60	55-200	6.40-7.90	2.70- 3.90	2.70-4.10
Average	11	30	13	8	52.5	125	7.15	3.3	3.4

Hg; Haemoglubin, PCV; Packed Cell volume, RBC; Red Blood Cells, WBC; White Blood Cells, (Source; Pampori, 2003)

Low albumin suggests poor clotting ability of blood and hence poor prevention of hemorrhage (Robert *et al*, 2000). A decrease in serum globulin is an indication of reduction in disease fighting ability of the animal body system. This could lead to high mortality when there is an infection or outbreak of disease in the flock (Iheukwumere *et al*, 2005). The amount of cholesterol in serum is associated with the quantity and quality of protein supplied in the diet (Esonu *et al*, 2001). Iheukwumere *et al* (2008) reported changes in the immune status and serum metabolites values of West African Dwarf (WAD) goats on concentrate supplementation or FSH+LH (pergonal) treatment. The change in values however, fell within the normal ranges for adult WAD does.

Animals on high plane of nutrition have high haemoglobin and parked cell volume count than similar animals fed poor diet (Olayimi *et al*, 2000). On the other hand, high white blood cells count is attributed to parasite and bacterial infection among animals (Egbe-Nwiye *et al*, 2000; Schalm *et al*, 1975). WBCs are the soldiers of the body, their high count rate in the blood stream may be to increase or complement the immune system of the animal (Coles, 1980). Baiden *et al* (2007) fed sheep and goats with different levels of cassava pulp (residue left after starch extraction) and reported the haematological profile as indicated in Table 2.7.2. They recorded a significant change ($P<0.01$) in the haematology of sheep fed the pulp compared to the control. The changes were attributed to the pulp. However, there was no significant change in goats fed the pulp. The Packed Cell Volume (PCV) was significantly ($P<0.05$) higher in sheep on 15% and 30% pulp diets compared to those on the control diet. The same trend was also found in goats. Total white blood cell (WBCs) counts and total red blood cell (RBCs) counts were significantly higher ($P<0.01$) in goats than in sheep. Haemoglobin (Hb) values were significantly ($P<0.01$) higher in sheep on the 15% and 30% pulp diets than goats. Diet and animal species had no statistical effect ($P>0.05$) on the WBC differential counts.

Table 2.7.2 Haematological values of sheep and goats on various diets

Parameter	**0% Pulp**		**15% Pulp**		**30% Pulp**		
	Goat	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**SEM**
PCV%	29.5^a	28.5^a	29.8^a	34.3^b	32.0^a	34.5_b *	1.13

WBCs x 10^3/µl	15.3^{a}	6.94^{b}	14.3^{a}	7.09^{b}	14.2^{a}	10.5^{b} **	1.05
RBCs x 10^6/µl	14.0^{a}	8.23^{b}	13.7^{a}	10.8^{b}	14.6^{a}	11.1^{b} **	0.74
Hb g/100ml	9.50^{a}	9.00^{a}	9.45^{a}	11.8^{b}	9.91^{a}	11.4^{b} **	0.40
Percentage distribution of leucocytes							
Lymphocytes	57	57	52	49	56	46 NS	3.0
Neutrophils	41	43	46	49	41	52 NS	3.1
Eosinophils	2	0	2	2	2	3 NS	0.6
Basophils	0	0	0	0	0	0 NS	0
Monocytes	1	0	1	1	1	0 NS	0.3

PCV = Packed cell volume; RBC = Total red blood cell count; WBC = Total white blood cell count
Hb = Haemoglobin values; SEM = Standard error of the mean
Means within the same row with different superscripts are significantly different (P<0.05; **P<0.01)*
NS = Not significant. Source; (Baiden et al, 2007)

The leucocytes in the body work as part of the body immune system and reacts to foreign substances (David, 2008). The components that make up leucocytes are given as neutrophils, eosinophils, basophils, monocytes and lymphocytes. The functions of the individual leucocytes are described (David, 2008) as follows; neutrophils; these are plentiful in the blood stream and have the main function of breaking down bacterial cells in the body with its enzymes stored in grains located in the cytoplasm to prevent further multiplication and infection of the body by the bacteria. The neutrophil cells die soon after phagocytosis due to the depletion of their glycogen reserves. Eosinophils stain red when microscopic slide is stained with acidic stain, the number of eosinophils increases in the blood in the presence of allergens or parasites in the animal's body. Basophils are the least plentiful leucocytes that stain for viewing when treated with basic stain on a slide. These cells are called to action at the beginning of inflammation in response to an injury or irritation in any part of the body. And it is characterized by redness, warmth, swelling and pain in that place. During these process basophils migrate from the blood stream to the site of the inflammation. Monocytes are the largest leucocytes that help devour foreign microorganism in the body and also digest dead body cells and remove unwanted cellular materials from the body. An increase in monocytes number in an animal's body is an indication of evasion of foreign microorganisms in the body or high rate of body cells death (David, 2008). Lymphocytes use the blood to travel round the body but can wander freely in other types of tissues using the lymphatic channels. An increase in lymphocytes number is in response to viral, parasitic and bacterial infection of the animal's body (Coles, 1980). Ekenyem and Madubuike (2007) reported significant differences (P<0.05) in haematological parameters in pigs fed varying levels of *Ipomoea asarifolia* leaf meal compared to the control. The white blood cells differential significantly differed (P<0.05) between treatments and increased as the level of the leaf meal increased in the diet and later fluctuated within the normal range. It therefore registered no deleterious effects on the haematology and serum biochemistry of the pigs. Serum cholesterol did not show any significant difference (P>0.05) assuring the safety of the leaf meal in pigs' diet at the inclusion level of 5, 10, and 15%. Gangapadhyah (1981) observed a depression in plasma protein concentration in Milch Murrah buffaloes on replacement of concentrate mixture with 15 and 20 parts of neem seed cake and Verma *et al* (1995) reported no effects in the level of serum total protein in growing goats on replacement of concentrate with 15 and 25 parts of water washed neem seed cake.

Blood glucose levels in ruminants are considerably lower than that of non-ruminants. They are also relatively insensitive to insulin secretion (Annison and white, 1961). The blood glucose level is expected to increase with feeding because propionate, the precursor for gluconeogenesis is produced in the rumen and absorbed after feeding (Bassett, 1975; Sano *et al*, 1999). Glucose is required for maintenance of nerve tissues, retina, germ and epithelial cells as well as synthesis of lactose in the animals' body (Bolukbasi, 1989). Trinders (1969) reported mean glucose levels of 51.18 g/dl ± 3.24, 50.33 g/dl ± 2.43 and 46.89 g/dl ± 5.32 when lambs were fed with straw alone, straw + Urea Molasses Mineral Block (UMMB), and straw + UMMB + Barley respectively for 30 days. The measurements of serum cholesterol levels are useful in the evaluation of the risk of coronary arterial occlusion, atherosclerosis, liver function, intestinal absorption, thyroid function and adrenal diseases (Trinders, 1969).

2.8 Feeding value of wheat bran and some straws

Wheat bran has been defined as the outer covering of wheat kernel as separated from the cleaved and scoured wheat in the usual process of commercial milling (Donkoh *et al*, 1999). Cullison and Lowrey (1975) stated that, wheat bran primarily provides bulk and mild laxative and source of phosphorus and secondarily as a source of protein. The chemical constituents of wheat bran was analyzed and the components given as shown in Table 2.8.1.

Table 2.8.1 Chemical composition of wheat bran

Component	DM	CP	EE	CF	Ash	NDF	ADF	Hem.	Lignin	Starch	ME MJ/kg
g/Kg	894.3	193.5	42.1	97.1	49.7	503,8	167.2	336.6	29.3	197.0	6.72

Hem = hemicelluloses. Source: Donkoh *et al* (1999**)**

Donkoh *et al* (1999) reported that increasing amount of wheat bran in the diet of poultry up to 15% or above increases feed intake and reduces weigh gain due to reduction in feed utilization. The phenomenon was attributed to calcium – phosphorus imbalances of wheat bran in high inclusion levels. It was earlier reported by Pond and Maner (1974) that wheat bran contains high phosphorus and low calcium which may result into nutritional imbalances. In swine, between 25 and 30% inclusion level of wheat bran in the diet of growing and finishing pigs has been reported as ideal inclusion level. Higher levels up to 70% may be used but reduction in growth rate, depressed in weight and dressing percentage have been reported at that level and may only be encouraged when lean pork is needed (Donkoh *et al*, 1999). It is concluded that, in non – ruminants, high inclusion level of wheat bran above the respective thresholds could increase or not affect feed intake but may decrease body weight gain. In sheep, effects of varying inclusion levels have not been reported. However, it has been included in energy concentrate diets at various levels (10% by Smith, 1982; 35% by Otchere *et al*, 1983 and 45% by Ouandaogo, 1981) without any reported adverse effects.

Straw is the largest byproduct of cereal production. It is however, under utilized as a feed resource for feeding ruminants. The major biological constraints of the utilization of cereal straws and other poor quality roughages are related to the low crude protein and low degradability of carbohydrates in straw in the digestive tract of the animals, which results in low voluntary intake (McDonald *et al*, 1995). The ammoniation method (using ammonia gas, ammonium hydroxide and urea) to improve the digestibility of fibrous roughages like rice straw, is now an accepted technique. Fadel (2004) reported that feeding ammonia or ureacalcium hydroxide treated straws alone to sheep without supplementation will not be sufficient to meet the maintenance requirement of the sheep. It is therefore necessary to supplement sheep as well as other ruminants when straw is offered as the basal diet to maintain productivity or improve performance. Despite the large quantity of straws and poor roughages available for ammonia treatment in developing tropical countries, commercial application of this technology has so far been limited mainly to the developed countries because of technical and economical constraints (Fadel, 2004).

Groundnut haulms (the straw left after harvesting groundnut) have been reported to contain 15 to 18% crude protein and considered as a good protein source for ruminant supplementation in the dry season (Ikhatua and Adu, 1984). Lamidi *et al* (2006) reported relatively high intake of groundnut haulms by ruminants in the dry season. Table 2.8.2 gives the chemical composition of groundnut haulms and rice straw on dry matter basis (Lamidi, 2006).

Table 2.8.2 Chemical composition of rice straw and groundnut haulms

Ingredient	***Parameters on DM basis (g/100g)***							
	DM	OM	CP	CF	EE	NFE	Ash	ME(MJ/kg)
Groundnut haulms	91.43	-	11.65	28.71	2.14	42.51	-	-
Rice straw	91.88	85.40	3.85	34.03	1.83	45.62	14.65	5.64

Source: Lamidi *et al*, (2006).

2.9 Soy bean meal as a protein source for animal production.

According to Lassiter and Hardy (1982), soya bean meal is the product obtained by grinding the flakes which remain after removal of most of the oil from either whole or dehulled soyabean by the solvent extraction process. Soya bean cakes are widely used as protein source or protein supplement in both non ruminant and ruminant animal production in industrial countries (McDonald *et al*, 1995). This is as a result of its richness in indispensable amino acids, notably lysine, and its moderate price as compared to other protein sources like fish meal. Soya bean meal has been reported as a good source of quality protein, energy and minerals such as magnesium and potassium (Lassiter and Hardy, 1982). It is often used in large proportions in poultry and other non ruminants' diets than in ruminants (Say, 1995). The addition of soya bean meal to sheep diet as a supplementary concentrate to straw basal diet results in increased dry matter intake because there is increased protein supply to rumen microbes which makes them active and increase dry matter digestibility (McDonald *et al*, 1995). Jamie *et al* (2009) reported greater ($P<0.01$) nitrogen intake and retention and apparent dry matter digestibility in growing lambs supplemented with soya bean meal compared to browse legume hay supplementation when the lambs were fed with bahiagrass (*Paspalum notatum*) as a basal diet. Obese (1998) reported significantly ($P<0.05$) higher mean weight gain in Djallonke sheep fed soya bean cake as a supplement compared with other by-products. The treatments were 200 g of cassava peels and 100 g of soya bean cake (T_1), 200 g of cassava peels and 100 g of groundnut haulms (T_2) and no supplement (T_3) as control. The result obtained indicated that the average daily supplementary feed intake did not differ significantly in T1 and T_2. The highest mean weight gain (2.96 kg) was recorded in T_1 while T_3 had the lowest (0.96 kg). The average (± s. d.) daily weight gains were 48 ± 4 g, 32 ± 3 g and 16 ± 3 g for T_1, T_2 and T_3 respectively. This makes soya bean meal an important feed ingredient for supplementing ruminants fed poor quality forage.

2.10 Nutrient Requirement of Sheep

Several different methods have been used to estimate nutrient requirement of livestock. Examples include comparative slaughter of animals at different weights and ages, calorimetric method and others. These methods have their disadvantages such as high cost of equipment, labour intensive and unnatural conditions of animals under the calorimetric method. Also, some assumptions must be made before the estimates (Luo *et al*, 2004). Another method is the use of body weight gain (BWG) as a measure of retention and to relate BWG to energy or protein intake using regression equations. The lapses of these relations are gut fill and variations in the composition of the gain (Paul *et al*, 2003). Mandal and Trinder (2004) stated that, the knowledge of nutrient values especially the energy values of the feeds are only estimate for most tropical feeds, and that there is inadequate information on digestibility, degradability, and metabolizability of protein in tropical feeds. It is debatable whether a very high precision is necessary. In practical feeding of roughages, foliages, straws, and grasses the animals are often fed *ad libitum* to ensure high feed intake. This is important when formulating tropical feeds to meet the nutrient requirement of the animals. Roy (1979) reported 80% increase in nutrient requirement of ewes during the last six weeks of gestation and three times maintenance requirement needed during the first eight weeks of lactation. If the ewe is nursing twins, its nutritional needs are 15% more than those nursing single lambs. This underscores the importance of supplementing ewes during pregnancy and early part of lactation. For lambs and growing sheep, concentrate containing 18% crude protein is an ideal supplement for better performance as it meets their protein requirement well (Croston and Pollot, 1994). According to McDonald *et al* (1995), growing lambs of 20 kg body weight and gaining 0 – 50 g /day require 0.46 kg / day of dry matter intake, 4.8 MJ/kg of metabolizable energy and 58 g of degradable protein per day (made up of 40 g rumen degradable protein and 18 g of rumen undegradable protein) for steady growth.

CHAPTER THREE MATERIALS AND METHODS 3.1 Location

The experiment was carried out at the Animal Research Institute (ARI) of the Council for Scientific and Industrial Research (CSIR) at Nyankpala, in the Tolong-Kumbungu District of the Northern Region. Nyankpala is located at longitude $0^0\ 58^1\ 42^{11}$ W and latitude $9^0\ 25^1\ 41^{11}$ N and at a height of 183 m above sea level and in the dry savanna ecological zone of Ghana (SARI, 2007). It has a unimodal rainfall pattern that begins in late April and ends in October. The mean annual rainfall is 1043 mm. Temperatures generally fluctuate between 15^0C (minimum) and 42^0C (maximum) with a mean annual temperature of 28.3^0C. The mean annual day time relative humidity is 54% (SARI 2007). The area experiences dry cold harmattan winds from November to February and a period of warm dry conditions from March to mid April. The dry season therefore stretches from November to late April.

3.2 Experimental Animals

Six young Djallonke rams with a mean age of 12 ± 2 months were used. The average live body weight was 12.8 ± 2.4 kg at the start of the work. The experimental design was double 3x3 Latin square. The animals were randomly distributed to three treatment diets at the beginning of the experiment. The adjustment period was three weeks (Ranjhan, 2001) after which measurements were taken for one week.

3.3 Housing

Each animal was housed in a pen and fed individually. The floor of the pen was made of concrete and the divisions were done with wood. The area of each pen was 4.5 × 2 m with a height of 3.0 m. The wall was made of concrete blocks and roofed with aluminum sheets. There were ventilation holes for free movement of air in and out of each pen. The experimental duration was 12 weeks; starting from October 18, 2008 to January 10, 2009.

3.4 Experimental Treatment Diets and lay out

There were three treatment diets used for the experiment designated as T1, T2 and T3 and three rounds as shown in Table 3.4.1. The content of the treatment diets were;

T1: Rice straw (62.5%) and groundnut haulms (37.5%) on dry matter basis

T2: T1 plus 11.5% shea nut cake in a concentrate supplement (on dry matter basis)

T3: T1 plus 23% shea nut cake in a concentrate supplement (on dry matter basis)

The rice straw (62.5%) and the groundnut haulms (37.5%) were chopped into 20 mm pieces and mixed together to constitute the control diet (T1).The two concentrate supplements (CS) contained 11.5% (T2) or 23% (T3) shea nut cake (on dry matter basis). Table 3.4.2 gives the details of the experimental diets. Each animal was offered 700 g of the control diet (62.5% rice straw and 37.5% groundnut haulms), plus 200 g of the supplemental concentrate in the case of those on T2 and T3 per day. The amount of the basal diet offered was more than the standard requirement of 0.46 kg/day for sheep weighing 20 kg and growing at 0 to 50 g/day (McDonald *et al*, 1995). This was given to allow left over for intake measurement.

Table 3.4.1 Experimental lay out

ROUNDS	**TREATMENT DIETS OFFERED**					
	Anl 1	Anl 2	Anl 3	Anl 4	Anl 5	Anl 6
1	**T 2**	T 2	T3	T 3	T 1	T 1
2	**T 3**	T 3	T 1	T 1	T 2	T 2
3	**T 1**	T1	T 2	T 2	T 3	T3

Key; T; treatment, Anl: animal

Table 3.4.2 Inclusion levels and analyzed chemical composition of the experimental diets offered (dry matter basis).

COMPONENT (%)	**TREATMENT DIETS**			
INGREDIENTS	T1		T2 CONCENTRATE	T3 CONCENTRATE

Rice straw	62.5		-	-
Groundnut haulms	37.5		-	-
Wheat bran	-		55.0	55.0
Shea nut cake	-		11.5	23.0
Soyabean meal	-		33.5	22.0
Analyzed chemical composition				
DM	89.55		89.02	89.17
Organic Matter	91.81		94.28	93.78
Crude Protein	6.78		28.59	24.99
Crude Fibre	32.04		8.38	8.80
Ether Extract	1.95		4.43	5.77
Ash	8.19		5.72	6.22
Nitrogen free extract	51.05		52.88	54.22
NDF	82.24		48.15	43.92
ADF	71.51		25.24	24.75
ME (MJ/kg)	10.17		12.63	12.82

Key: DM; Dry Matter, NDF; neutral detergent fibre, ADF; acid detergent fibre, ME (MJ /kg); Metabolisable energy (MJ /kg)

Mineral lick and water were given *ad libitum.* All the animals were injected with 2 ml each of an antibiotic (Oxytetracycline 10%, Kuipersweg Ltd, Woerden, Holland), and dewormed with albendazole 2.5% oral suspension (Cipila LTD, India, 3 ml per animal) to control endoparasites before the start of the experiment. Both concentrate and basal diets were offered together at about 08:00 h GMT daily. The concentrate was put in a plastic container for each animal while the straw was chopped into 20 mm pieces and put in a wooden trough for each animal.

The SNC was collected from **Sekaf Ghana Ltd** (a medium scale shea nut processing company at Kasalgu a suburb of Tamale). Soya bean meal was bought in Kumasi and transported to Nyankpala for the work while the wheat bran was bought from an Agricare outlet in Tamale. The rice straw was collected from the SARI (Savanna Agricultural Research Institute) experimental rice field in Nyankpala and the groundnut haulms were collected from a local farmer's groundnut field in Nyankpala.

3.5 Data Collection

Data were collected in the last week of every feeding period or round. Feed offered and refusals were weighed daily for the measurement of feed intake. Samples of feed were taken during the week of data collection and were stored in a refrigerator at 4 - 8^{0}C for laboratory analysis. Live weight was measured every two weeks (at the end of the second and fourth weeks, taken two weeks as stabilization period) of each round in the morning before feeding to determine weight gain. The animals were bled between 06:30 and 07:30 h GMT using a needle and a syringe in the last day of each feeding period from the jugular vein and the blood samples were analyzed to determine the effect of the dietary treatments on some blood constituents. Total faeces were collected daily for seven days during the last week of every feeding period from each animal for digestibility studies.

The substitution of basal diet with the supplemental concentrate referred to as Substitution rate (SR) was determined using the formula given by Nguyem *et al* (2008) as;

$$\frac{\text{FI in un -supplemented treatment - FI in supplemented treatment}}{\text{CI in supplemented treatment}}$$

Where: FI is Forage Intake and CI is Concentrate intake.

3.5.1 Apparent Total Tract Digestibility

The animals were fitted with harnesses for total collection of the faeces. These were collected in every 24 hours at 7:30 h GMT. Each day's collection was kept in a fridge at 4 - 8^{0}C till the seventh day and each animal's faeces were then mixed thoroughly and the fresh weight taken and sampled for analysis. The Dry Matter (DM) of both feed and faeces was determined by putting samples in an oven at 60^{0}C for 48 hours and the lost of weight was taken as the moisture content. The apparent total tract percentage digestibility of DM, OM, CP, CF, EE, Ash, NDF and ADF were calculated using the formula given by Vhile *et al (*2005) and
Ranjhan (2001) as;

$$\frac{\text{Amount of Nutrient in Feed minus Amount of Nutrient in the Faeces times 100\%}}{\text{Amount of Nutrient in Feed}}$$

3.5.2 Chemical analysis

Chemical analysis was done to determine the nutrient composition of the experimental diets and the faecal matter collected. The following were considered: DM, OM, CP, CF, EE and ash using the AOAC (1997) methods. NDF and ADF were determined as described by Van Soest *et al* (1991). Both feed and faecal samples were ground to pass through 2 mm sieve for the chemical analysis. The metabolizable energy (ME (MJ/kg DM)) of the feed offered was calculated according to MAFF (1975) equation for determining energy allowance in ruminants as shown below;

ME (MJ / kg DM) = 0.012 CP +0.031 EE + 0.005 CF +0.014 NFE

Haematological and biochemical analysis**;** The blood samples taken were put into two test tubes; plain one for serum preparation and the other containing Ethylene Diammine Tetra Acetic acid (EDTA) anticoagulant for Hb, PCV and WBCs count as well as leucocytes differential count. The blood glucose level was determined immediately after blood sampling by putting a drop of fresh blood without an anti-coagulant on the strip of One Touch Ultra Glucometer (Johnson & Johnson Company, U K) and the glucose value displayed digitally after 5 seconds. The content of the plain test tube was analyzed in the Spanish laboratory at the University for Development Studies (UDS) to determine the effect of the diet on some blood parameters as follows; Haemoglobin concentration was measured by the cyanmethaemoglobin method (Benjamin, 1961). White Blood Cells (WBCs) count was determined by using haemocytometer after mixing the blood with Turks solution in a proportion of 1:19 using WBC diluting pipette (Schalms *et al*, 1975). Packed Cell Volume (PCV) values were read using a haematocrit reader after spinning the blood at a high speed of 5000 rpm for 5 minutes in a haematocrit centrifuge (Coles, 1980). WBC- differential was determined as described by Turfery (1995). The plain test tube containing whole blood without any anticoagulant was allowed to clot after which it was centrifuged and serum separated from the clotted blood. The extracted serum was stored at 2^0C to 8^0C in the fridge. It was put in ice chest containing ice blocks and transported from Tamale to Kumasi after one week for determination of serum cholesterol, total protein, albumen and globulin at the KNUST CANlab.

The cholesterol level was determined by *in vitro* means using liquid stable reagent based on Trinders (1969) method. Serum total protein (STP) was determined as described by Kohn and Allen (1995) while albumin was determine by using Bromocresol Green (BCG) method as described by Peters *et al* (1982). The globulin level was determined as the difference between total protein and albumin.

3.6 Statistical analysis

The data collected were subjected to ANOVA using the VSN International (2008) Genstat computer software programme and means compared using least significant difference.

CHAPTER FOUR RESULTS

The results of the experiment are presented in this chapter. It has been categorized into feed intake, digestibility, growth performance, faecal matter collected and haematological analysis and presented in tables as named in the following text.

4.1 The nutrient composition of dietary treatments offered

Table 3.4.2 shows the proportion and chemical composition of feed given as treatment diets. The CP content of T2 and T3 were higher than T1. Metabolizable energy content was similar in all the treatment diets and CF levels in the two concentrate supplements were close but that of the T1 was very high relative to T2 and T3.

4.2 Nutrient Intake of experimental animals

The CP intake of all the treatment groups were significantly different ($P<0.05$), animals on T2 registered the highest CP intake. The CP intake ranged between 31.10 g/day and 61.68 g/day. Crude fibre intake did not follow the trend of CP intake in this experiment. Animals on T1 recorded the highest value for crude fiber intake which was significantly higher ($P<0.05$) than those of animals on T2 and T3 (See Table 4.2.1). The intake of crude fat or ether extract ranged between 5.06 g/day and 13.93 g/day and was significantly lower ($P<0.05$) in T1 than in T2 and T3. Mineral intake (ash) was the reverse of the crude fat intake among the three treatments. Animals on T1 had the highest ash intake followed by T3. NDF intake was significantly higher ($P<0.05$) in animals on T1 than those on T2 and T3. The ADF intake differed significantly in all the treatment diets given. In general animal on concentrate supplementation recorded higher protein intake than the control animals, which consumed high fibre.

Table 4.2.1 Nutrient intake (g/day) of Djallonke rams fed rice straw and groundnut haulms with graded levels of shea nut cake in a concentrate supplement

Nutrient intake g/d	***Treatment diets***			
	T1	T2	T3	SEM
OM	401.52^{a}	538.74^{b}	487.59^{c}	19.71
CP	31.10^{a}	61.68^{b}	54.82^{c}	1.46
CF	151.6^{b}	132.0^{a}	127.0^{a}	7.17
EE	5.06^{a}	12.86^{b}	13.93^{c}	0.42
ASH	37.6^{b}	34.2^{a}	35.2^{a}	2.55
NDF	377.2^{b}	363.6^{a}	329.7^{a}	17.76
ADF	327.9^{a}	294.7^{b}	269.2^{c}	15.50

The means within same row with different superscript are significantly different (P<0.05).

The Concentrate Intake (CI) was similar in T2 and T3. The basal diet intake (BDI) was significantly (P<0.05) lower in T3 than in T1 and T2 animals. Total dry matter intake (TDMI) was significantly different (P<0.05) among the three treatments in the order of T1< T3 < T2 (Table 4.2.2). Animals on T2 recorded the highest OM intake.

Table 4.2.2 The performance of Djallonke rams fed rice straw and groundnut haulms with graded levels of shea nut cake in a concentrate supplement.

parameter	***Treatment diets***			
	T1	T2	T3	SEM
Concentrate intake g/d	-	154.07^{a}	152.61^{a}	2.04
Basal diet intake g/d	439.12^{a}	418.87^{a}	370.17^{b}	23.74
Total dry matter intake g/d	439.12^{a}	572.94^{b}	522.79^{c}	25.78
Substitution rate (SR)	-	0.13	0.45	-
Average daily gain (g)	20.88^{a}	31.19^{b}	37.74^{c}	2.01
Weight gain / feeding period (g)	292.3^{a}	436.7^{b}	528.3^{c}	17.18
Average daily gain (g)	20.88^{a}	31.19^{b}	37.74^{c}	2.01
FCR (Feed /gain)	21.03^{a}	18.34^{b}	13.85^{c}	0.37
TDMI (g/kg body weight)	26.84^{a}	33.74^{b}	30.29_{ab}	3.43

The means within same row with different superscripts are significantly different (P<0.05). FCR; Feed Conversion Ratio,TDMI; Total Dry Matter Intake.

4.3 Average daily gain

From Table 4.2.2 animals on T3 recorded the highest average daily gain (ADG) of 37.74 g/day which was significantly (P<0.05) higher than what animals on T2 and T1 obtained. The gain per day of T2 animals was also significantly (P<0.05) higher than that of T1. Animals on T3 converted the feed more efficiently than the rest as indicated in Table 4.2.2. The substitution rate increased from 0.13 to 0.45 as the SNC inclusion level increased from 11.5% to 23% in the treatment diets.

4.4 Apparent nutrient digestibility

From Table 4.4 the dry matter digestibility values obtained were significantly (P<0.05) different in the order of T3 > T2 > T1. Treatment diet T3 had the highest dry matter digestibility suggesting a more effective utilization of that feed. OM digestibility followed the same trend as that of DM. Animals on T3 digested more protein than those on T2 and T1.

Indeed animals fed with T1 diet had abysmally low protein digestibility (Table 4.4).

Table 4.4 Apparent nutrient digestibility of Djallonke rams fed rice straw and groundnut haulms with graded levels of shea nut cake in a concentrate supplement

Nutrient Digestibility (%)	***Treatment diets***						
	T1		T2		T3		SEM
DM	47.44^{a}		56.67^{b}		66.07^{c}		4.42
OM	51.53^{a}		60.13^{b}		72.27^{c}		4.30
CP	28.90^{a}		57.86^{b}		66.07^{c}		5.53
CF	48.51^{a}		52.56^{b}		65.28^{c}		1.28
EE	36.10^{a}		51.56^{b}		74.37^{c}		1.54
Ash	-16.64^{a}		08.48^{b}		14.72^{c}		1.60
NDF	44.29^{a}		62.39^{b}		67.13^{b}		4.47
ADF	41.75^{a}		52.76^{b}		63.65^{c}		4.25

Means within same row with different superscripts are significantly different (P<0.05).

Crude fibre digestibility was fairly good. Animals on T1 recorded the lowest rumen crude fibre degradation compared to those on T2 and T3. It was however significantly different (P<0.05) in all the treatment diets. Ether extract digestibility was between 36.10% and 74.37%, and followed the trend of crude protein. Mineral (ash) digestibility was very low in both T2 and T3 with T1 recording a negative figure. ADF digestibility values were significantly different ($P<0.05$) in all treatment groups similar to that of dry matter, as shown in Table 4.4.

Generally, animals on concentrate supplementation digested more of the nutrients in the diets offered to them than those not supplemented.

4.5 The nutrient composition of faeces collected

The crude protein level of faeces of animals on T3 were significantly lower ($P<0.05$) than that for those on T1 and T2. The dry matter content of faeces of animals on all the treatment groups was significantly different ($P<0.05$). Table 4.5 gives the details of the nutrient content of the faecal matter collected.

Table 4.5 Analyzed chemical composition of faecal matter collected from Djallonke rams supplemented with graded level of shea nut cake.

Components (g/d)	**Treatments**						
		T1		T2		T3	**SEM**
Dry Matter		234.1^{a}		248.20^{b}		164.20^{c}	1.32
Organic matter		194.63^{a}		214.80^{b}		133.34^{c}	1.26
Crude protein		22.11^{a}		25.99^{a}		18.60^{b}	1.02
Crude fibre		78.05^{a}		61.72^{b}		40.00^{c}	1.08
Ether extract		3.23^{a}		6.72^{b}		3.57^{a}	0.50
Ash		43.06^{a}		31.30^{b}		30.02^{b}	0.56
NDF		210.14^{a}		136.73^{b}		108.35^{c}	3.15
ADF		190.99^{a}		129.20^{b}		94.85c	1.61

Means within same row with different superscripts are significantly different ($P<0.05$). NDF; neutral detergent fibre, ADF; acid detergent fibre.

4.6 Haematology and serum metabolites of sheep on graded levels of shea nut cake.

The general haematology of the Djallonke sheep on the experimental diets is shown in Table 4.6. The values obtained were not significantly different among the three treatment diets offered to the sheep in all the blood parameters measured. Some of the blood serum metabolites however, differed.

The animals on treatment T3 had the highest serum total protein (61.50 g/L) which was significantly (P<0.01) higher than what those on the other two treatment diets obtained (Table 4.6). The highest albumin value was recorded for animals on T3 which was significantly (P<0.01) higher than the value for animals on T1 but similar to that for those on T2. The globulin levels did not show any significant difference in all the treatment diets offered.
However, animals on T3 had a higher globulin figure than those on the other two diets.

The cholesterol level in animals on T3 was the highest followed by T2 with T1 having the lowest but the differences were not significant among the three treatment diets.

Table 4.6 Haematology and serum metabolites of Djallonke rams fed rice straw and groundnut haulms with graded levels of shea nut cake in a concentrate supplement.

Parameter	**Treatment diets**			
	T1	T2	T3	SEM
Haemoglobin g/DL	10.87^{a}	10.53^{a}	10.67^{a}	2.83
PCV %	32.7^{a}	31.2^{a}	31.5^{a}	8.16
WBCs x 10^{6}/L	8.67^{a}	8.37^{a}	9.30^{a}	2.13
Leucocytes Distribution				
Lymphocytes%	53.8^{a}	50.5^{a}	54.8^{a}	10.98
Monocytes%	1.33^{a}	1.17^{a}	0.83^{a}	0.86
Neutropyils%	36.2^{a}	41.3^{a}	38.7^{a}	12.06
Eosinophils%	5.83^{a}	5.64^{a}	6.83^{a}	3.36
Basophils%	0.17^{a}	1.33^{a}	1.00^{a}	0.66
Serum Metabolites				
STP g/L	56.00^{a}	59.50_{ab}	61.50^{b}	4.55
Albumin g/L	18.33^{a}	19.67_{ab}	21.17^{b}	1.62
Globulin g/L	37.67^{a}	39.83^{a}	40.17^{a}	4.42
Glucose Mmol/L	5.63^{a}	5.90^{a}	5.77^{a}	1.03
Cholesterol Mmol/L	1.07^{a}	1.10^{a}	1.23^{a}	0.36

Means within the same row with same superscript are not significantly different (P>0.01). PCV; packed cell volume, WBC; white blood cells, STP; serum total protein.

CHAPTER FIVE DISCUSSION

5.1 Nutrient composition of the treatment diets relative to the animals' requirement

The CP levels were more than the 180 g/kg in supplementary diet of lambs reported by Croston and Pollot (1994). On energy, McDonald *et al* (1995) stated metabolizable energy requirement of 4.8 (MJ/kg DM) per day for growing sheep. The energy content of the dietary treatments was higher than the standard given to make room for accessibility problems due to the indigestible nature of some components of diets such as rice straw.

5.2 The dry matter intake of Djallonke rams fed rice straw and groundnut haulms with graded levels of shea nut cake in a concentrate supplement

Nutrient intake is the most important factor that affects animal performance (McDonalds *et al* 1995). The total dry matter intake (TDMI) increased in T2 and T3 (concentrate supplementation) and was significantly lower in the control group. This was similar to the findings reported by Nguyem *et al* (2008). The dry matter intake increased with concentrate supplementation due to increase in supply of protein and readily available energy to the rumen microbes which speed up digestion and create more space for intake (Jamie *et al,* 2009; Njwe and Olubajo, 1992). The TDMI values obtained were close to those of Njwe and Godwe (1988) reported for Djallonke sheep. The slight differences may be due to palatability differences of the basal diets. Issaka (2006) reported same finding for sheep fed fresh pasture grass supplemented with shea nut cake in a concentrate at a level of 0%, 15% and 30%. The dry matter intake increased at 15% but decreased at 30% shea cake inclusion levels. The significant increase in TDMI in the supplemental group may be due to palatability of the concentrate supplemental diets and agrees with the finding of Jamie *et al* (2009). The TDMI however, decreased in T3 in this work and at 30% in the findings of Aboakye (2004), who attributed the decline to anti-nutritional factors such as tannin, saponin and theobromine present in the SNC that might have reduced the appetite of the animals (McDonalds *et al,* 1995; Brown, 2008; EFSA, 2009). It might also be that the decrease in the dry matter intake was due to nutrient concentration (Ranjhan, 2001; Jamie *et al*, 2009) but in this work, the nutrient concentration in both T2 and T3 were approximately the same.

Concentrate intake (CI) did not show any difference between T2 and T3. The intake value in T3 was however, lower than the T2 mean intake, indicating a depression which was in line with TDMI. This may mean that the higher SNC inclusion level did affect the palatability of the concentrate diet which led to a depression in CI of animals in T3. Salifu (2004) reported similar decrease in concentrate intake at 30% shea nut cake inclusion level. There was no difference in CI perhaps because the Djallonke rams were able to withstand the effects of the anti – nutritional factor in the SNC (Brown, 2008), but begun losing that ability at T3 inclusion level. Esien (2003) had similar results in his preference study of SNC with sheep.

This may be due to ruminant's ability to contain low levels of anti- nutritional factors present in the diet (Brown, 2008).

Basal diet intake (BDI) was higher in the control treatment (T1) than in the supplemented animals on T2 and T3. This is similar to the report of Njwe and Olubajo (1992) which indicated that intake of forage in ruminants fed forage alone is higher than those under concentrate supplementation due to the concentration of carbohydrates and other nutrients in the concentrate diet. The basal diet intakes in this study were lower than what was reported by Ndemanisho *et al* (2007) for Djallonke sheep fed fresh napier grass and supplemented with graded levels of undefatted soya bean meal. This could be due to differences in palatability of the basal diets offered. The present BDI indicates that as the SNC inclusion level increased in the diet the basal diet intake depressed. This made the animals on T3 with high SNC inclusion level to record the lowest BDI among the three treatment groups. This agrees with the report of Esien (2003) and Aboakye (2004) on sheep using the same SNC. This finding may be partly due to the concentration of highly available energy in the supplementary diet (Jamie, 2009) that depressed intake of the basal diet. It may also be due to the anti- nutritional factors present in the supplemental diet that affected the general appetite of the sheep (Longstaff and McNab, 1991).

Organic matter intake was higher in T2 at 11.5% SNC inclusion level and decreased as the amount of SNC increased in the diet (T3). Other components such as fibre and crude protein did not differ much from the trend of TDMI and OM and tally with what was reported by Okai and Bonsi (1989) on swine, and Esien (2003) and Aboakye (2004) on sheep.

The substitution rate; defined as the decrease in roughage dry matter intake per kg increase in concentrate dry matter intake (Sehested *et al*, 2003) was modest; 0.13 for T2 and 0.45 for T3. The 0.45 for T3 was similar to the 0.3-0.5 reported by Nguyem *et al* (2008) for cattle and the findings of Thomas (1980), who stated an average substitution rate of 0.50 when feeding silage, and close to that of Peyraud and Gonzalez-Rodrigez (2000) who in a review reported a rate of 0.60 for grazing systems. Nguyem *et al* (2008) stated that reduced fibre digestibility is the primary cause of substitution.

5.3 Apparent nutrient digestibility

Digestion in the rumen is dependent on the activity of micro-organisms. It also requires energy, nitrogen, minerals and a suitable medium to enable the microbes perform well (Ranjhan, 2001). Poor quality forages such as straw have insufficient nitrogen, readily available starch and minerals to meet rumen microbial requirement. These kinds of feed need energy and protein supplement to meet the animals' body requirement for maintenance and production (McDonald *et al*, 1995). The dry matter digestibility (DMD) in this study improved in the supplemented groups (T2 and T3) and agrees with the report of Bolukbasi (1989). It also increased as the level of SNC increased in the supplemental diet. This is contrary to the findings of Aboakye (2004) who reported a decrease in DMD as SNC inclusion level increased. This could be due to the high shea nut cake inclusion level (30%) relative to the current highest shea nut cake inclusion level of 23%. The current results could also be attributable to the additional protein source (soya bean meal) in the supplemental diet that may have increased protein availability to rumen micro organisms to speed up the digestion process (Jamie *et al*, 2009). The DMD mean of 56.72% is lower than the report of Jamie *et al* (2009) for sheep fed fresh grass and supplemented with crop residues. This may be due to the high digestible nature of the fresh grass Ranjhan (2001). The DMD values obtained in T3 fell within the range of 60% to 69% deemed as indicative of fairly high digestible level (Lee, 2008). That of T1 was lower than the 50% to

55% digestibility range regarded as moderately acceptable for average animal production performance (Devendra and McLeory, 1982).

Crude protein digestibility in T3 was significantly (P<0.05) higher than in T2 with T1 being the least digested. The combination of feed ingredients in T3 might have favoured high rumen fermentation and facilitated good synthesis of volatile fatty acids (VFAs) for absorption and increased production of rumen biomass (McDonald *et al*, 1995). This is contrary to what was reported by Aboakye (2004). This may be due to the addition of soya bean meal as a second protein source in the supplementary diet compared to SNC alone as a protein source in the supplementary diet used by Aboakye. Mineral digestibility was very low and recorded negative value in T1. This may have resulted from the provision of mineral block to the animals *ad libitum*, the intake of which was not measured. Only the ash component in the feed was measured. For fibre (NDF and ADF) digestibility, T3 recorded the highest value closely followed by T2 while T1 recorded a significantly lower value. This indicates that the increasing levels of SNC in the diets reduced DMI but increased digestibility of fibre in the animals given the supplementary diets. This agrees with previous findings (Njwe *and Godwe*, 1988; Swell, 1993; McDonalds *et al*, 1995). Generally, animals on concentrate supplementation digested more of the nutrients in their diets than those fed straw alone. This may be due to the available energy provided by the concentrate supplement to the rumen microbes that facilitated high nutrient degradation by rumen microorganisms (McDonalds *et al* 1995, Ranjhan, 2001).

5.4 Nutrient composition of faecal matter of Djallonke rams

There were significant differences (P<0.05) in DM contents of the faeces collected from the animals fed the three diets. The CP content of faeces from T2 animals was significantly higher (P<0.05) than that of the animals in T3 but not statistically different from that of animals on T1. This suggests that the CP in T2 and T1 could not be utilized effectively relative to that of T3 in this experiment. This agrees with the report of Annoh (2004) and Aboakye (2004) on sheep fed same shea nut cake as a supplement. The ash content of feaces from animals on T1 was high and corresponded to the ash content in the feed. It could be that the T1 animals took more of the salt lick which was not measured than the other animals. Fibre content of the faecal matter from the animals fed the three treatment diets was significantly different between the treatment groups (P<0.05) and in line with dry matter digestibility.

5.5 The growth rate of Djallonke rams fed rice straw and groundnut haulms with graded levels of shea nut cake in a concentrate supplement

In this study, the average daily gain (ADG) increased with increasing levels of SNC inclusion in the diets. This was attributed to increased protein supply to rumen microbes for effective utilization of the straw which made nutrients available for the animals' absorption (Jamie *et al*, 2009 and Ranjhan, 2001). The ADG obtained were 20.88 g/d, 31.86 g/d and 37.74 g/d for T1, T2 and T3 respectively. This indicated that, SNC inclusion level of 23% (T3) did not lead to a decrease in weight gain though the dry matter intake depressed at that inclusion level. This does not agree with the findings of Esien (2003) and Issaka (2006) who reported a decreasing weight gain as SNC inclusion levels increased from 15% to 30% in the supplemental diet of Djallonke sheep. This could be due to the high inclusion level of the shea nut cake (30%) compared to the inclusion level (23%) in this study. It could also be attributable to the additional source of protein (soya bean meal) that was present in the concentrate supplementary diet offered in this study. The average daily gain values obtained are far below what was reported by Esien (2003) and Issaka (2006) but agree with the Djallonke growth rate values reported by Obese (1998) and close to the findings of Ngwa and Tawa (1991) who supplemented Djallonke sheep with rice straw, groundnut haulms, cotton seed and cowpea vines and recorded an average daily weight gain of 29.24 g, 48.98 g, 52.4 g and 49.19 g/d respectively. The differences in the growth rate values are attributable to differences in nutrient composition of the basal diet offered (McDonalds, *et al* 1995), since the straw offered in this study has less nutritive value and low digestible components compared to fresh pasture grass basal diet by Esien (2003), Issaka (2006) and Ndemanisho *et al* (2007).

5.6 The haematolgy and serum metabolites of Djallonke rams on supplemental concentrate containing graded levels of shea nut cake

There were no negative haematological changes in the blood of animals used for the present experiment. Specifically there were no effects on Haemoglobin (Hb) and Packed Cell Volume (PCV) at all the SNC inclusion levels in the diets. This agrees with the findings of Baiden *et al*

(2007) on Djallonke sheep fed cassava pulp. Similar findings were also reported by Olored and Longe (1999) in poultry fed graded levels of SNC. The percentage distribution of leucocytes was not also affected by the SNC in all the three dietary treatments offered to the sheep. Baiden *et al* (2007) had the same finding in sheep and goats fed cassava pulp. The WBCs counts of all the treatment groups were similar and fell within the normal range (5 x 10^6/dl to 11 x 10^6/dl) reported by Scott *et al* (2006). This means that the SNC did not influence the WBCs counts in any way. No foreign organisms were introduced into the body that would have made the WBCs count to increase in order to fight against their evasion in the animal's body (Schalm *et al*, 1975; Egbe-Nwiye *et al*, 2000).

On the specifics of the leucocytes distribution, the lymphocytes figures obtained for T1 (control), T2 and T3 were not significantly different among the treatment groups. This did not agree with the findings of Baiden *et al* (2007) but was similar to what was reported by Thorp *et al* (1991) as normal range of sheep WBCs count (60% - 65%). High lymphocytes count above the normal range is a response of the body to viral, bacterial or parasite infection (Coles, 1980). This finding indicates that the present inclusion level of SNC did not introduce any infection into the animal's body or expose the animals' body to infectious organisms. Neutrophils count in leucocytes was similar in all the treatment groups. The increasing levels of SNC did not affect percentage neutrophils count and was similar to the findings of Baiden *et al* (2007). The stable and low neutrophil granulocyte count prevents potential inflammatory process (Naskalski *et al*, 2007). Eosinophils count was not significantly different among treatment groups. Eosinophils number increases in the bloodstream in the presence of allergens or parasites in the animal's body (David, 2008). The present finding means that the SNC as a feed ingredient for sheep contains no allergic substances that the animal's body may react to it neither does it introduce harmful parasites into the body of the animals. Basophils percentage in the WBCs of all the treatment groups was slightly different but statistically similar which agrees with the report of Baiden *et al* (2007) and falls within the normal range for sheep (David, 2008). The monocytes count in the leucocytes in all the treatment groups was similar. The present finding is contrary to the report of Ekenyem (2007) on pigs fed varying levels of *Ipomoea asarifolia* leaf meal where the monocyte count increased as the leaf meal increased in the diet. This was attributed to introduction and/or facilitation of microorganisms' growth in the animals' body or an increase in the rate of body cells death that has led to increase in the number of monocytes to devour the harmful organisms or get rid of the dead body cells (David, 2008). The similarity of the monocytes count in all the treatment groups indicates that, the present inclusion level of SNC did not introduce any harmful organisms in the body or increased dead body cells that need to be removed.

The leucocytes distribution did not show any significant difference in all the treatment groups even as the SNC level increased. This means that SNC as a feed ingredient to Djallonke sheep has no deleterious effects on the animals health. This agrees with the findings of Ekenyem (2007) on pigs and assures the safety of animals fed with SNC as a supplemental diet. This means that SNC at this present inclusion level do not have any known negative effect on the immune system of the animals. The serum metabolites values obtained in this study were all within the normal range for sheep serum metabolite as reported by Pampori *et al* (2003). The serum metabolites of the experimental animals showed some differences among the treatments which could be due to the increase in SNC level in the diet; 0% in T1, 11.5% in T2 and 23.0% in T3. The slightly higher serum total protein may be responsible for the increasing ADG among the treatment groups as the SNC inclusion level increases (20.88 g/d, 31.86 g/d and 37.74 g/d for T1, T2 and T3 respectively). The serum albumin level in T3 was significantly higher ($P<0.01$) than that of T1 but not statistically different from that of T2 animals. The Albumin level increased with an increasing level of SNC in the treatment groups and may be responsible for higher ADG in supplemented animals. This is important because low level of albumin will mean low level of blood clotting ability and hence poor prevention of hemorrhage when the need arises (Robert, *et al* 2000). Decreased globulin below the normal level also leads to weak immune system of the body and consequently decreased disease fighting ability of the animals' body which leads to high mortality rates in the event of disease outbreak (Iheukwumere, *et al*, 2005). Serum cholesterol level did not show any significant difference between treatment groups. The values obtained in this study were within the normal range of 100 – 150 mg per 100 ml of serum reported by Pamori (2003) but did not tally with the findings of Iheukwumere *et al* (2008) in WAD goats under concentrate supplementation. This may be due to species difference.

The serum cholesterol levels depend on the amount and quality of protein offered in the feed (Esonu *et al*, 2001). This means that the protein provided by the SNC and SBM combined was enough and of good quality to meet the nutritional needs of the animals.

CHAPTER SIX CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the results obtained in this research work, the following conclusions have been made;

The inclusion of shea nut cake from11.5% to 23% (230 g/kg DM) in the supplemental diet of growing Djallonke sheep fed crop residues (rice straw and groundnut haulms) led to improved growth performance of the sheep.

An increasing inclusion level from 11.5% to 23.0% of shea nut cake in the concentrate diet of Djallonke rams led to depression in the straw intake but increased dry matter digestibility and so did affect positively the average daily growth rate in this study.

Shea nut cake inclusion levels from 115% to 23% in the supplementary diet of Djallonke rams did not cause any negative effect in the haematology and serum metabolites of the Djallonke rams.

6.2 Recommendations

Carcass analysis of sheep supplemented with graded level of shea nut cake in a concentrate diet should be carried to determine whether there is an unusual deposition of fat in the body that may threaten meat quality.

Another research should be carried out at higher shea nut cake inclusion levels to find out whether there will be change in the trend of the performance of animals.

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APPENDICES

Appendix I. Intake and apparent digestibility of Djallonke sheep fed rice straw and groundnut haulms with or without shea nut cake in concentrate supplementation.

TRT	NUTRIENTS	DM	CP	CF	EE	ASH	NDF	ADF	OM
T1	Amount in feed	439.12	31.10	151.6	5.06	37.6	377.2	327.90	401.52
	Amount in faeces	234.1	22.11	78.05	3.23	43.86	210.14	190.99	194.52
	Amount digested	205.02	8.99	73.55	1.83	-6.23	167.06	136.91	206.89
	DC	0.4744	0.2890	0.4851	0.361	-0.1664	0.4429	0.4175	0.5153
T2	Amount in feed	572.94	61.68	131	12.86	34.20	363.60	294.70	538.74
	Amount in faeces	248.20	25.99	61.72	6.23	31.30	136.73	129.20	214.80
	Amount digested	324.74	35.96	69.28	6.63	2.90	226.87	155.50	323.94
	DC	0.5668	0.5786	0.5288	0.5156	0.0848	0.6239	0.5276	0.6013
T3	Amount in feed	522.79	54.82	127.00	13.93	35.20	329.70	269.20	487.59
	Amount in faeces	164.20	18.60	40.00	3.57	30.02	108.35	97.85	133.34
	Amount digested	358.79	36.22	87.00	10.36	5.18	221.35	171.35	354.25
	DC	0.6862	0.6607	0.6529	0.7437	0.1472	0.6714	0.6365	0.7265

Key; DC= Digestibility Coefficient

Appendix II. Feed intake of Djallonke rams fed rice straw and groundnut haulms basal diet with graded levels of Shea nut cake in supplemental concentrate (dry matter basis)

Feed Intake (g/d)	T1	T2	T3	**Feeding periods**
Day 1	379.1	400.9	367.65	**Period 1**
Day 2	389.5	437	337.25	
Day 3	483.6	364.8	324.9	
Day 4	314.5	376.2	324.9	
Day 5	408.5	438.9	399	
Day 6	342	400.9	337.25	
Day 7	347.7	446.5	434.15	
Total	**2760**	**2462.4**	**2200.2**	**Period 1**
Average	**394.3**	**351.5**	**313.5**	**Period 1**
Day 1	457	402.8	462.65	**Period 2**
Day 2	395.2	510.15	420.85	
Day 3	511.1	483.55	436.05	
Day 4	532	488.3	353.4	
Day 5	490.2	380	387.6	
Day 6	450.3	352.45	378.1	
Day 7	438.9	438.9	362.9	
Total	**3259**	**3057.1**	**2801.55**	**Period 2**
Average	**465.5**	**436.725**	**400.216**	**Period 2**
Day 1	356.3	448.4	342	**Period 3**

Day 2	498.8	446.5	441.75	
Day 3	498.8	465.5	494	
Day 4	490.2	544.35	457.9	
Day 5	423.7	454.1	294.5	
Day 6	413.3	441.75	448.4	
Day 7	532	477.85	394.25	
Total	**3203**	**3278.45**	**2777.8**	**Period 3**
Average	**457.6**	**468.35**	**396.8245**	**Period 3**

Appendix III. Concentrate intake of Djallonke rams fed rice straw and groundnut haulms basal diet with graded levels of Shea nut cake in supplemental concentrate on dry matter basis.

CI g/day	**T1**		**T2**		**T3**	**Feeding periods**
1	0		160.95		147.03	**Period one**
2	0		155.73		146.16	
3	0		154.86		148.77	
4	0		156.6		146.16	
5	0		160.08		157.47	
6	0		146.16		154.86	
7	0		153.12		151.38	
Total	**0**		**1087.5**		**1051.83**	
Average	**0**		**155.36**		**150.26**	
1	0		159.21		142.68	**Period two**
2	0		153.99		149.64	
3	0		147.03		163.56	
4	0		153.12		147.03	
5	0		148.77		152.25	
6	0		151.38		153.99	
7			158.34		160.95	
Total	**0**		**1071.84**		**1079.1**	

Average	**0**		**153.12**		**152.87**	
1	0		160.08		158.34	**Period three**
2	0		155.73		155.73	
3	0		147.9		144.42	
4	0		145.29		154.86	
5	0		156.6		158.34	
6	0		154.86		165.3	
7	0		155.73		160.08	
Total	**0**		**1076.19**		**1097.07**	
Average	**0**		**153.74**		**156.72**	

Key CI = concentrate intake

Appendix IV**.** Average feed intake and faecal matter output of Djallonke rams fed rice straw and groundnut haulms basal diet with graded levels of Shea nut cake in supplemental concentrate on dry matter basis

Parameter (g/day)	**T1**	**T2**	**T3**	**Feeding periods**
Feed intake	394.25	506.86	463.76	Period 1
Faeces output	130.29	114.24	87.5	Period 1
Feed intake	465.50	589.88	551.07	Period 2
Faeces output	124.8	107.9	85.4	Period 2
Feed intake	457.62	622.09	553.54	Period 3
Faeces output	234.1	190.2	157.2	Period 3

Appendix V**.** The growth rate of Djallonke rams fed rice straw and groundnut haulms basal diet with graded levels of Shea nut cake in supplemental concentrate

Parameter	**T1**	**T2**	**T3**	**Periods**	**Remarks**
Live body weight (kg)	14.33	13.67	17.58	1	base
Live body weight (kg)	14.6	14.12	18.13	1	end
Weight gain (kg)	0.275	0.45	0.55	1	14 days
Gain/day(kg)	**0.01946**	**0.03214**	**0.03929**		
Live body weight (kg)	18.1	15.79	16.27	2	base
Live body weight (kg)	18.4	16.21	16.80	2	end
Weight gain (kg)	0.312	0.42	0.525	2	14days
Gain/day (kg)	**0.02229**	**0.03000**	**0.03750**		
Live body weight (kg)	16.21	20.76	17.12	3	base
Live body weight (kg)	16.50	21.20	17.63	3	end
Weight gain (kg)	0.29	0.44	0.51	3	14 days
Gain/day (kg)	**0.02071**	**0.03143**	**0.03643**		

Appendix VII An experimental sheep fitted with harness for faecal matter collection

Appendix VIII. An experimental sheep in a scale ready for weighing

Appendix IX Laboratory technician assisting student to sample blood from the jugular vein of the sheep for analysis