THE USE OF SOME NON-CONVENTIONAL PROTEIN SOURCES FOR FATTENING CATTLE

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DEDICATION

This thesis is dedicated first to the **ALMIGHTY ALLAH**, Who has made everything possible, then to

My late Father
Alhaji Lamidi Atoyebi Akanbi

My Beloved Mother
Alhaja Asiawu Oyepeola Lamidi

My Beloved Wife
Mrs. Kudirat Biola Abdulhamid

My Son
Master Farouq Abiodun Abdulhamid

My Daughter
Miss Farida Fehintola Abdulhamid

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Miss Rukhayat Oyepeola Abdulhamid

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ABBREVIATIONS

ADF	=	Acid detergent fibre
BUN	=	Blood urea nitrogen
CP	=	Crude protein
CPD	=	Crude protein digestibility
DM	=	Dry matter
DMI	=	Dry matter intake
GAA	=	gossypol acetic acid
g	=	gramme
kg	=	Kilogramme
l	=	litter
ME	=	metabolizable energy
MJ	=	Mega joules
Mg	=	Milligrams
N	=	nitrogen
NDF	=	Neutral detergent fibre
OM	=	Organic matter
PCV	=	Packed cell volume
RAN	=	Rumen ammonia nitrogen
SDLL	=	Sun-dried layer litter
SDBL	=	sun-dried broiler litter
SEM	=	Standard error of mean
TP	=	Total protein
WCS	=	Whole cotton seed

ABSTRACT

Twenty one different feed sources collected in and around Zaria were analyzed for nutrient composition. One energy source (maize offal) and three protein sources (layer litter, broiler litter and whole cotton seed) were selected for the three cattle fattening trials based on their nutritive value, availability and cost.

In the first fattening trial, twenty Bunaji bulls weighing between 230- 250 kg were used to study the effect of sun-dried layer litter (SDLL) as protein source to replace cotton seed cake for fattening bulls fed sorghum stover basal diet. The concentrates were offered at 60% of 3% body weight individually and sorghum stover, water and mineral salt lick were offered ad libitum.

Intake of the concentrate decreased with increase in the proportion of SDLL replacing CSC in the diets. Intake of the concentrate containing 0, 25, 50 and 75% SDLL were similar ($P>0.05$) but different significantly ($P<0.05$) from those containing 100% SDLL. The range was from 2.55 to 4.74kg/head/day. Level of SDLL in the diets had no effect on the intake of sorghum stover. Total daily feed intake ranged between 3.73 and 5.96kg, there were no differences between diets containing 0, 25, 50 and 75% SDLL, but diet containing 100% SDLL differed significantly ($P<0.05$) from others. Body condition score ranged from 4.58 to 4.88 while rumen ammonia nitrogen (RAN) level was from 8.13 to 14.10mg/100ml and rumen pH from 6.38 to 6.88. The values taken at the end of the study were not significantly different ($P>0.05$) for pH and body condition score but RAN was affected by the levels of SDLL replacing CSC in the diets. Average liveweight gain increased with increase in the level of SDLL replacing CSC in the diets up to 50% and then declined, there were no

difference between bulls on diets containing 25, 50 and 75% SDLL. The range was between 0.570 and 0.873kg/day. Feed conversion efficiency was significantly (P<0.05) affected by the level of SDLL replacing CSC in the diets while feed cost per gain decreased linearly as the level of SDLL replacing CSC decreased in the diets. Crude protein digestibility and nitrogen retention were significantly affected by the level of SDLL replacing CSC in the diets. Dressing percentage of the bulls ranged from 49.49 to 50.57%, the differences were not significant (P>0.05). Over all income over feed cost ranged between ₦6228.00 and ₦1303.35. Bulls on diet in which 50% of the CSC was replaced by SDLL had the highest (P<0.05) overall income over feed cost.

In the second experiment, twenty Bunaji bulls weighing between 200 and 250kg were used to study the effect of replacing CSC with sun-dried broiler litter (SDBL) at 0,20,50,75 and 100% on feedlot performance of bulls fed bracharia hay as basal diet.

Intake of the concentrate containing 0, 25, 50, 75 and 100% SDBL replacement were 3.98, 3.85, 3.84, 3.82 and 3.82kg/head/day respectively. The differences were not significant (P>0.05). Intake of bracharia hay and total DM intakes were also not significantly (P>0.05) affected by the levels of SDBL in the diets. Average daily liveweight gain decreased linearly as the level of SDBL replacing CSC increased in the diets. There was no significant difference between the liveweight gains of bulls on diets in which 0, 25 and 50% of the CSC was replaced by SDBL. Feed conversion efficiency decreased significantly (P<0.05) as the levels of SDBL replacing CSC increased in the diets. There were no differences between diets containing 0, 25 and 50% SDBL. Feed cost per gain was lowest on diet which contains 50% SDBL replacement. Body condition score, rumen ammonia nitrogen, PCV, total protein and blood urea nitrogen level taken at the end of the

trial were affected significantly (P<0.05) by the levels of SDBL replacing CSC in the diets. Digestibilities of DM was highest in diet containing no SDBL and lowest for diet containing 100% SDBL. There were no differences between the DM digestibility of diets containing 0 and 25% SDBL. CP digestibility increased significantly (P<0.05) with increased level of SDBL up to 50% level of replacement then declined. Nitrogen retention increased significantly (P<0.05) as the levels of SDBL replacing CSC increased in the diets up 25% SDBL replacement the declined. The amount of nitrogen retained on diets containing 25 and 50% SDBL were similar. Dressing percentage of the bulls ranged between 50.51 and 51.44%, the differences were not significant (P>0.05) between the treatments. Overall income over feed cost ranged between ₦ 5403.52 and ₦ 2860.52, there were no significant (P<0.05) differences in overall income over feed cost in bulls on diets in which SDBL replaced 0, 25 and 50% of the CSC in the diets.

In the third experiment the effects of graded levels of maize offals and whole cotton seed on the fattening performance of Bunaji bulls were studied using twenty bulls of liveweight ranging between 200-250kg.

Intake of the concentrates, gamba hay and total DM increased (P<0.05) as the proportions of WCS decreased in the diet. There were no significant (P>0.05) differences between diets containing 20, 40 and 60% WCS. The total DMI of the concentrates containing 80, 60, 40 and 20% WCS was 5.18, 6.42, 6.70 and 6.82 kg/head/day. Crude protein intake ranged between 737.20 to 866.16g/head/day and was affected (P<0.05) by the levels of WCS in the diets. Average daily liveweight gain of the bulls on diets containing 80, 60, 40 and 20% WCS were 0.470, 0.570, 0.789 and 0.631kg/head respectively. Bulls on the diets containing 40% WCS had the highest (P<0.05) daily liveweight gain. Feed efficiency and feed cost per gain was also best

for bulls on diet the containing 40% WCS. Body condition score, PCV; blood urea nitrogen, rumen ammonia nitrogen taken at the end of the trial were all affected ($P<0.05$) by the levels of WCS in the diets. However, levels of WCS in the diets and sampling time had no effect on the total protein and rumen pH. Dry matter and CP digestibility were similar ($P>0.05$) for diets containing 20, 40 and 60% WCS. While digestibilities of CF, ether extract ADF, NDF and organic matter were not affected by the levels of WCS in the diets. Nitrogen retention was positive for all diets and was affected ($P<0.05$) by the level of WCS in the diets. Dressing percentage ranged from 50.43 to 52.13% and income over feed cost ranged between ₦1012.36 and ₦4084.53. Bulls on diets containing 40% WCS gave the highest income over feed cost.

CHAPTER ONE

1.0 INTRODUCTION

In Nigeria beef cattle are raised largely through the extensive management system. Under this system animals obtain their nutrients mainly from overgrazed range and crop residue (Olayiwole and Olorunju, 1987) which are low in both quality and quantity (Blair Rains, 1963., Kapu, 1975., Umoh and Koch, 1971). Furthermore, the extent to which such range is declining due to increase in land use for crop production, overgrazing, urbanization and population increase is alarming. The summary of reports on range and feed resources inventory (Egunjobi, 1970., de Leeuw, 1977 and Awogbade and Famoriyo, 1982) suggests that under the existing level of grassland management, there is inadequate feed to sustain the present population of 14 million cattle. The traditional system of beef production cannot therefore, be expected to meet the present and future beef demand of the country. The intensive beef production system in the form of feedlot fattening offer a means of increasing edible carcass rapidly as a short term measure.

Feedlot operation is not entirely new to Nigeria and several of the earlier fattening trials carried out in the country (Olayiwole and Fulani, 1980., Olayiwole *et al.,* 1981 and Ikhatua and Olayiwole, 1982) showed appreciable increase 30-40% in the liveweight of the indigenous breeds of cattle (Olayiwole *et al.,* 1975). However, the adoption rate of the results of these studies is very low due to the high cost of feed ingredients (maize grain, guinea corn, maize silage, groundnut cake and cotton seed cake) used in these studies, making the scheme less profitable and unattractive. There is therefore, the need to continuously search for alternative and cheaper protein and energy sources. Feed constitutes about 70-80% of the variable cost of fattening cattle (Powel, 1975, Olayiwole *et al.,* 1981), consequently, any feeding system that will

reduce feed cost will ultimately result in reduction of total cost of production and increase profit margin. Thus, the use of non-conventional feedstuffs and crop residues which have little opportunity cost in the other uses on the farm can be substituted for the conventional and very expensive feedstuffs to reduce cost.

Maize offal is a by-product of maize grain processing which is a major staple food in the northern part of Nigeria. Poultry litter (PL) is a waste product of the poultry industry; it is nutritious, available and very cheap. Poultry litter has been used as a source of manure for crop production for a long time, however, there is also considerable evidence in literature that PL has been used as a source of nitrogen in ruminant diets, containing moderate to high energy level (El-Sabban *et al.,* 1970., Smith and Calvert, 1976). Poultry litter is less harmful than urea, inexpensive and available; it is fairly high in crude protein while the energy content compares favourably with those of high quality roughages (Fontenot and Jurubesco, 1980., Flachwosky and Henning, 1990). Poultry litter is capable of supplying the rumen microbes' nitrogen necessary for rumen bacteria synthesis and the nitrogen is ten times more efficiently utilized as fed to ruminants than when used as manure for growing crops or for methane generation (Smith and Wheeler, 1979 and Fontenot *et al.,* 1983). Feeding poultry litter to cattle will help to dispose of huge amounts of these otherwise waste products and reduce environmental pollution, decrease cost of feeding cattle and recycle nutrients in the poultry litter as animal feed. In addition, poultry litter is not used in the diets of monogastric animals and the competition for use as organic fertilizer is not critical yet.

Cotton is also an important cash crop grown mainly in the northern parts of the country. The crop supplies some of the raw materials required by the local textile industries. Whole cottonseed is a by-product of the cotton ginnery industries found all over in the cotton producing zone of

Nigeria. The cotton belt coincidentally is the main cattle producing area of the country. Whole cottonseed (WCS) is an excellent supplement for average to high producing cattle (Chandler, 1992., Arieli, 1998 and Bernard, 1999). It is rich in protein (22-24%), energy (14 MJ/kg) and fibre and therefore could be referred to as a concentrate (Arieli, 1998). Cottonseed is cheaper than the oil cakes and it is known to most livestock farmers and can be fed whole or in combination with other feedstuffs and does not require grinding, rolling, milling or any other processing/ preparation (Peters, 2002). However, the primary concern about the feeding of whole cotton seed stems from its content of natural toxin-gossypol. The gossypol is found in the pigment gland scattered throughout the kernel and it is about 1.0% of the total weight of the kernel (Peters, 2002, Ikurior and Fetuga, 1984). Although ruminants have detoxifying mechanisms for gossypol (Reiser and Fu, 1962), signs of toxicity such as depressed heamoglobin and total protein of plasma and increased erythrocyte fragility has been reported in lactating cows fed 10.00 kg/cow/day of whole cotton seed (0.225% free gossypol) during 14 weeks (Lindsey *et al.*, 1980). The earlier attempt to fatten bulls using WCS (Olayiwole 1975) gave daily liveweight gain of about 0.8 to 0.9 kg per head. The major limitation of this study was the use of maize silage, groundnut cake and maize or guinea corn in combination with WCS. These feedstuffs are expensive and out of reach of most farmers and hence, the need to re-evaluate WCS with other agro-industrial by-products that have little opportunity cost in other uses for fattening. The objectives of the present studies are:

- to determine the nutritive value of some non-conventional feed resources
- to determine feedlot performance of cattle fed graded levels of non-conventional feed sources.
- to determine the economics of fattening bulls on these feed sources.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 FEEDLOT OPERATION IN NIGERIA

Beef plays a significant role as a source of animal protein in Nigeria; it accounts for 45% of the total meat supply from domestic animals (Olayiwole, 1982). Cattle production in the country is mainly by transhumant pastoralists. Under this system, animals receive most of their nutrients from natural range which is poor in quality (Blair Rains, 1963 and Kapu, 1975). In most areas the range is not only being overgrazed but also declining in size due to population and cropping pressure. It is therefore obvious that the traditional system of beef production cannot meet the future demand for beef production (Green Revolution Commission report, 1980). If Nigeria intends to increase animal protein supply, the traditional system of beef cattle production/management has to give way to semi and or intensive system of beef production in order to meet the increasing demand for animal protein. Feedlot operation comes under these systems.

Feedlot operation is a modification of an intensive system of cattle production. This system involves large numbers of cattle for intensive feeding (Price, 1981) for a short period of time. The system involves growing and fattening of young cattle with meaty potential under confinement. The animals are placed on full feed of high energy and high protein diets for a period lasting for 90-120days. The system should afford the animal the opportunity to exhibit the highest feed conversion efficiency and best growth performance. Cattle producers can thus reduce cost of beef production and improve quality through better dressing out percentage, composition and quality, while cattle would yield adequate marble, juicy and tender beef. Edible carcass yield of animals under feedlot operation increased by 30-40% when compared to animals

not fattened (Olayiwole *et al.*, 1981).

Feedlot can be classified into four different types based on the feeds fed to the animals. These are:-

- Grains and dry roughage
- Grains and silage
- Soilage i.e. green chop or fresh cut forage
- Grains only

In Nigeria it is not economical to operate all grain feedlot because of high cost and scarcity of grains or all green chop feedlot because of the low nutritive value of most indigenous forage. What is therefore most feasible is the combination of grain and roughage (Olayiwole *et al.*, 1975).

Pilot studies on feedlot operation in Nigeria were carried out by Olayiwole *et al.* (1975); Piotrowska and Olayiwole, (1976) and Olayiwole *et al.* (1981). These studies showed that feedlot operation was profitable and commercially viable in the country. Other works carried out in Kenya (Greek and de Leeuw, 1978), Ethiopia (Jepson and Greek, 1976) and Niger (Wardle 1979) have also proved that commercial feedlot operation was viable in those countries. In Nigeria, Piotrowska and Olayiwole (1976) compared Sokoto Gudali and Bunaji breeds on two feeding regimes and concluded that Sokoto Gudali was superior to Bunaji in fattening. Olayiwole *et al.* (1975) reported that average daily weight gains ranged between 0.96 and 1.05 kg/head/day and group mean dressing percentage ranged from 48.00 to 54.50 for Bunaji and crossbred steers fed various protein sources such as groundnut cake, brewers' dried grain, delinted cotton seed cake, undelinted and undecorticated cotton seed cake, whole cotton seed and beef cubes (marketed by Pfizer). In another study, Olayiwole *et al.* (1981) reported liveweight

gains of 0.98, 1.34, 1.40 and 0.92kg/head/day for Bunaji bulls fed brewer's dried grain, undelinted cotton seed cake, delinted cotton seed cake and whole cotton seed. Ikhatua and Olayiwole, (1982) reported no significant effect of providing shade on live weight gains of the bulls under fattening. Despite these very encouraging results, commercial feedlot cattle fattening is not very common in Nigeria. There are only few large farms and many small scale fattening schemes around all major cattle markets (Zango) and sub-urban areas. Apart from the National Animal Production Research Institute (NAPRI) where fattening takes place, some government owned organizations or parastatals which had been involved in fattening operations include the Livestock Project Unit (LPU), the National Livestock Projects Department (NLPD) at Mokwa cattle ranch, Galambi ranch in Bauchi and Manchok cattle ranch in Kaduna state. All these companies are no longer in existence probably because they were based on feed resources which were too expensive to be sustained. In Mokwa ranch, the use of molasses as cattle feed was adopted. However, the system could not be sustained due to unavailability of molasses. Furthermore, the feeding of maize silage involves some level of mechanization, making it very expensive and uneconomical. It is imperative therefore, that beef cattle feeding system based on agro-industrial by products and crop residue be evolved to make feedlot operation more economically viable. This will attract investors since feeds account for between 70-80% of the variable cost of feedlot operation (Powell, 1975; Olayiwole, 1981).

2.2. Protein sources in cattle feeding

2.2.1 Conventional protein sources

The most important conventional protein sources in Nigeria are the oil seed cakes which include cotton seed cake, ground nut cake, soybean cake and palm kernel cake.

Cotton seed cake (CSC): The most widely used oil seed cake for feeding ruminant animals in Nigeria is undelinted, undecorticated cotton seed cake. This is because of its availability and cost in relation to that of its closest competitor, groundnut cake. The crude protein content of delinted decorticated cotton seed cake (CSC) is about 26%. It is however low in cystine, methionine and lysine (Ikurior and Fetuga, 1984). The decline in production of cotton in Nigeria has seriously affected the availability of CSC in the country. The use of CSC as ruminant feed is also constrained by its popularity in monogastric diets, which makes the cake to be over priced and very uneconomical for ruminants.

Groundnut cake (GNC): This is much higher in crude protein (45%) than CSC but it is more expensive and scarce. GNC is highly degradable in the rumen with nitrogen degradable value range of between 0.71 and 0.90 (ARC, 1980). Lufadeju and Olorunju, (1986) also reported degradable value of 0.86 for GNC. However, the use of GNC as ruminant feed is not economical because of its high cost.

Soybean cake*:* The crude protein content of soybean meal is about 50%. The cake is considered to be one of the best protein sources because it contains all the essential amino acids, although the quantity of cystine and methionine are sub-optimal. Ruminants generally are not affected by some inhibitory and toxic factors (Trypsin inhibitor) present in soybean, in addition, the lack of Vitamin B12 associated with feeding soybean cake does not affect cattle. However,

soybean cake is highly priced making it uneconomical for feeding ruminants.

Palm Kernel cake*:* The crude protein content of palm kernel cake (PKC) ranges between 14 and 16% (ARC, 1980). The cake is dry and gritty and high in oil content. It is not readily acceptable by all classes of livestock. The solvent extracted cake is unpalatable and should be increased gradually when fed to livestock. Adult cattle can be fed up to 2-3kg/head/day. The degradation of protein in PKC is low (ARC, 1980). Although, PKC is cheaper than GNC and CSC, the cost of transporting it to the northern part of the country from the south or the middle belt where it is produced makes it slightly expensive.

Another oil seed cake is sunflower (31% CP).This cannot be fed to ruminants because it is currently being highly priced.

2.2.2 Non-conventional protein sources

The non conventional protein sources can be categorized into:

a. Agro - industrial by-products of animal origin
b. Farm wastes (crop residues or crop after math)
c. Animal wastes

Agro - industrial by-products of animal origin

By-products which belong to this category include dry rumen content (rumen digesta). At present this is a major abattoir pollutant. Rumen content has the potential as protein supplement. It has CP content of about 16% and can be raised to 34% with the addition of blood (Alhassan *et al.*, 1983).

Farm wastes (crop residues or crop aftermath)

Farm wastes of protein origin include groundnut haulms, cowpea pod shell and leaves, lablab

leaves, soybean leaves and threshing. These feed resources and cereal straw constitute the most important field crop residues for ruminants. They are higher in CP compared to the cereal residues (Alhassan *et al.,* 1985), but low in ADF. The CP content of cowpea haulms range from 5.9 to10.4 percent while that of cowpea shell ranges from 6.9 – 7.1 % and groundnut haulms between 11.40 and 16.70 (Alhassan *et al.,* 1983).

The use of these crop residues has led to improvement in animal performance. Adu and Lakpini (1983) recorded live weight gains of 90.20g/day and 130.7.0 g/day from Yankassa sheep when unchopped and chopped groundnut haulms was fed as sole protein sources. Ikhatua and Adu (1984) concluded from the performance of Red Sokoto goats fed groundnut haulms and *digitaria smutsii* hay that the haulms is a better quality roughage with adequate protein to maintain ruminants than *digitaria smutsii*.

Cotton seed: This is a by-product of the ginnery industry which is common in the Guinea and part of Sudan savanna zone i.e around Funtua and Malumfashi in Katsina State. Whole cottonseed is commonly used as a source of protein, energy and fibre. The CP content of whole cottonseed is about 22.1%, but it is low in methionine and lysine. Whole cottonseed can be fed without any form of processing, however, the lint on the seed makes it difficult to handle mechanically.

Animal Waste

The most important animal waste used in ruminant diets is poultry litter. The CP content of poultry litter varies depending on the type of feed offered to the birds (Calvert, 1979). Usually a bird will defecate about ¼ of the quantity of feed consumed as faeces (Ogundipe, Personal communication). Various authors have reported various values of CP for poultry litter. Adegbola, *et al*., (1990) reported 16.5% CP for layer litter while Lamidi (1995) reported 17.00%.

Broiler litter has higher CP content than layer litter (Lamidi, 1995). Adu and Lakpini (1983)., Devendra, (1978) and Lamidi (1995) all reported 25% CP for broiler litter. Poultry litter is an excellent nitrogen source for rumen microbes and it has been used as a source of nitrogen in ruminant diets containing moderate to high energy levels (El-Sabban *et al.,* 1970., Smith and Calvert, 1976). Poultry litter is also a source of minerals and vitamins. Utilization of poultry litter in ruminant diets will serve as a means of disposing the huge quantities of the litter produced across the nation. The greatest advantage associated with poultry litter is its low cost, making it very economical to incorporate in ruminant diets. However, because of its low palatability, especially for the layer litter, maximum inclusion rate of 30% has been recommended by Devendra, (1978). Adu and Lakpini (1983) suggested 10% optimum level of inclusion in molasses based diets for sheep.

2.3. Protein metabolism in ruminants

Dietary protein is degraded in the rumen by microbial population to peptides, amino acids and ammonia. Dietary proteins that escape microbial degradation in the rumen are broken down in the small intestine by more efficient gastric digestion systems. The ammonia released by the microbial action is utilized by the microbes to synthesize their tissue protein. Therefore, the quantity of ammonia produced in the rumen is important in ruminal protein synthesis (Noman and Evans, (1972). McDonald (1954) found that when 94% of the total nitrogen in sheep ration was fed as zein, 40% of it was used by rumen microbes to synthesize their own protein. The volatile fatty acids formed from the microbial breakdown of amino acids and non protein nitrogen compounds appeared to be acids with 2-5 carbon chains (Orskov, *et al*.1986). Those with 5 carbon atoms are principally branched chain acids and although, they can be absorbed, they are probably not available for absorption (El-Shazly 1957., Orskov, *et al.*1986).

Ruminal nitrogen metabolism and ruminal ammonia production is influenced by protein solubility (Satter and Roffler, 1975; Orskov *et al.,* 1980, Owen and Isaacson, 1977), composition of the microbial population and nutrient availability within the rumen, including the relative availability and rates of availability of specific nutrients (Orskov *et al.,* 1980). However, highly soluble nitrogen sources such as urea and casein when fed in large quantities yield excess ruminal ammonia which the microbes are unable to utilize efficiently (Orskov and Fraser, 1973). The excess ammonia is usually absorbed from the rumen and may be converted into urea in the liver and then excreted through the urine or it may be recycled to the rumen in saliva to supplement the rumen ammonia pool. (Nolan and Leng 1972 and Nolan *et al.,* 1973).

2.3.1. Sources of nitrogen available for rumen metabolism

Feed sources

Ammonia is produced in the rumen by the metabolism of protein, peptides, amino acids, amides, urea, nitrates and some other non-protein nitrogen compounds. Dietary proteins are hydrolyzed in the rumen to varying degrees depending upon their solubility. When rumen fluid is strongly proteolytic the ruminal concentration of free amino acids will be low (Annison, 1975; Orskov, 1982) because there is rapid deamination of amino acids by microbial deaminase leading to the production of ammonia (Warner, 1956; Orskov, 1982). The action of rumen microbes on amides, glutamine, asparagines and the amides groups of protein also produces ammonia (Abou-Akkada and Blackburn, 1963; Warner, 1964., Satter and Slyter, 1974). Some agro-industrial by products commonly used for ruminant feeding has also been studied for nitrogen content and ruminal degradability (Lufadeju and Olorunju, 1986). The use of agro-industrial by-products of protein origin has become more relevant in view of the high cost of vegetable protein sources.

Another important source of rumen ammonia is non-protein nitrogen (NPN) compounds. The

NPN compounds constitute about 10% of the nitrogen in herbage plants. Substituting NPN compounds for plant or animal protein in the diets for ruminants often lowers the cost of supplementation. Dietary NPN is generally regarded as a useful source of ammonia for the ruminal microbes but it also serves as a base in the rumen to maintain pH in a desirable range for cellulose digestion. Post ruminal administration of NPN may be useful because of recycling of nitrogen to the rumen or large intestine (Owens and Bergen, 1983). The NPN compounds that has been used in ruminant diets include:-

- Anhydrous ammonia. This is applied as a liquid or gas to high or low quality forage (Huber and Kung, 1981),
- Ammonium salt (chloride, phosphate and lactate) and feed grade urea.
- Other forms of NPN used in ruminant diets include biuret, triuret, and complexes formed with urea (Milligan *et al.,* 1972; Smith *et al.,* 1976 and Nikolic *et al.,* 1980), sulfur coated urea (Umunna and Woods, 1970) and poultry manure (Bhattacharya and Fontenot, 1966; Bhattacharya and Taylor, 1975; Smith and Calvert, 1976; Lamidi, 1995 and Belewu and Adeneye, 1996). Other forms of NPN are in form of free amino acids and they include nucleic acids, purine, nitrates, alkaloids and peptides.

The development of slow releasing urea is aimed at avoiding ammonia toxicity and improves ammonia utilization. These materials (slow releasing ammonia) release ammonia in the rumen at an attenuated rate that should be more closely parallel with energy available for bacteria (Johnson, 1976). However, Forero *et al.* (1980) and Owens *et al.* (1980) have shown that utilization from slow releasing compound has not improved the utilization of nitrogen as measured in the performance of cattle. Perhaps, nitrogen recycling to the rumen compensates for the rapid ammonia release by maintaining an adequate supply of ammonia in the rumen for

several hours after peak ruminal ammonia concentrations.

Non-protein nitrogen compounds are rapidly broken down into ammonia and carbon dioxide by urease (Chalupa, 1969). The utilization of urea will depend on the type and amount of carbohydrates simultaneously fed. The fast rate of urea hydrolysis led to the search for methods of reducing the rate of ammonia release from urea derivatives. One of such compounds is biuret, a conjugation of two urea molecules prepared by condensation. Biuret is tasteless, non toxic and much slower than urea in ammonia release (NRC, 1989). Starea is a mixture of urea and cereal grain prepared in a cooker extruder. Urea and other NPN compounds can be fed as liquid supplements with molasses or a urea/molasses block. It could act as a carrier for minerals and vitamins (Huber, 1972). The major NPN compound in poultry litter is uric acid and it accounts for about 30-60% of the total nitrogen (Bhattacharya, 1964 and Morgan, 1970). Uric acid is less soluble in water and more slowly available to the rumen microbes when compared to urea. It is therefore, subjected to less loss through ammonia production by direct absorption. Other nitrogen sources for rumen bacteria include: salivary urea, blood plasma urea, nitrogen from abraded epithelia tissues of the gastro intestinal tract (Nolan *et al.*, 1973) and from lyses of bacteria cells Orskov *et al.* (1980).

Urea nitrogen from saliva

The quantity of saliva produced is greatly influenced by the diet (Orskov *et al.*, 1972). High concentration of saliva is produced on high roughage, coarse diets (hay) than on finely grounded hay or concentrate. This is due to increased time of mastication of coarse roughages to reduce their particle size. The ability of ruminant animals to return significant quantities of urea into the rumen provides additional source of nitrogen for microbial protein synthesis and fermentation of poor quality roughages. The extent to which urea is returned into the rumen via saliva is

proportional to blood urea concentration and rate of saliva secretion (Nolan *et al.,* 1973). Sheep secret up to 6 - 16 litters of saliva per day while cattle secret up to 100-190 litters per day (Kay, 1960). Nolan and Leng (1972) indicated that salivary urea in sheep could account for most of the urea entering the rumen. Kennedy and Milligan (1980) have shown that up to 7.3gm/day nitrogen was entering the rumen in sheep as urea and only 15% of that was accounted for by salivary urea, which indicates that normally, the entry of urea from the blood is most important.

Nitrogen from abraded epithelial cells of the GIT.

Epithelia lining the GIT are constantly being shed into the rumen (Nolan, *et al*.1973). Nitrogen originating from the epithelia lining of the fore-stomach may contribute to the ruminal microbial protein synthesis ((Nolan *et al.,* 1973). The extent and quantities of nitrogen from these abraded cells used for microbial cell synthesis have not been adequately quantified. Orskov *et al.* (1980) estimated up to 1.4g/day for sheep, 5.4g/day for calves and 8.3g/day for cattle in the rumen of animals nourished solely by intra gastric infusion.

2.3.2 Factors affecting extent of protein degradation

The rate of degradation of feed protein in the rumen varies depending on the source of the protein, and the quantity of protein passing to the lower GIT are dependent on a number of factors such as: solubility of the protein (Chalupa, 1969 and Hume *et al.*, 1970)., physical form of the diet (Orskov, 1982), voluntary feed intake (Miller, 1973) and rumen turnover rate (Orskov and Fraser, 1973 and Satter and Roffler 1975).

Solubility of protein is the most important factor determining the extent to which a protein is degraded in the rumen. Soluble proteins are rapidly degraded in the rumen resulting in the concentration of ammonia that may exceed the optimal concentration necessary for efficient

utilization (Wohlt, *et al.*, 1973). The quantity of feed protein that is presented to the intestine can be improved by altering the solubility of protein.

Protection of protein from ruminal degradation (By-pass protein)

Protection of dietary protein may increase the efficiency of nitrogen utilization in ruminants by reducing ruminal proteolysis and allowing by-pass to the lower GIT with a subsequent increase in nitrogen retention. Some proteins are naturally protected from rumen degradation because of their structure e.g. corn gluten meal is a high by-pass protein. The different methods developed to protect dietary proteins from degradation in the rumen are heat treatment, use of tannic acid, aldehyde, use of chemicals and VFAs (Orskov, 1982).

Heat treatment decreases ammonia production in the rumen. This effect is caused by Maillard reaction which causes an irreversible binding between aldehyde groups of the sugar and free amino acid groups (Orskov, 1982). Heat treatment of protein has increased nitrogen retention in lambs (Goering *et al.*, 1972). Tannic acid treatment of soybean meal increases nitrogen retention in lambs (Driedger and Hatfield, 1972). Ehoche *et al.* (1983) reported a decrease in nitrogen accumulation and improvement in nitrogen retention in sheep fed cotton seed cake treated with bagaruwa tannin. Treatment of protein with VFAs reduced the rate of ruminal ammonia accumulation in sheep and cattle (Atwal *et al.*, 1974 and Adamu *et al.*, 1988). Lipid coating of the dietary protein was effective in reducing ruminal degradation and increase nitrogen retention in lambs (Glenn, *et al*., 1977).

Hemsley and Moir, (1973) reported improved gains in sheep supplemented with corn gluten meal- urea compared to those fed urea alone. Umunna *et al.* (1982) reported that sheep fed corn gluten meal or corn gluten meal-urea rations retained more nitrogen and had better protein and dry matter digestibility than those with urea alone.

Availability of energy also plays an important role in microbial protein synthesis. Available energy may not be optimal from roughages at the time of peak ammonia release from urea. Differences in the degree of degradability of dietary protein in the reticulo-rumen have some influence on the quality and quantity of nitrogen reaching the abomasum in ruminants (Hume *et al.,* 1970 and Adamu *et al.,* 1988).The degradation of proteins is related to type of protein, level of feeding and roughage to concentrate ratio in the diet (Orskov *et al.,* 1980). Protein of lower degradation in the rumen may have higher value for ruminants than highly degradable proteins because of ammonia losses.

Wohlt *et al.* (1976) found that the non essential amino acids were higher in highly soluble diets than low soluble diets. Also intake was higher on high solubility diets than low solubility diets. Consequently high correlation between dietary protein solubility and rumen ammonia concentration was established.

Solubility of protein in the rumen has influence on ammonia production, and VFA concentration. The molar proportions (percent) of propionate decreases significantly while butyrate increases with increased solubility. Wohlt *et al.* (1976) reported that the influence of the degradation of soluble protein in the rumen affected several metabolic parameters in the animals. Water intake and urine secretion increased with increased dietary protein solubility (Wohlt *et al.,* 1976). Nitrogen retention also decreased significantly in Holstein heifers with increased dietary protein solubility (Sniffen, 1979). Hudson *et al.* (1970) reported that heating soybean protein at 149 ^{O}C for 4hours reduced the protein solubility from 72% to 35%.. Nitrogen, cellulose and dry matter digestibility were not affected by heating the soybean meal. Body weight of lambs improved though not significantly ($P>0.05$) by heating soybean meal at the 10 and 14% level but not at 12% dietary protein level; it may indicate that 12% crude protein level is near the optimum

protein required for these lambs. Feeding the heated soybean meal also improved cellulose digestibility. Excessive feeding of preformed protein lowered pH below 6.5 in rumen of sheep whereas the pH of the sheep fed excessive urea had their rumen pH exceeding 8.0 (Orskov *et al.*, 1980). They concluded that breakdown of protein is accompanied by the production of VFA which tended to buffer the rumen contents at an acid pH resulting in slower rate of ammonia absorption than the higher pH. Decreasing protein solubility by heating resulted in decreased levels of isovaleric, valeric acid and increased cellulose digestion. This suggests that decrease in rate of hydrolysis in the rumen results in a more efficient utilization of the available nitrogen (Aganga, e*t al.* 1983).

Depending on the diet, 60-90% of the daily nitrogen intake by the ruminant is converted to ammonia and 60-80% of the bacterial nitrogen is derived from ammonia (Pilgrim *et al.*, 1970 and Nolan and Leng 1972).

2.3.3 Rumen ammonia concentrations and rumen microbial protein synthesis

Optimal ammonia concentrations required to ensure the most rapid microbial growth differ between diets (Orskov, *et al.* 1980). Orskov *et al.* (1972) showed that although, microbial protein produced per unit of substrate fermented was not altered as a result of urea supplementation of barley grain, the extent of rumen fermentation and degradability was increased. Low rumen ammonia concentration limits rates of protein degradation. This may be due to reduced cellulolysis, resulting in low microbial cell synthesis in nitrogen deficient medium.

There is no general agreement on the ruminal ammonia concentration for maximum microbial protein synthesis. Estimate of optimal ammonia concentration for microbial protein synthesis ranged from 3.5 to 29mg/100ml (Satter and Slyter, 1974; Hespell and Bryant, 1979 and Slyter *et*

al., 1979.). Mehrez, *et al.* (1976) reported 100mg/10ml for sheep fed whole barley. Most in vitro studies, however, showed maximum microbial growth to occur when the ammonia nitrogen concentration was 5 to 8mg/100ml (Allison 1970; Satter and Slyter, 1974 and Annison, 1975). Hume *et al.* (1970) observed in an in vivo experiment that maximum microbial growth was obtained when rumen ammonia nitrogen concentration reached approximately 9mg/100ml, however. Lamidi (1995) reported the rumen ammonia nitrogen in cattle fed sun-dried poultry litter to range between 9.13 to 12.51mg/100ml. Okorie *et al.* (1977) reported a much lower value of 5mg/100ml as the rumen ammonia for maximum microbial growth and 8.5mg/100ml as rumen ammonia nitrogen concentration required for optimum bacterial protein yield. These observations are consistent with what Satter and Slyter (1974) reported. Adegbola (2002) reported the rumen ammonia nitrogen to range from 6.74 to 27.7mg/100ml. There were also differences in the rumen ammonia nitrogen due to type of diet and time of sampling. Mehrez and Orskov, (1977) gave rumen ammonia nitrogen between 19 to 25mg/100ml as optimum for forage digestion. When rumen ammonia concentrations fell below 3.5mg/100ml, microbial growth decreased significantly (Satter and Slyter, 1974). Some of the differences in ruminal ammonia concentration obtained may be due to differences in sampling techniques and variation in rumen ammonia concentration post feeding (Satter and Slyter, 1974).

The rate of rumen fermentation has greater influence on both total and digestible feed intake (Orskov, 1982). Feed intake may be reduced if the ammonia concentration is limiting the rate of fermentation. Orskov, (1982) reported an increase in intake and digestibility as the concentration of urea increased in the diet, though, the increase was not linear. Similar result was also reported by de-Faria and Huber, (1984) when they fed corn silage supplemented with urea to steers.

2.4. The use of poultry litter in ruminant feeding

Animal wastes are valuable resources if utilized judiciously. Animal wastes may be used as source of plant nutrients, animal feedstuff, substrate for methane generation and substrate for microbial and protein synthesis (Fontenot, 1996). Although the use of animal waste to produce microbial and insect protein may sound technically feasible (Smith and Wheeler, 1979), the practice is not economically feasible (Calvert, 1979). Likewise, methane production from animal waste is technically feasible (Calvert, 1979), but it is not profitable. Thus the most feasible methods of recycling animal wastes are as sources of nutrients for plants and animals. In Nigeria the traditional use of animal waste is as organic manure. When there was heavy subsidy on inorganic fertilizer, the farmers shifted from the use of organic manure to almost complete dependence on chemical fertilizer. However, recent increases in the cost of inorganic fertilizer due to the withdrawal of subsidy have resulted in increasing use of animal waste for cropping. The use of animal waste as manure may not be very economical, especially if it has to be transported over long distance. In monetary terms, the value of the manure as ruminant feed exceeds that of its value as organic manure (Martin *et al.,* 1983). The nitrogen in the manure is ten times more efficiently utilized when fed to ruminants than when applied to crops (Smith and Wheeler, 1979). The manure can supply nitrogen necessary for rumen microbial synthesis (Belasco, 1954; Jurtshuk *et al*, 1955).

2.4.1. Chemical composition and nutritive value of poultry litter

Poultry litter is ranked the best among various animal wastes in terms of nutritive value for ruminants (Fontenot, 1996). There is also considerable evidence in the literature to show that poultry litter is fairly high in crude protein, while the energy content compares favourably with

those of high quality roughages (Fontenot and Jurubesco, 1980).

Protein value of poultry litter

Crude protein content of poultry litter varies between 14 and 30% on dry matter basis (Bhattacharya and Taylor, 1975; Smith *et al.*, 1976). The crude protein content depends on the crude protein content of the diet of the birds. Smith, (1973) reported that layers liter contained 4.48 – 5.76% nitrogen and broilers litter contains 6.08- 6.40% nitrogen. El-Sabban *et al.* (1970) reported a lower value of 3.2% and 4.48% nitrogen for layers and broiler manure respectively. Ruffin and McCaskey (1990) reported an average of 25% crude protein for broiler manure while Fontenot *et al.* (1971) reported 30%. Lamidi (1995) gave the crude protein content of layer, broiler, pullet and cocks manure to be 16.13%, 25.58%, 18.45% and 15.65% respectively and Belewu and Adeneye (1996) also reported 18.40% as the CP content of broiler litter. The type of bedding material used in poultry houses affects the composition of the litter, especially crude protein and fiber contents (Fontenot, 1971). About 30- 60% of the total nitrogen in the manure is in the form of uric-acid nitrogen (Bhattacharya and Taylor, 1975, Morgan, 1970) and about 30-50% of the CP content is true protein (Bhattacharya and Fontenot 1966). Polin *et al.* (1971) reported a value of 11% as the true protein in poultry litter. The true protein of poultry litter may contain at least 16 different amino acids (Belasco,1954; and Flagel and Zindel,1971). The true protein is high in glycine and low in arginine, lysine, methionine and cystine (Bhattacharya and Fontenot, 1966).

Energy value of poultry litter

Poultry litter is generally low in energy (Lowman and Knight, 1971). This is because of its high ash content. Gross energy value of layers, broilers, pullets and cock litters were reported to be 3.29, 4.21, 3.57 and 3.49 Mcal/kg respectively by Lamidi, (1995). Belewu and Adeneye (1996)

also gave the gross energy of autoclaved broiler litter to be 3.21 Mcal/kg. Dry layer litter has a digestible energy value of 2.0Mcal/kg for sheep and cattle, making it approximately equivalent to good quality hay (Bull and Reid, 1971; Bhattacharya and Taylor 1975). Addition of cooked or autoclaved poultry manure did not change the digestible energy value of a purified sheep ration when incorporated at approximately 25% of the diet in place of soybean meal (El-Sabban *et al.*, 1970). Apparent digestible energy of diets containing 0, 25, 50, and 100% dry poultry waste decreased as the level of the manure increased in the diet (Adu and Lakpini, 1983). Digestible energy value of broiler litter in sheep has been reported to be 2.44 Mal/kg which compares favourably with 2.478 Mcal/kg for alfalfa hay, while metabolizable energy content of broiler litter has been reported as 2.181Mcal/kg on dry matter basis (Bhattacharya and Taylor, 1975). Types of bedding material used could also affect the energy value. Changing the bedding from wood shavings to peanut hulls did not affect the energy value (Bhattacharya and Fontenot, 1966). However, when citrus pulp was used as a bedding material in place of wood shavings, the digestible and metabolizable energy values increased significantly (Malik and Bhattacharya 1971).

Mineral composition of poultry litter

Poultry litter has high ash content of 28% (Bull and Reid, 1971; Polin *et al.*, 1971).The ash content of broiler litter is about 15% and compares well with most natural foodstuffs (El-Sabban *et al.*, 1969). Lamidi (1995) reported 28.93, 16.16, 20.91 and 21.44% as the ash content of sun-dried layer, broiler, pullet and cock litter respectively. Adu and Lakpini (1983) reported slightly lower value 24.20% for dried layer litter while Belewu and Adeneye (1996) reported a much lower value of 20.32% for autoclaved broiler litter.

Poultry manure is a good source of phosphorus and calcium with layer litter having higher

calcium and phosphorus (5.7 and 2.5%) than broiler manure (1.7 and 1.5%) respectively (El-Sabban *et al.,* 1969; Polin *et al.,* 1971., Lamidi, 1995; Fontenot, 1996). In a laying hen diet in which 12- 24 % of the calcium was derived from dried poultry litter, the utilization decreased by 16% and when 10% of the dietary phosphorus was derived from dried poultry litter, the utilization decreased by 6% (Polin *et al.*,1971). In ruminants, however, the calcium and phosphorus of dried poultry manure were found to be 95% and 75% available when the dried poultry waste was used as sole source of phosphorus supplement in a diet (Bull and Reid, 1971).

Fiber content of poultry litter

The fiber content of broiler litter is usually higher than layer litter, because the broiler litter usually has higher litter materials. Bhattacharya and Fontenot, (1966) and Adu and Lakpini (1983) reported the crude fibre content of 24.20% for sun-dried layer litter while, Lamidi (1995) gave the value of ADF and NDF of layer and broiler litter to be 20.31% and 19.40% and 47.62% and 44.47% respectively. Belewu and Adeneye (1996) reported a much higher value of ADF (35.87%) and NDF (68.30%) for broiler litter.

2.4.2. Effect of processing on nutritive value of poultry litter

Processing of poultry litter is necessary to destroy pathogens, improve storage and handling characteristics and enhance quality maintenance or palatability (CAST, 1978). Processing methods that have been used include dehydration, pelleting, ensiling alone or with other ingredients, deep stacking and compositing (Fontenot, 1996).

Dehydration

Heat drying has been used to process poultry litter, though, the resulting product is rather dusty but has good keeping quality (Fontenot and Ross, 1980). Heat drying may result in loss of

nitrogen in poultry litter, but acidifying the litter before drying was shown to reduce the nitrogen loss (Harmon *et al.,* 1974). When poultry litter was dried in conventional oven at 65^{o}C for 24 hours, Manoukas *et al.* (1964) observed a decrease of 1.2 to 20.2% and 7.1 to 15.2% in gross energy and nitrogen respectively. The higher the temperature and period of drying,, the greater the extent of nitrogen loss (Kubena *et al.,* 1973). Manoukas *et al.* (1964) and Fontenot (1996) reported an inverse relationship between drying temperature and resulting total protein in poultry litter. Hydrolyzed hen manure (steam treated) was found to contain more crude protein and ether extract (35.4 and 3.6%) than hen litter air dried at 42 ^{o}C (24.9 and 2.2%) (Long *et al.,* 1969). Fontenot *et al.* (1971) observed that heating poultry litter at 100 or 150 ^{o}C for 4 hours successfully sterilized the litter, although the crude protein and ether extract of the litter decreased from 42.5 and 6.2% to 34.4 and 2.9% respectively. This was however, compensated for by an increase in NFE

Ensiling

Ensiling poultry litter alone or in combination with other ingredients has been very successful in processing poultry litter for use as ruminants feed. Good corn silage was made by mixing corn forage and broiler litter (Harmon *et al.,* 1975). For good silage, the level of litter should not exceed 30% of the dry matter (Harmon *et al.,* 1975). Harmon *et al.* (1975) reported sufficient nitrogen utilization and dry matter intake by sheep fed ensiled poultry litter. McClure and Fontenot (1985) also reported that the performance of finishing cattle fed ensiled poultry litter was similar to that of cattle fed corn silage plus conventional protein supplement. When poultry litter is ensiled alone, the moisture content should be about 40% for good ensiling (Caswell *et al.,* 1978). Chaudhry (1990) successfully ensiled broiler litter and rumen content with pH value of 5.6. Caged layer waste has been successfully ensiled with hay (Saylor and Long 1974),

sugarcane baggasse (Samuels *et al.,* 1980), corn stover (Moriba *et al.,* 1982), corn forage (Goering and Smith, 1977) and sorghum forage (Richter and Kalmbacher, 1980).

Deep stacking

Poultry litter can be stacked to a depth of a minimum of 1.5meters in a building with ample ventilation. Maximum temperature is reached after a few days, after which the temperature in the stack gradually decreases until it reaches ambient temperature (Abdelmawla, 1990). In an earlier experiment, temperature of 50 ^{o}C was reached 4 to 8 days after deep-stacking broiler litter to a depth of 1.2 meters (Hovatter *et al.,* 1979). The maximum temperature appears to be related to moisture level in the litter. The highest temperature recorded for litter deep stacked at 15% moisture was 57.5 ^{o}C , compared to 61.2 ^{o}C and 60.2 ^{o}C for litter deep stacked at 25 and 35% moisture respectively (Chaudhury, 1990). Increasing the moisture above 35% appeared to result in lower maximum temperature (Abdelmawla, 1990). Covering the stack with polyethylene resulted in lower temperature within the stack (Rankins *et al.,* 1993).

Nitrogen retention was similar for ruminants fed poultry litter ensiled or deep stacked (Abdelmawla *et al.,* 1988). Performance was similar for finished cattle fed ensiled broiler litter corn forage or ensiled corn forage and deep stacked broiler litter (McClure and Fontenot, 1985). Excessive heating may occur during deep stacking, resulting in dark, charred-appearing litter, which may reduce dry matter digestibility (Ruffin and McCaskey, 1990). It was also reported that the nitrogen in ‘’charred’’ litter from a stack exposed to the weather was less soluble and lower in rumen degradability than normal deep-stacked litter (Kwak, 1990). Apparent digestibility of dry matter, acid detergent fiber and crude protein were lower when charred litter was fed to sheep than for sheep fed normal deep-stacked litter from the same stack (Fontenot, 1996). However, the differences in nitrogen retention were not significant.

Composting

This process involves initial stacking and mixing of the waste and mixing to enhance aerobic fermentation. Composting is described as the rapid but partial decomposition of most solid organic matter by the use of aerobic microorganisms under controlled conditions Fontenot (1996). This process has been used to process animal waste for land application, but animal waste may be composted for use as animal feed (CAST, 1978). Considerable loss of nitrogen may occur during composting. Composting litter by stacking, mixing after 2 days, then at weekly intervals for 6 weeks resulted in a 15% decrease in crude protein (Abdelmawla *et al.,* 1988). Apparent digestibilities of dry matter, crude protein and nitrogen utilization by sheep fed composted litter were similar to those for sheep fed deep-stacked litter (Fontenot, 1996).

2.4.3. Safety in feeding poultry litter

Many pathogenic organisms (bacteria, viruses and fungi) capable of causing disease in humans, livestock and poultry have been isolated from animal wastes (USDA, 1957; Lovett , 1972; Fontenot and Webb, 1975; McCaskey and Anthony, 1979). There are also circumstances when animals are symptomatic carriers of certain organisms which can infect and cause disease in other species (Adler *et al.,* 1953 and Fontenot and Webb, 1975). It is on this basis that the United States Agency for Food and Drug Administration (USDA, 1980) enacted some regulations on the feeding of animal wastes and withdrawal time. It is therefore, important that any animal waste should under-go some kind of processing to reduce or eliminate the bacterial load to a tolerable level as well as to obtain a more stable and odourless material.

Pathogens,drugs and chemicals in poultry litter and disinfection methods

Poultry manure or litter is a potential source of pathogenic organisms. Freshly voided poultry droppings may contain S*almonella, Mycobacterium, Clostridium, Streptococcus, Staphylococcus*, Shigella, Listeria, *Escherichia coli*, mould, yeast, proteus and coliforms (Alexandra *et al.*, 1968; Caswell *et al*.,1978; McLoughlin *et al.*, 1988 ; McCaskey and Anthony, 1979; Neill *et al*.,1989; Bienvenu and Morin, 1990; Jean *et al.*, 1995).The level of pathogens found in manure depends on factors such as the management system, pH, moisture content and temperature. Length of storage has little influence on the microbial content of the manure (Lovett, 1972). However, a recent report by Martin and McCann, (1996) cited by Fontenot *et al.* (1983) in which 86 samples of poultry litter obtained from Georgia (USA) were analyzed for the presence of pathogens indicated that even prior to processing, the presence of pathogenic organisms was not a problem. No *Salmonella* or *E. coli* were isolated from any of the 86 samples. Lovett (1972) also did not detect any *Salmonella* in samples taken from four farms in Ohio. Martin and McCann (1996) concluded that poultry litter does not appear to be a source of harmful micro-organism when fed to beef cattle.

Processing methods that have been found to render poultry litter safe as cattle feed include oven drying, ensiling, sun drying, air drying, autoclaving, freeze drying, para formaldehyde and ethylene oxide treatments (Fianu *et al.*, 1984). Heat processing destroys pathogens (Fontenot and Webb, 1975). Messer *et al.* (1971) observed that all the salmonella in poultry litter were eliminated when dried at 68^{o}C for 30min., irrespective of the moisture content. Proper ensiling of animal waste also appears to be effective in destroying pathogens (McCaskey and Anthony, 1979). A pH of 4 to 4.5 and a temperature of over 25 ^{o}C were found to be important for destruction of salmonella (Fontenot and Webb, 1975). However, due to the ammonia and

minerals in poultry litter, it is rather difficult to reach a pH of less than 5 without additional material such as whole plant corn forage. Ensiling of broiler litter with water has been shown to destroy coliforms even when the pH did not go below 5.4 (Caswell *et al.,* 1978). Deep stacking has been shown to destroy coliforms (Hovatter *et al.,* 1979; Chandler *et al.,* 1996). Some earlier reports have shown that storing poultry manure for 1-2 months was adequate in destroying all the salmonella that reside in the droppings (Alexandra *et al.,* 1968). In another study, storing droppings in a 50 litter drum for 6 days in summer (temperature 16-25^{o}C) and for 26 days in winter (5-11 ^{o}C) completely destroyed salmonella (Strauch and Muller 1986).

In Israel, an alleged outbreak of botulism in cattle fed poultry manure suggested potential risks of *Clostridia* in diet containing ensiled poultry waste (Egyed *et al.,* 1978). A major outbreak of botulism (type C) was reported in cattle fed ensiled poultry litter in Northern Ireland (McLaoughlin *et al.,* 1988). The outbreak occurred 24 hours after the introduction of purchased ensiled litter. In Quebec, 28 of 41 cattle fed diet containing poultry litter had botulism (Bienvenu and Morin 1990). Botulism incidence as a result of feeding poultry litter was also reported by Jean *et al.* (1995) and Trueman *et al.* (1992).

Clegg *et al.* (1995) and Hogg *et al.* (1990) reported that botulism was diagnosed in United States in cattle grazing on pasture that had been fertilized with poultry litter. They suggested that the source of the toxin was the ingestion of poultry carcasses containing types C and D *clostridium botulism*. Similar result was also reported by Appleyard and Mollison (1995) in Scotland; Mcllory and McCracken (1987) in Northern Ireland and Smart *et al.* (1987) in England. The presence of poultry carcasses has been implicated as the source of the toxins in all the reported cases, and McLoughlin *et al.* (1988) suggested that the carcasses be removed before the litters are fed to animals.

Residues of drugs and chemicals in poultry litter

Drugs such as antibiotics, hormones, arsenic, nitrofuran, coccidiostat and pesticides are routinely mixed with poultry feed to enhance production or to prevent diseases. In Nigeria, drugs fed to poultry include antibiotics, amprolium, sulfur containing drugs and vitamins.

Mycotoxins pose greater problems in poultry litter than in common feedstuffs (Lovett, 1972).There has not been report of pesticide accumulation in tissues of animals fed poultry litter (Fontenot *et al.*, 1983). Heavy metals have not been found to be sufficiently high in poultry litter to present any problem in fattened cattle (Westing *et al.,* 1985). Feeding of diets containing poultry litter did not significantly affect cadmium, copper, lead, zinc and tocopherol in milk (Bruhn *et al.,* 1977). Medicinal drug residues are present in broiler litter in variable amount if the drugs had been included in the broiler diet (Webb and Fontenot,1975). However, chlortetracycline, nicarbazin and amprolium did not accumulate in tissues of finishing beef cattle after 5 days withdrawal. It thus appears that with a modest withdrawal period, there is no serious tissue problem from feeding broiler litter.

Toxicity

Copper toxicity has been documented in sheep fed broiler litter at 25 and 50% containing 195 ppm copper levels (Fontenot and Webb, 1975). The first fatality was observed after 137 days on the test diet. At the end of 254 days, 60% of the ewes fed the higher level of litter and 55% of the ewes fed 25% litter had died (Fontenot and Webb, 1975). Suttle *et al.* (1988) reported elevated copper level in the liver of lambs fed dried battery or broiler litter, but no sign of toxicity was observed. Feeding molybdenum and sulfate may help in preventing copper toxicity in sheep. Copper accumulation in the liver of ewes fed poultry litter decreased by about 50% when 25ppm molybdenum and 5g sulfate was added to the diet (Olson *et al.,* 1984). The problem of copper

toxicity will not be as severe in cattle since they are not as sensitive to high dietary copper (Fontenot 1996). However, few cases of copper toxicity have been reported on farms where dairy cows were fed broiler litter containing 620ppm copper and steers were fed litter containing 685 to 920ppm copper (Barton *et al.,* 1987). In a study involving beef cows fed diets containing high levels of broiler litter containing high levels of copper with or without additional copper for seven days showed no deleterious effect (Webb *et al.,* 1980). Rankins *et al.* (1993) reported increased liver copper in cattle fed high copper litter for 84 days, but they did not report any clinical signs of copper toxicity. Pugh *et al.* (1994) also reported that practising veterinarians have reported a limited number of cases of copper toxicity in cattle fed poultry litter. Cardiomyopathy was observed in cattle fed litter from broilers fed coccidiostat and maduracyin (Shlosberg *et al.,* 1992). Hypocalcaemia in beef cows has also been reported on farms when broiler litter was fed (Ruffin *et al.,* 1994). In another study in which beef cows were fed high levels of broiler litter, decreased blood serum calcium was observed, but there was no physical signs of milk fever on the cows (Pugh *et al.,* 1994). When pregnant cows were fed 8kg of a mixture of 80% litter and 20% corn plus a small amount of long hay, there was a drop in serum calcium, although there was no physical sign of milk fever (Wright, 1996).

2.4.4. Response of animals fed diets containing poultry litter

The performance of animals on any feed will depend on its intake and the eventual utilization of by the animal. Intake of poultry litter depends on its quality and odour. Animals will generally consume only small amounts of wet poultry litter (Flachowsky and Henning, 1990). Lamidi (1995) observed a gradual decrease in the amounts of supplement intake as the level of sun-dried layer litter increased in the supplements. However, Belgado *et al.* (1978) did not notice any decrease in intake as a result of inclusion of poultry litter in the diet. Intake of dried poultry litter

is usually low when first introduced to animals, but improves with time (Abu-Izzedin and Bhattacharya, 1969). Intake of broiler litter was observed to be higher than layer litter when they were included in supplements for growing Bunaji bulls (Lamidi, 1995). Inclusion of broiler litter in finishing ration did not affect intake or digestibility in steers (Odhuba,, 1998). Similar observations were made in Sheep by Kayongo and Irungu (1986).

Digestibility of organic matter declined from 76-67% when the level of dried layer manure was incorporated at 20-80%, even though the feed intake of all rations remained the same (Tinnimit *et al.*, 1972). Crude protein content of dried poultry waste has been reported to be about 53% digestible when fed as the main source (90%) of protein in an adequate ration for sheep (Tinnimit *et al.,* 1972). Adu and Lakpini (1983) reported 55.67% digestibility of nitrogen in sheep fed diets containing graded levels of dried layer litter. Higher digestibility value (77%) has been reported with sheep by Brugman *et al.* (1964) and Lowman and Knight (1970). Smith and Calvert, (1976) substituted dried poultry waste at 0, 50, and 100% of the soybean meal in sheep ration and reported no differences in dry matter and crude protein digestibilities was observed among the diets. Okorie *et al.* (1977) showed that poultry litter could replace groundnut cake in the diets of goats without any depression in growth rate and efficiency of feed utilization. They also reported an increase in CP digestibility from 65-67% when the CP content of the ration increased from 6-34%. However, a significant (10%) depression in CP digestibility was observed by Tinnimit *et al.* (1972) when 45% of soybean meal was replaced by dried poultry waste. Apparent CP digestibility of broiler litter when fed at 50% inclusion rate in diets of sheep was reported to be 72.5% (Bhattacharya and Fontenot, 1966). When the litter level increased from 0-60% in calve rations, Belewu and Adeneye (1996) reported an increased CP digestibility from 33.54 to 67.19%. However, Adu and Lakpini (1983) reported a decrease in N digestibility as

dried poultry waste replaced cotton seed cake from 0-100%. Bhattacharya and Fontenot (1966) also noticed a gradual decrease in N digestibility as the level of poultry litter increased in the diet of sheep. Decrease in crude fiber digestibility was also noticed as the level of poultry litter increased. A significant ($P<0.05$) reduction in DMD was observed at 100% level of poultry litter inclusion (Bhattacharya and Fontenot, 1966). Malik and Bhattacharya (1971) did not observe any decrease in CP digestibility in sheep when litter containing wood shavings was incorporated at 45% of the diet as compared to soybean meal (SBM).

Total N absorbed and percent of absorbed N retained per day did not show any change when the total N in purified diet for sheep was replaced by 50% litter nitrogen. However, when the litter nitrogen contributed up to 100% of the dietary nitrogen, the retention value dropped significantly (Bhattacharya and Fontenot, 1966). Adu and Lakpini (1983) also reported a significant drop in N retention in sheep when 50% of the cotton seed cake was replaced by dried poultry litter. Nitrogen retention and percent of nitrogen absorbed from diet in which 45% of SBM was replaced by dried poultry litter was 20% higher than the control. However, when dried litter provided 88% of the total nitrogen intake in the same trial, total nitrogen retained and percent absorbed nitrogen dropped significantly by 30%. Conversely, El-Sabban *et al.* (1970) reported an improvement in the retention values when cooked or autoclaved poultry waste replaced soybean meal as a sole nitrogen source in a semi-purified diet for sheep. When uric acid constituted about 12% of dietary nitrogen, the nitrogen retained was 23 and 13% respectively for total-N and uric acid-N (El-Sabban *et al.*, 1970). Nitrogen retention from sheep fed diet containing 45% wood shaving litter was not significantly different from that of soybean meal control diet. However, when citrus pulp replaced wood shaving as litter material, the daily N-retention improved significantly (Malik and Bhattacharya, 1971).

Performance of ruminants fed different levels of poultry litter was summarized by Smith and Wheeler (1979). Feeding diets containing an average of 24% poultry litter (DM basis) to cattle resulted in 5% depression in rate of gain and 10% increase in feed dry matter per kilogram gain, probably reflecting the lower energy value of litter than the proportion of the diet that was replaced. Incorporation of 32% dried poultry litter (DPL) in to replace all the SBM and part of corn grain a ration for beef steers, resulted in a highly significant depression in average daily gain (Bucholtz *et al.,* 1971). This was attributed to lack of adequate intake of the DPL. Feed required per unit gain was also increased by 30% in the animals fed the diets containing the waste. Similar observation was made by Westhuizen *et al,* (1972). Conversely, other reports showed satisfactory use of DPL in beef production. Belewu and Adeneye (1996) reported an increase in the liveweight gain of Bunaji bulls as the level of autoclaved poultry litter increased in the ration. Lamidi (1995) also reported increase liveweight gain in Bunaji bulls grazing natural pastures and supplemented with diets containing up to 50% sun-dried layer litter. Cross *et al.* (1978) reported increased weight gain in steers fed diets containing 44% broiler litter. Adu and Lakpini (1983) concluded that CSC in the ration of Yankasa sheep can be replaced by up to 10% with dried poultry litter without any detrimental effect on liveweight gains.

In fattening rations for beef cattle, Oliphant (1974) observed that the average daily liveweight gain did not change when the steers were started at 150kg and finished at 450kg as a result of incorporating 17.5% DPL. Similarly, Smith (1973) did not record any differences in DMI, average daily gain, feed efficiency and nutrient utilization in cattle fed corn meal containing 12.8% cotton seed cake and 20.5% DPL. In another study in which heifers were given full feed of corn silage and 1.4kg corn based grain supplement containing DPL,SBM or urea in iso-nitrogenous amounts, no differences in liveweight gains among the groups were noticed (Cooper

et al., 1974). Six months old lambs fed diets containing 36% DPL as equal weight replacement for carob bean for 135 days showed no differences in liveweight gains (Rodrigues, 1967). Smith and Calvert (1976) in another trial in which lambs were fed diets in which the CP of SBM was replaced by that of DPL at 0, 50 and 100%, reported no significant changes in average daily gain and feed required per unit gain, although, the performance of the lambs tended to decline by 9 and 15% respectively at 50 and 100% SBM replacement. Beef cattle were successfully fattened without any significant reduction in liveweight gains and carcass quality when 20% unprocessed broiler litter was incorporated in a basal ration to replace SBM and some hay (Bhattacharya and Taylor 1975). However, when 50% broiler litter was incorporated in the fattening ration, there was a significant depression in feedlot performance and carcass quality. Contrary to the above observations, Bastman (1973) observed no differences in daily gains of beef cattle when poultry litter accounted for 20, 40 and 60% of the total ration. Galmez *et al.* (1970) observed that growing lambs gained faster with better feed efficiency when fed rations containing 38 and 62% rice hull and poultry litter than when fed alfalfa hay. Harmon *et al.* (1975) also observed no differences in dry matter digestibility and nitrogen retention when ensiled poultry manure was fed to sheep. Adegbola *et al.* (1990) observed no differences in liveweight gains and feed efficiency in West African Dwarf sheep fed 55.0g feed in which DPL replaced groundnut cake from 0-100%. A depression in daily weight gain of steers fed diets containing 32% poultry manure was reported by Bucholtz *et al.* (1971). A similar observation was made by Westhuizen *et al.* (1972). Feeding poultry manure does not have any detrimental effect on milk production in sheep. The quality and quantity of milk produced from ewes fed concentrate containing 50% DPL were similar to those without DPL (Zorita *et al.,* 1967). Bull and Reid (1971) and Thomas *et al.*(1972) also observed no adverse effect on milk production when the dairy concentrate

included 30% DPL. Bull and Reid (1971) also reported that feeding up to 4.1kg of dried cage layer waste had no adverse effect on milk composition and flavor. Silva *et al.* (1976) reported that feed flavor in milk was less in cows fed 30% DPL than in those fed no waste. Overall flavor quality score were similar for milk from cows fed 0, 10, 20 and 30% poultry waste. Flavor of milk from dairy cows fed diets containing dried layer waste was similar to that of cows fed diets not containing waste (Thomas *et al.,* 1972). Arave *et al.* (1990) reported no adverse effect on milk flavor when processed poultry litter was fed up to 17% in a diet to dairy cows. Milk odor, colour and taste were not adversely affected in ewes fed poultry litter (Muwalla *et al.,* 1995). In a taste panel assessment of milk from ewes fed poultry litter, only 2 out of a 14 members scored the milk from poultry litter fed ewes unacceptable compared to 8 for milk from ewes on control diet.

2.5. Cotton production in Nigeria

Cotton belongs to the family *Malvaceae* and genus *Gossypium* with about 39 species of annual, perennial and small trees (Frywell,1969). Cotton is distributed throughout the tropics and sub-tropical regions of Africa, Asia, Australia and America. Commercial cotton production in Nigeria started in 1902 by the British Cotton Growers Association with the aim of supplying cotton lint to Lanchashire cotton industry in UK. However, the history of the improved varieties of cotton in Nigeria started with the introduction of an American upland type: “Allen long staple’’ from Uganda in 1912. From this stock, improvement was made through selection leading to subsequent development of the Nigerian Allen and later the Samaru Allen (Choyce, 1968). Several commercial varieties (Samaru 26J, Samaru 68, Samaru 69, Samaru 70 and Samaru 71) have been developed from Samaru Allen which thus forms the basic stock in Nigerian cotton breeding programme.

The major cotton producing areas are in the north western zone, i.e., Kaduna, Katsina, Kebbi, Zamfara, Sokoto and Kano States. This zone produces up to 65% of the total cotton in Nigeria. The north east zone comprising of Borno, Adamawa, Gombe, Yola, Bauchi and Jigawa States produce about 30% of the total cotton. The remaining 5% comes from the southern cotton zone, comprising Kwara, Niger, Nasarawa, Taraba, Plateau and Benue states. In all the zones, cotton is grown mainly under rain fed conditions

Cotton seed is made up of approximately 9% cotton lint, (a short cellulose fiber used in paper manufacturing and other cellulose application), 25% hull (used as animal feed and for other specialized industrial applications), 16% crude cotton oil (which is predominantly used for salad oil and other lipid applications for human consumption). The bulk of the seed (45%) constitute the cottonseed meal, a high protein supplement primarily used as animal feed. The remaining 5% is attributed to waste. Whole cotton seed can be fed alone or in combination with other feedstuffs and it does not require any grinding, rolling, milling or any other processing or preparation. Cattle unaccustomed to eating whole cotton seed may have to be trained by adding some cotton seed then slowly removing the grains.

The major concern in the use of cotton seed and its by-products is that it contains a naturally occurring polyphenolic compound called gossypol. This compound is found to give some level of protection to the plant against insect pest attack. The seed of *Gossypium barbadense* (L), contains more gossypol than the seed of *Gossypium hirsutum* (L). Within the G. *barbadense* species, the seed of the sea island contain more gossypol than the Egyptian seed. The Nigerian varieties are hybrid of the staple types of G. *hirsutum* and local material (Faulkner 1974).

2.5.1. Chemical composition of whole cottonseed

Whole cotton seed is a by-product of cotton gin-industry and has sufficient feeding value for average and high producing dairy cattle (Chandler, 1992). It is a unique feedstuff that contains high concentration of energy (14 MJ/kg) and fiber and moderate concentration of protein (22-24%) (Bernard, 1999 and Peters, 2002). The DM is high in fat and NDF (NRC, 1989). The fiber provided by the lint and the hull of whole cotton seed is a good source of effective fiber (Clark and Armentano, 1993). It is commonly used in diets for high producing dairy cows to increase the energy density and maintain acceptable fiber concentration (Coppock *et al.,* 1987).

2.5.2. Occurrence and distribution of gossypol

The predominant naturally occurring gossypol pigment and the one which has been investigated far more thoroughly than any of the others, is the yellow pigment gossypol, $C_{12}H_{30}O_{8,}$ named by Marchlewski in 1899. Gossypol as well as other similar pigments are contained in discrete sub epidermal glands (or resin glands) dispersed in the root bark, (Royce *et al.,* 1944., Stipanovic *et al.,* 1975), leaves, stem and seed of cotton plants (Randel, *et al.,* 1991). The pigment gland occurs in greater amount in the roots than in the seed and other parts of the plants (Rao and Sarma, 1945). The gland constitute about 2.4-4.8% of the weight of the kernel (Boatner, 1948). The root tips have an enzyme system necessary for the production of gossypol. Apart from gossypol proper, about 14 other gossypol pigments or derivatives are reported in the extracts of cottonseed or cottonseed oil and meal (Boatner, 1948). However, only six of these pigments have been isolated in more or less purified form and characterized. They include diaminogossypol (yellow), gossypurpurin (purple), gossyfulvin (orange), gossycaerulin (blue) and gossyverolurin (green). Gossypol occurs in greater amounts in raw cottonseed than in cottonseed that has been

subjected to moist heat treatment (cooking) during processing. Gossypurpurin and gossyfulvin occur in the cooked seed. Gossypurpurin content increases during storage of cottonseed and gossycearulin occurs almost exclusively in cooked cottonseed.

Several workers have shown that gossypol levels in the seed and plant vary with the cultivar (Pons *et al.,* 1953) and location (Cherry, *et al.,* 1978). Smirnova (1934) observed that the average content of gossypol pigments is a characteristic of the species, even though different varieties of the same species may differ with respect to the content of gossypol pigments when the seed are grown under different conditions. Boatner,(1948) reported that *Gossypium barbadense* seeds contain more gossypol and gossypurpurin than the seed of the species *Gossypium hirsutum.* Frampton *et al.* (1960) reported that the total gossypol contents of seeds from several species range from 0.13-6.64%. Pons *et al.* (1953), Frampton *et al.* (1960) and Ikurior and Fetuga (1984) gave the gossypol content of moisture free kernel to range from 0.39 to 1.70% and that both varieties of the seed and environment influence the content of the pigment. They concluded that the content of gossypol pigments is negatively correlated with temperature of the environment and positively correlated with rainfall. Pondey and Jappa (1975) reported a mean gossypol content of 1.32% (Range 0.59-2.35%) in cottonseed (n=46) collected from *G. hirsutum.* In Nigeria, Ikurior and Fetuga, (1984) reported that average values of free gossypol ranged from 1.14% for S72 to 1.28% for S77. The total gossypol value of 1.59% for S77 was found to be higher than 1.21% and 1.25% obtained for S71 and S72 varieties respectively. About 80- 98% of the gossypol exist in Free state (Ikurior and Fetuga, 1984).

Gossypol is not peculiar to cotton but is present in many plants belonging to the order Malveceae. Okro, which belongs to this order, contains 3.2mg of gossypol/100g of dried seed (Martinez *et al.,* 1961). This level is within the acceptable food level of 0.045% free gossypol

according to the United States Agency for Food and Drug Administration or 1.2% total gossypol recommended by the FAO (1980).

2.5.3. Effect of processing whole cottonseed on gossypol content.

The quantity of gossypol in cottonseed depends on the method of processing the seed. During processing the rupture of the pigment glands containing the gossypol and other complex polyphenols allow binding of these highly reactive compounds with components of the meal. Thus the portion of gossypol, which has combined through condensation of gossypol and amino acid in protein, is known as bound gossypol. The remaining uncombined gossypol is called "free" gossypol. In raw unprocessed cottonseed, the gossypol is considered to be all in the free form since pigment gland membrane protects it from degradation. Drastic processing treatment does not only lower the free gossypol content of the meal but also reduce the availability of amino acids and reduces nitrogen solubility (Berandi and Goldblatt, 1980). While heat treatment of cottonseed may reduce protein degradability, it may also increase the quality of intestinal protein (Arieli, 1998). An intermediate heat input is thus required to reduce heat damage and thereby achieve the maximum amount of protein available for small intestine digestion (Satter, 1986). The optimum heat input required for whole cottonseed to give maximum amount of protein at the intestinal level is $45^0C\ h^{-1}$ (Arieli,1998 and Schroeder et al.,1995). Fadel (1990) compared the effect of heat damage in various feedstuffs and concluded that whole cottonseed was the least sensitive to heating as compared to almond hulls and alfalfa. The acid detergent insoluble nitrogen (ADIN) in whole cottonseed was found to increase with time of heating. Similar results were also reported by Arieli et al.,(1996) and Pena *et al.* (1986).

Processing methods that have been found to be useful on whole cottonseed to improve handling

characteristics include pelleting (Bernard *et al.,* 1999), extruding (Stutts *et al.,* 1988; Pena *et al.,* 1986 and Bernard *et al.,* 1999) and acid delinting (Coppock *et al.,* 1985). Mechanical processing which ruptures the seed increases the amount of free oil in the rumen and this has been shown to reduce ruminal fiber digestion (Pires et al.,1977; Moody, 1978 and Mohammed *et al.,* 1988). Coating whole cottonseed with starch to bind the lint and create free flow product has resulted in shift in ruminal fermentation that favoured higher concentration of total VFA and propionate, reduced the acetate: propionate ratio and reduced ADF and NDF digestibility (Bernard *et al.* (1999), Laired *et al.* (1998) and Laired *et al., (*1997).

Pelleting reduces ruminal ammonia concentration and increases the flow of nitrogen to the abomasum (Bernard and Amos, 1985). The reduction in CP digestibility in the rumen as a result of pelleting might partially be due to heating of the whole cottonseed during the pelleting process. Grinding whole cottonseed increases total tract organic matter digestibility and tends to increase rumen undegradable protein (Pires *et al.,* 1977). Exposing cotton lint to sodium hydroxide (NaOH) had a positive effect on digestibility (Palmquist 1995), though alkaline treatment did not change the crystallinity of the lint cellulose. Treating whole cottonseed with NaOH increases ruminal and total tract dry matter disappearance. This is probably due to weakening of the whole cottonseed coat (Arieli *et al.,* 1996).

Processing of whole cottonseed may also reduce the chances of gossypol toxicity. Increasing temperature favours the formation of stable bond between gossypol and other molecules. Bound gossypol is generally considered to be physiologically inactive (Randel *et al.,* 1991). Pelleting and addition of iron sulphate are means of decreasing the toxicity in cottonseed products (Barraza *et al.,* 1991). Ammonia treatment of whole cottonseed also decontaminates cottonseed (Rogers and Poore, 1995). Heat treatment of whole cottonseed is usually aimed at reducing

protein degradability in the rumen and increasing the amount of whole cottonseed protein flow to the intestine. Whole cottonseed particle size reduction and NaOH treatment may improve overall digestibility.

2.5.4. Gossypol toxicity in livestock

The major concern in the feeding of large amounts of whole cottonseed stems from its content of the plant pigment gossypol. Lindsey *et al.* (1980) stated that gossypol toxicity is an enigma and suggested that because of the greater susceptibility of non-ruminant to gossypol toxicity, a functional rumen is essential for the successful feeding of whole cottonseed. In this respect, Randel, *et al*.,(1992) reported a case of suspected gossypol toxicity in 2-4 week old calves fed cottonseed in two dairy herds in Israel.

Gossypol molecules are not metabolized either by bacteria in the rumen or by the animal itself (Abou-Donia, 1976). However, one mechanism of detoxification by rumen action has been the binding of the gossypol by the epsilon amino acid group of lysine (Feiser and Fu, 1962) or by dilution and slow absorption (Risco et al.,1992). This protein bound gossypol was found to be physiologically inactive in the rumen. Apparently, the process of detoxification is more complex and multiple mechanisms are probably involved. Detoxification by inactivation of the binding site of gossypol in overcoming the toxic effect of gossypol toxicity in ruminants has been identified with the use of high levels of iron salt (Cummins and Hawkins, 1982). The benefit of dietary Fe in counteracting the toxic effect of gossypol was long reported by Risco et al, (1992). Dietary protein level may affect accumulation of gossypol in the organ by supplying a greater number of free epsilon amino group with which gossypol may combine in the GIT and then be excreted in the feces as bound gossypol. This facilitates the mechanism and detoxification of the

absorbed gossypol (Nikokyris *et al.*, 1991).

Clinical symptoms of ingesting high levels of free gossypol in cottonseed in swine include labored breathing, dyspnea, decreased growth rate, anorexia and reduced oxygen carrying capacity of the blood and haemolytic effect on the erythrocytes (Smith, 1957 and Clawson *et al.*, 1961), causing death in monogastrics. Post mortem findings indicated fluid accumulation in the body cavities, edema and congestion in the liver, lungs and spleen and dilation and hypertrophy of the heart with degeneration of muscle fibers (Alford *et al.*, 1996). Similar clinical and post mortem symptoms with that of the swine have also been reported for calves with undeveloped rumen (Rogers et al.,1975; Hudson et al.,1970 and Kerr, 1989). Gossypol toxicity has also been reported in mature dairy cows fed relatively high amount of ammoniated whole cottonseed (2.7 to 4.5kg/cow/day) with post mortem findings similar to those found in non-ruminant species (Smalley and Bicknell, 1982). These findings show that ingestion of free gossypol at high levels may overwhelm ruminal detoxification and hence result in the absorption of quantities of free gossypol that may be potentially toxic. However, Kandylis *et al.* (1998) did not report any detrimental effect on the health of the animals when young sheep were fed diets containing up to 30% whole cotton seed or cotton seed cake. Cattle, sheep and goats fed 18.5, 1.7 and 1.1g/day free gossypol for 56, 105 and 110 days respectively showed no sign of gossypol toxicity (Menges *et al.*, 1991). He also reported no sign of gossypol toxicity in goats fed diets containing 0,12.5 and 25% whole cottonseed for a period of 126 days, where the free gossypol intakes were 0, 29.3 and 51.4mg/kgLW^{-1}/day respectively.

Dietary gossypol concentration in cotton seed cake diet did not have any harmful effect on blood parameters such as plasma total protein, albumin, globulins, urea, glucose, haemotocrit, haemoglobin and mean corpuscular haemoglobin concentration (MCHC) for lambs (Nikokyris *et*

al., 1991). However, some changes were noticed in all blood constituents measured. Furthermore, neither haemotological nor patho-morphological changes were observed in lambs given cotton seed cake supplying 66-103mg of free gossypol daily for about 2 months. In dairy cows, feeding of diets containing gossypol (42.7g free gossypol/ animal /day) resulted in lowered haemoglobin, greater erythrocytes osmotic fragility and death (Lindsey, *et al.,* 1980). Coppock *et al.*,(1985); Hawkins *et al.* (1985) and Castelli *et al.* (1993) reported lower values for haematocrit and haemoglobin concentration and higher values for concentration of total protein, albumin, glucose and cholesterol in dairy cows fed diets containing whole cottonseed. Haemoglobin and haemotocrits values were inversely related to the gossypol content of the ration in pigs and rats (Braham and Bressani *(*1975). Decreasing haemotocits and haemoglobin concentration have been reported in calves with gossypol toxicosis (Morgan,1989). Previous studies have shown that in swine, gossypol feeding resulted in iron deficiency and anemia probably due to the binding of iron by the gossypol, which resulted in low haemoglobin and haemotocrits, and high Fe-binding capacity of the blood serum (Morgan, 1970).

The greater sensitivity of pigs or monogastrics compared to ruminants is as a result of the considerably higher proportion of gossypol absorbed from the GIT (Berandi and Goldblatt 1969). Adou-Donia (1976) reported that the level of gossypol in organs of pigs were inversely related to the level of protein and directly related to the level of gossypol in the diets and to the length of time the diet was fed.

2.5.5. Effect of gossypol on reproduction

Free gossypol may adversely affect reproduction functions in many animal species. The ruminant female is relatively insensitive to dietary gossypol but males show marked testicular

damage (Randel *et al.,* 1996). Interference in testicular development in bulls and rams as a result of gossypol has been reported by Arshami and Reiffle, (1988) and Kramer, *et al.* (1989).

Gossypol is known to inhibit oxidative phosphorylation (Randel *et al.,*1991). Furthermore, several lactate dehydrogenases occur throughout the body and gossypol appears to inhibit each of them to some extent (Randel *et al.,* 1990). The greatest inhibiting effect, however, is on lactate dehydrogenase X (LDH-X) which is an enzyme found only in the sperm and mammalian testes (Randel *et al.,* 1990).

There is wide variation in the susceptibility of males animals to anti fertility effect of gossypol acetic acid (GAA) in the literature. Male rabbits were reported to be insensitive to anti fertility effect, yet demonstrate other signs of gossypol intoxication (Chang *et al.,* 1980; Saksena *et al.,* 1981). A trial conducted in China involving humans (n= 4000) given GAA at 20mg/day for 75days followed by weekly doses of 50mg. Showed that 99.9% of the people had sperm concentration reduced to < 4million/ml according to the National coordinating group on male anti fertility agent (1978). More sensitive human clinical studies indicated that sperm motility was first markedly reduced and this was followed by reduced sperm number. In another study conducted with male ruminants, Smalley and Bicknell (1982) noted a severe reproductive problem in one herd of dairy cattle. The authors suggested that reproductive failure was caused by feeding high levels of ammoniated whole cottonseed (3.6 kg/animal/day) and cottonseed meal (1.4 kg/animal/day) to the bulls. Fertility reportedly improved in the herd 2-3 months after the ammoniated seed was removed from the diet. In another study, puberty was delayed in bulls fed 60mg of free gossypol/kg body weight /day (Chase *et al.,* 1989). Appearance of first sperm cell in the ejaculate was not delayed, however, but sperm concentration and motility were suppressed by a dosage of 60mg of free gossypol/kg body weight/day. Feeding of gossypol did not affect

scrotal circumference, testicular and epididymal weight of bulls (Stahake, 1986 and Chase *et al.*, 1989) or rams (Arshami and Reiffle, 1988 and Kramer, *et al.*, 1989) .

Few studies are available concerning the effect of gossypol on bovine female reproduction. Addition of gossypol acetic acid (GAA) to bovine embryos cultured *in vitro* lowered the percentage that got to the blastocyst stage, lowered the final developmental scores and decreased the time to generation in a dose dependent fashion (Zirkle *et al.*, 1988). The presence of gossypol resulted in synthesizing lower concentration of progesterone in bovine luteal cells cultured *in vitro* (Gu *et al.*, 1990). Heifers fed moderate levels of free gossypol (0.4-16.3g/animal/day) for 62days were not affected in the mean serum progesterone concentration during the estrous cycle (Gray *et al.*, 1990). Other data from female bovine indicated that gossypol interfered with *in vitro* development of embryo and *in vitro* synthesis of progesterone by luteal cells (Zirkle *et al.*, 1988). The *in vivo* report for heifers indicated no effect on serum LH, pogesterone or pregnancy rate. There is also evidence that gossypol causes infertility by inhibiting nuclear maturation of cultured bovine oocytes (Lin *et al.*, 1994) . Wyse *et al.* (1991) found that feeding 5.0g gossypol/animal/day from cotton seed meal increased the number of degenerative embryos from super ovulated Brangus heifers.

Published data for female non-ruminants indicate that GAA interfered with the expression of normal estrous cycle. Administration of GAA before implantation inhibited pregnancy in cows (Randel *et al.*, 1991); embryo survival also seems to be a potential problem. Endocrine imbalance is possibly responsible for the effect of GAA Randel *et al.* (1991).

2.5.6. Fate of ingested gossypol

This has been the subject of a number of investigations. It is generally believed that ingested bound gossypol is stable and it is eliminated essentially unchanged by non ruminants, therefore it is not deleterious. However, Bressani *et al*.,(1964), showed that some bound gossypol is liberated during passage through the GIT of dogs. Jones and Smith (1975) indicated that bound gossypol in the diet can cause an increase in the faecal nitrogen level compared to controls, and can decrease amino acid absorption, increase rate of passage of digesta and inhibit action of gossypol on proteolytic enzymes (Lyman and Midmeri, 1966 and Tanksley, 1970).

The biological half life of gossypol is 30 hours for hen (Abou-Donia and Lyman 1971) 78 hours (Abou-Donia and Dieckett, 1975) for Swine and 48 hours for rat (Abou-Donia and Dieckett, 1975). Addition of iron reduced the half life to 23 hours (Abou- Donia *et al.*, 1970). Lyman and Midmeri (1966) reported on the recovery of radioactive gossypol in the faeces and tissues of chicks fed gossypol labeled ^{14}C. About 87.3 % of the ^{14}C was found in the feces and only 8.9% in the tissue; of these, approximately one-half (4.4%) was found in the liver, almost as much was found in the muscles, 1.6% in the blood and less amount in the kidney, lung, heart brain and spleen. They found that gossypol ingested by laying hen was largely excreted in the feces and lesser amount in the urine and in the expired CO_2. Much of the absorbed gossypol in laying hens is transmitted to the egg and a small portion was deposited in the tissue. In swine, Lyman and Widmer (1966) reported higher proportion of gossypol ^{14}C recovered in the tissue (25.1%) and feces 61.6%. They concluded that the higher absorption of gossypol from the GIT of pigs compared to chicks is probably responsible for greater sensitivity of the pig. Again, much larger concentration of the activity was found in the liver. The greatest amount of free gossypol accumulation was also observed in the liver, followed by kidney and lastly by the heart when

lambs were fed on whole cottonseed or cotton seed product for a long time (Nikokyris *et al.*, 1991). For humans who have consumed gossypol containing products, toxicity may occur if the concentration of gossypol is higher than the 450mg/kg^{-1} (maximum level of free gossypol established by the Food and Drug Administration of the United States for human consumption) (Jones, 1988). Also in man, because gossypol is an appetite depressant, it is recommended for use to treat obesity. Close clinical surveillance extended over 2 years in Guatemala and six months in Peru failed to disclose any evidence of toxicity in children fed foods containing cottonseed protein (Cater *et al.*, 1977).

2.5.7. Effect of feeding whole cottonseed (WCS) and rumen fermentation

Whole cottonseed is high in energy, protein and fiber and may promote growth and stimulate functional development of the rumen (Anderson *et al.*, 1982). Direct measurement of methane production revealed a 12-14% reduction in sheep fed 250g whole cottonseed at maintenance level (Arieli, 1992), and in dairy cattle fed a diet including150g/kg whole cottonseed (Holter, *et al.*, 1992). Methane production is positively correlated to intake of digestible cellulose, hemicelluloses and non-fiber carbohydrate; however, Anderson *et al.* (1982) reported a reduction in methane production where as fat reduces methane production (Wilkerson *et al.*, 1995). Thus a reduction by whole cotton seed feeding suggests that quantitatively, the effect of whole cottonseed fat is larger than that of whole cottonseed fermentable carbohydrates. Since methane serves as a major hydrogen sink in the rumen, its altered production is associated with complementary modification in rumen fermentation characteristics. The effect of fat on rumen fermentation characteristics is explained by the detrimental effect on rumen cellulolytic microorganisms. Feeding of whole cottonseed was reported to increase ruminal protozoa (Horner *et al.*, 1988 and Mohammed *et al.*, 1988) and reduced butyrate concentration (Mohammed *et al.*,

1988 and Malcolm and Kiesling 1990). Similar observation has also been reported when whole cottonseed was fed to cattle with low ruminal acetate: propionate ratio (Kajikawa *et al.,* 1990). However, Clark and Amentano (1993); Harrison *et al.* (1995) and Pires *et al.* (1997) have observed that feeding whole cottonseed has no effect on rumen fermentation.

There is no consistent report on the effect of feeding whole cottonseed on acetate : propionate ratio. While Mohammed *et al.* (1988); Keele *et al.* (1982) and Arieli (1992) reported an increase in the ratio as the level of whole cottonseed increased, Horner, *et al.,* 1988) and Sklan *et al.* (1992) reported a decrease as the whole cottonseed increased. Kajikawa *et al.* (1990) reported that the effect of whole cottonseed on rumen fermentation depends on the basal fermentation balance.

Supplementing whole cottonseed to steers (Zinn and Plascencia, 1993); non lactating cows (Keele *et al.,* 1989) or lactating dairy cattle (Pires *et al.,* 1997) resulted in increased saturated fatty acid and decreased unsaturated fatty acids in the small intestine. This indicates extensive hydrogenation of fat from whole cottonseed in the rumen. Similarly, Adams *et al.* (1995) found that the high percentage of polyunsaturated fatty acids in whole cottonseed may have a negative effect on rumen fermentation. On the other hand, Sklan *et al*.(1992) reported that fat fed as whole cottonseed did not cause marked changes in VFA in the rumen. This is because either the fat may be released slowly in the rumen or it leaves the rumen still partially enclosed within the seed.

Mean rumen crude protein degradability of whole cottonseed was estimated at 74.0$\pm$ 6.0% (Pires *et al.,* 1977). Orskov, (1982); Pena *et al.* (1986); Tagari *et al.* (1986); Miller *et al.* (1991); Arieli, (1992) and Pires *et al.* (1997) reported crude protein digestibility of 77% (SD 11) by in-situ rumen digestibility in 13 studies using sheep. A slightly lower value (70%) of CP degradation

was reported by Satter (1986) in both in-situ and *in-vitro* studies.

A high rumen degradability of whole cottonseed protein is reflected in increased rumen ammonia *in vitro* (Tagari *et al.*, 1986). Contrary to the above observation, Mohammed *et al.* (1988) and Pires *et al.* (1997) reported no modification in rumen ammonia level when whole cottonseed was offered up to 200g/kg dry matter. The high degradability of whole cottonseed protein often leads to increased plasma urea nitrogen when whole cottonseed is consumed (Tagari *et al.*, 1986).

Heat treatment has been suggested to decrease ruminal degradability of protein, partly by blocking the active site for proteolytic enzymes and partly by reducing protein solubility (Broderick and Craig, 1980). Roasting or extrusion of whole cottonseed may decrease *in vivo* rumen ammonia level when whole cottonseed comprised 400g/kg of the dietary DM (Pena *et al.*, 1986). Feeding heated whole cottonseed to dairy cattle was associated with decreased blood urea level which may reflect decreased ruminal degradation as well as increase biological value of the absorbed amino acid profile (Roseler *et al.*, 1993).

2.5.8. Effect of feeding whole cottonseed on dry matter intake, hematological variables and blood mineral levels

The effect of whole cottonseed feeding on dry matter intake is an important issue for cattle husbandry. It is generally believed that functional rumen is required for successful feeding of whole cottonseed (Arieli 1989). Anderson *et al.* (1982) fed concentrate with 25% whole cottonseed (with and without hay) to newborn Holstein calves for 12 weeks and found that those fed whole cottonseed had greater feed intake, body weight and rumen development than those that were not fed whole cottonseed. Coppock *et al.* (1987) reported that dry matter intake of dairy cattle was not altered when whole cottonseed was included up to 25% of the diet. However, when the diet was fed under hot weather conditions, dry matter intake declined (Coppock *et al.*,

1987); Lanham *et al.,* 1992). The decline was attributed to increase in fiber content which increased as the proportion of whole cottonseed increased (Lubis *et al.,* 1990). A decrease in dry matter intake by dairy cattle fed whole cottonseed diet with similar energy intake was observed (Mohammed *et al.,* 1988 and Hawkins *et al.,* 1985). It can be concluded that the dry matter intake response to the feeding of whole cottonseed in diets is a function of both climatic and dietary factors. Fat, fiber, energy concentrates and perhaps crude protein degradability in the rumen may control DMI of cattle fed whole cottonseed diets. In another trial conducted during hot weather, Belibasakis and Tsirgogianni (1995) reported that feeding whole cottonseed at 200g/kg body weight did not affect dry matter intake negatively. Kandylis *et al.* (1998) reported no differences in feed intake, live weight gains, dripping losses, rumen volume, intestinal fat and liver weight among fattened lambs fed diets containing up to 30% whole cottonseed. However, Coppock *et al.* (1985) reported a significant linear depression (10%) in DMI per body weight and per unit metabolic body weight as whole cottonseed increased from 0-30% of the diet in dairy cows. They also did not report any toxicity even at 30% whole cottonseed but a slight decline in digestibility of DM as whole cottonseed increased in the diet. Smith *et al.* (1981) however, did not observe any decline in DM digestibility.

In sheep fed diets containing 20% whole cottonseed, there was no significant change in plasma glucose and urea-N (Nitas et al.,1998). Nikokyris *et al.* (1991) and Keay and Doxey (1984) gave the values of serum protein from healthy lambs of 3 and 9 months old as 61.4 and 63.9g/l for total protein, 28.3 and 32.0g/l for albumin and 33.0 and 34.5g/l for globulin respectively. The serum inorganic K concentration in lambs ranged between 4.6 and 5.4 mmol/l (Nikokyris et al.,1991). This range is the same for all livestock species. However, Youssef (1985) reported that the normal levels of K in sheep were 6.1- 6.7mmol/l. Potassium is said to be deficient when the

serum level is 3.1mmo/l.

Coppock et al.,(1985) and Colin-Negrete *et al.* (1996) reported that blood glucose, total protein, urea, Ca and P were not significantly affected by adding 15% whole cottonseed to the diet of lactating cows. Horner *et al.* (1986) reported that plasma urea increased and glucose was significantly affected by adding 15% whole cottonseed in the total diet of lactating cows. Blood plasma glucose, total protein, urea, sodium, potassium, phosphorus and magnesium concentration were significantly affected by adding whole cottonseed to the diet of cows.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of the study

The trials were carried out at the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika-Zaria, Nigeria. Shika is located within the Northern Guinea Savanna ecological zone of the country between latitude of 11 and 12^{o} N and between longitudes 7 and 8^{o}E. It is about 640 m above the sea level. The zone has one wet season which starts in April/May, stabilizes by June and ends in mid October. The mean annual rainfall is 1100 mm; the maximum temperature varies between 27^{o}C and 35^{o}C depending on the season and relative humidity of 72%. The dry season commences with a period of dry, cool weather known as harmattan, lasting from October to January. The harmattan is followed by dry, hot weather from February to April. The relative humidity at this period is about 37%. The physical properties of the soil in the zone was described by Kowel (1968) as a well drained sandy loam soil with a clay fraction consisting mainly of kaolinite and small qualities of illite deficient in nitrogen and phosphorus.

3.2 Experiment 1:

Nutrient composition of some selected non-conventional feedstuffs

The aim of the study was to determine the nutrient composition of some non-conventional feedstuffs found in the locality from which rations used for subsequent experiments were selected.

The non-conventional feedstuffs were:-

Whole cotton seed (White and brown seeds)

Cowpea haulms

Cowpea pod shell

Sweet potatoe vine, peels and whole tuber

Yam peels and whole tuber

Maize offal and maize husk

Sorghum stover

Sorghum panicle

Maize stover

Layer litter

Broiler litter

Chick litter

Samples of the above feed sources were collected over a period of four years (1999-2002) and analyzed on yearly basis. Dry matter, crude protein, ether extract, crude fibre and ash contents were determined using the Kjeldahl procedure (AOAC,1990). The acid detergent fibre (ADF) and neural detergent fibre (NDF) of the feed samples were analyzed according to the procedure of Van Soest (1991). The gross energy of the feed samples was determined by combustion of 0.5 gm in an adiabatic bomb calorimeter. The mineral contents of the samples were analyzed using the atomic absorption spectrophotometer model 960 (Shimadzu) and the phosphorus was determined by using the auto analyzer flame photometer (Corning flame photometer 410). The means of the four years are presented.

3.3. Experiment 2:

Replacement value of sun-dried layer litter (SDLL) for cotton seed cake in fattening rations for bulls

The specific objectives of this study were:

- To determine the feedlot performance of bulls fed rations containing graded levels of layer litter.
- To determine the optimum levels of cottonseed cake that can be replaced by SDLL.
- To study the economics of fattening bulls on diets containing layer litter.

Methodology:

Twenty Bunaji bulls of live weight range between 230-250kg were used for the trial. The bulls were blocked by weight and allocated to five dietary treatments in completely randomized design. The bulls were dewormed a week to commencement of the trial and dipped in arcaricide to control ectoparasites.

The bulls were individually pen fed. The treatments were derived from a standard fattening ration consisting of 60% maize offal and 40% cotton seed cake (CSC) in which the SDLL replaced 0, 25, 50, 75 ad 100% of the CSC (weight for weight). The concentrate rations were:-

RATION 1= 60% Maize offal and 40% CSC (Positive control)

RATION 2= 60% Maize offal, 30% CSC and 10% SDLL

RATION 3= 60% Maize offal, 20% CSC and 20% SDLL

RATION 4= 60% Maize offal, 10% CSC and 30% SDLL

RATION 5= 60% Maize offal and 40% SDLL

The concentrates were offered at 60% of the estimated dry matter intake of the animals (3% body

weight).Chopped sorghum stover was weighed before feeding and the following morning to calculate the quantity of sorghum stover consumed. Water and mineral salt block were offered ad-libitum. The concentrates were offered in the morning and 2-3 hours latter the chopped sorghum stover was offered. Feed remnants (orts) were weighed the following day in the morning before the day's feeds were offered.

The study lasted for 90 days and took place between February and May 2000.

The layer litter used for the trial was collected from NAPRI poultry farm, from deep litter house with wood shavings as the bedding material. The layer house from where the litter was collected was about 8 months in lay. The litter was dried for five days in January and stored until needed. The sorghum stover was collected from farmland within NAPRI premises after crop harvest and chopped using motorized chopper.

3.4. Experiment 3:

Replacement value of sun-dried broiler litter (SDBL) for cotton seed cake in the fattening ration for bulls

The specific objectives of this study are**:**

- To determine the feedlot performance of bulls fed graded levels of sun-dried broiler litter
- To determine the optimum levels of cottonseed cake that can be replaced by SDBL.
- To study the economics of fattening bulls on diets containing sun-dried broiler litter.

Methodology:

Animals and management

Twenty Bunaji bulls of live weight range between 200-250kg were used for the trial. The bulls were blocked by weight and allocated to five dietary treatments in completely randomized design. The bulls were dewormed a week to commencement of the trial and dipped in acaricide

solution to control ectoparasites.

The bulls were individually penned and fed the diets. The rations were derived from a standard ration made up of 60% maize offal and 40% cotton seed cake (CSC). The remaining four diets were formulated from the standard diet by replacing 0, 25, 50, 75 and 100% (W/W) of the cotton seed cake with SDBL as shown below:

RATION 1= 60% Maize offal and 40% CSC (Positive control)

RATION 2= 60% Maize offal, 30% CSC and 10% SDBL

RATION 3= 60% Maize offal, 20% CSC and 20% SDBL

RATION 4= 60% Maize offal, 10% CSC and 30% SDBL

RATION 5= 60% Maize offal and 40% SDBL

The concentrates were offered at 2% body weight and digitaria hay, water and mineral salt block were offered ad-libitum. Feed remnants (orts) were weighed the following day in the morning before the day feeds were offered.

The broiler litter was collected from NAPRI farm and from birds that were about 7 weeks of age. The bedding material was wood shavings. The broiler litter was treated by sun-drying for five days in January and February and stored until needed. The study lasted 90 days and took place in March and May 2001.

3.5. Experiment 4:

Effect of feeding graded levels of whole cotton seed and maize offal on the fattening performance of bulls

The specific objectives of this study were:-

- To determine the performance of Bunaji bulls fed fattening ration containing graded levels of whole cotton seed and maize offal.

- To determine the best combination of whole cottonseed and maize offal that gives the best fattening performance.
- To study the economics of fattening bulls on whole cotton seed and maize offal ration.

Animals, management and treatments

Twenty Bunaji bulls of live weight ranging between 200-250kg were blocked by weight and randomly allotted to four treatments in a completely randomized design. The bulls were confined to individual pens that had concrete floors and a roof. They were dewormed by administering Thiabendazole^{R} one week prior to commencement of the trial and dipped weekly in acaricide (Rhodiocides^{R}) solution to control ecto-parasites throughout the period of the experiment.

The treatments were:-

Treatment 1= 80% whole cotton seed (WCS) and 20% Maize offal (Dusa) (control)

Treatment 2= 60% WCS and 40% maize offal

Treatment 3= 40% WCS and 60% maize offal

Treatment 4=20% WCS and 80% maize offal

The concentrates were offered at 2% body weight in the morning; remnants of the concentrates were weighed the following morning and concentrate intake was calculated from the differences. gamba hay, water and mineral salt lick were provided ad libitum. The trial took place between April and May 2002 and lasted 90days.

3.6. Parameters measured in all the three fattening trials

3.6.1 Liveweight and body condition scores

The bulls were weighed at the beginning of the trial and at two weekly intervals usually before the morning feeding (-i.e 24 hours after the last feed and 12hours of water withdrawal). The concentrates offered to the animals were adjusted at two weekly intervals to take care of the

liveweight changes. Body condition scores of the bulls were taken by two scorers at the beginning and end of the studies, using the procedure described by Pullan (1978) and the average of the two scores recorded.

3.6.2 Feed consumption

Feed offered were measured for each of the experiments and the orts were taken and used to calculate feed intake of the bulls.

3.6.3 Rumen fluid sampling

Rumen fluid samples were collected from the bulls at the beginning, mid and end of the trial. About 50mls of the rumen fluid was drawn from each bull using stomach tube. The tube was about 150cm with a metallic strainer attached at the end. The tube was passed through a pipe placed in the mouth of the bulls into the rumen and a suction pump which helped in drawing out the rumen fluid was attached to the other end of the tube. The fluid was collected into plastic bottles containing equal quantity of 0.1N H_2SO_4 to trap the ammonia. The samples were frozen until analyzed. Rumen ammonia concentration was determined by steam distillation into boric acid and back titrated with 0.01N hydrochloric acid, according to the procedure described by Whitehead *et al.* (1976). Rumen fluid pH was determined using Philips digital pH meter (Model 9409).

3.6.4 Blood sampling

About 10mls of jugular blood was collected before the commencement of the trial, mid and end of the trial via jugular vein puncture. The samples were emptied into vacutainer tubes containing the anti-coagulant [ethylene diaminetetracetic acid, (EDTA)] and about half was used to measure packed cell volume (PCV) and total protein. The remaining half was spun and the plasma stored in freezer for the analysis of plasma urea nitrogen.

3.7. Digestibility studies

At the end of the fattening trials, three bulls from each treatment were placed in individual metabolism crates and fed the diets twice daily at 7.00am and 3.30pm. Orts were weighed and recorded daily before the morning feeding. The bulls were allowed 14 days adjustment period followed by 7 days of total collection of faeces and urine. Faecal collection for two days were mixed properly and 10% aliquot was taken and oven dried at $60^{o}C$ for dry matter determination. At the end of the 7 days collection period, the samples were bulked and 10% aliquot taken for analysis. Daily urine output from each of the bulls was collected in a plastic containers containing 100 mls 0.1N H_2SO_4 placed under the metabolism crates. Ten percent of daily urine output was taken from each bull and stored in a refrigerator. At the end of the 7 day's collection period, 10% of the urine sample taken from each of the bulls was sub-sampled and kept in the refrigerator for analysis (Osuji *et al.,* 1993). Representative sample of the roughages on offer, concentrate and feed remnants were taken daily, separately mixed thoroughly and sub- sampled at the end of the collection period and milled with a Christy and Norris mill to pass through 1mm mesh and stored in air-tight bottles until required for analysis. Daily intake of the diets and water were calculated for each bull.

3.8. Carcass Evaluation

Two bulls from each treatment were slaughtered to determine carcass composition. The bulls were slaughtered after 24 hours of feed and water withdrawal to get shrunk body weight. After slaughter, the external offal (head, limb, tail and hide) were removed and weighed separately. After evisceration the internal offal (liver, spleen, kidney, heart and lungs) were removed and weighed individually. The GIT was weighed with the contents and reweighed after washing. Total lean meat (Boneless) was separated and weighed. The bones were also weighed.

3.9. Analytical Procedures

3.9.1 Chemical analysis

Dry matter content of the pre dried faecal and feed samples were determined by drying at 100^{o}C. Nitrogen content of the feed samples, bracharia hay, gamba hay, and sorghum stover, faecal and urinary samples and the feedstuffs were determined using the Kjeldahl procedure (AOAC,1990). The samples were ashed by charring in muffle furnace at 500 ^{o}C for about 3 hours (AOAC, 1990). The acid detergent fibre (ADF) and neural detergent fibre (NDF) of the feed samples, faecal samples and the feedstuffs were analyzed according to the procedure of Van Soest (1991). The ether extract and crude fibre of the samples were analyzed according to AOAC (1990) procedure. The gross energy of the feed samples, feed ingredients, faecal samples, hay and the feedstuffs were determined by combustion of 0.5 gm in an adiabatic bomb calorimeter.

3.9.2. Biochemical analysis

Blood samples were analyzed for urea nitrogen level (BUN) using the procedure of Archer and Robb (1925). The procedure is outlined in appendix xix. Packed cell volume was analyzed using micro hematocrit and total protein was determined using refratometer as described in the routine laboratory procedures (Coles, 1974).

3.10. Statistical analysis

The data were analyzed using trend analysis of the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 1988) to study the effect of various levels of WCS and poultry liter on the various parameters measured. All statistical tests were done at 5% and 1% probability level. Where the trend analysis was quadratic, polynomial analysis (SAS, 1988) was conducted to show the trend of weight response to graded levels of

poultry litter in the diets, in addition to establishing the optimum level of poultry litter for maximum weight gain.

3.11. Calculations

- Live weight gains was calculated from the differences between initial body weight and final body weight divided by the number of days on feed.
- Feed intake was calculated from the differences between feed offered and feed refused. These differences were expressed on dry matter basis to obtain the appropriate DM intake values
- Metabolic body weight was computed as body weight of the animals raised to the power of 0.75
- Feed efficiency was calculated from the ratio of average daily DM intake to average daily gain.
- Value of gain was computed as total weight gain multiply by cost of a kilogram of live animals.
- Dry matter digestibility was calculated from the difference between DM intake and feacal DM output expressed as percent of DM intake. Digestibility of other nutrients was calculated from the differences between the nutrient intake and the nutrient output in the feaces expressed as percentage of the nutrients intake.
- Daily nutrient intake was obtained by multiplying digestible nutrient by daily DM intake.
- Digestible energy (DE) was calculated as gross energy intake minus feacal energy divided by DM intake.

- Metabolizable energy (ME) was determined by multiplying DE by a factor of 0.82 (ARC, 1980)
- Nitrogen retention was calculated by the differences between nitrogen intake and nitrogen in feaces and urine.
- Nitrogen retained as percentage of nitrogen intake was the difference between nitrogen retained and nitrogen intake expressed as percent.
- Empty body weight was obtained by subtracting the weight of the gut contents and the bladder from the fasted body weight.
- Dressing percentage was obtained by dividing warm carcass weight by the fasted body weight expressed in percentage.
- Economics of feeding was determined for bulls under the various experiments. Factors considered in the relative cost calculation included live weight gain, quantity of feed consumed and cost of feed consumed. Inputs such as capital required for construction of feeding pens, depreciation, purchase of stock and labour were not considered, since feed cost was generally considered to be the greatest input cost/unit throughout the period of feeding the cattle, and the one closely monitored in the study.

CHAPTER FOUR

4.0 RESULTS

4.1 Experiment One: Chemical composition of some non-conventional feed sources.

The nutrient and mineral composition of the non conventional feed resources found around Zaria and Shika are shown in Tables 1a and 1b. The crude protein content of threshed sorghum panicle and the stover were 2.14 and 6.63% respectively. The crude fibre, ADF and NDF were in the range of 33.12 to 30.77%, 54.31 to 46.94% and 66.14 to 57.13% respectively while the gross energy contents were 3.78 and 3.69Kcal/kg respectively. Maize husk had crude protein content of 3.06% and NDF content of 98.75%. The CP, ADF, NDF and gross energy contents of maize offal were 10.99%, 16.27%, 22.84%, 26.37% and 3.47kcal/kg respectively.

The sweet potatoe peels and whole plant had CP contents of 3.88 and 13.31%, the crude fibre, ADF, NDF contents were 3.66% and 3.97%, 8.94% and 13.08% and 37.95% and 48.47% respectively for the white variety and for the red variety, the CP, crude fibre, ADF and NDF values for the peels and whole plants were 11.06 and 5.08 %, 1.74 and 4.12 %, ADF, 19.39 and 62.66% and NDF 5.33 and 59.16% respectively. Irish Potatoe peels and whole plants have CP contents of 8.41 and 12.56%, The CF, ADF, NDF and gross energy values are 3.16 and 1.86%, 14.15 and 30.57%, 28.87 and 3.97% and 3.73 and 3.75kcal/kg respectively.

Cowpea pod and haulms had crude protein contents of 9.73 and 12.28%, CF 23.48 and 27.63%, NDF, 9.71 and 40.01 respectively. The CP contents of whole cottonseed were 21.35% and 25.91% for the brown and white seeded varieties respectively. CF, ADF and NDF and gross energy values were 25.94 and 37.75, 33.03 and 51.15%, 50.81 and42.15% and 5.51 and 5.63kcal/kg respectively

for the white and brown seeded whole cotton seed. The Ca, Fe and Cu contents of the white and brown seeded whole cotton seeds were 0.426 and 0.345%, 1.45 and 1.38%, 4000 ppm and 4000 ppm respectively.

The CP contents of layer, broiler and chick litters were 19.57, 26.41 and 18.65% respectively, The CF contents were 17.46, 21.67 and 18.25%, Ash contents were 18.00, 16.63 and 28.29%, ADF 19.19, 32.03 and 19.74% , NDF were 44.06,51.36 and 19.74 and gross energy contents were 4.08, 4.21 and 3.57kCal/kg for layers, broiler and chick litters respectively. The calcium, phosphorus, iron and copper contents were 6.10, 6.72 and 2.89%, 2.43, 1.15 and 1.52%, 4000,4160 and 4120ppp and 72.00, 76.00 and 69.00% for layers, broilers and chick litters respectively.

Table 1a. Nutrient composition of some non-conventional feed sources (%DM)

Feed sources	DM	CP	ASH	EE	CF	ADF	NDF	OM	NFE	GE (Mcal /kg)
Sorghum										
Panicle	94.91	2.14	18.37	6.31	33.12	54.34	66.14	76.54	31.07	3.78
Leaves	94.40	6.63	7.43	8.31	30.77	46.94	57.13	86.97	48.69	3.69
Maize										
Husk	94.60	3.06	3.33	9.12	nd	nd	98.75	90.67	nd	nd
Offal	92.10	10.93	5.02	9.26	16.27	22.84	26.37	86.91	55.23	3.47
sweet potatoe										
Vine	6.13	3.80	5.11	5.31	82.56	20.58	92.48	91.99	79.42	nd
Peels (White)	95.21	3.38	4.58	3.66	3.66	8.94	37.95	90.63	84.51	3.63
Whole plant (red)	94.93	5.06	3.20	3.33	4.12	62.66	59.16	91.73	40.84	nd
Whole plant (white)	94.48	13.31	5.68	4.80	3.97	13.08	48.47	88.80	72.40	2.97
Peel (red)	94.80	11.06	1.76	5.99	1.74	19.39	5.33	93.04	76.01	3.92
Irish potatoe										
Peel	94.09	8.41	5.89	7.55	3.16	14.15	28.87	88.20	71.13	3.73
Whole plant	93.92	12.56	4.06	6.76	1.85	30.57	3.95	89.85	72.78	3.75
Yam (white)										
Peel	93.91	10.25	2.80	5.92	4.67	11.71	77.71	91.11	73.07	3.42
Whole plant	93.73	14.66	3.98	8.71	1.63	83.72	3.08	89.78	68.76	3.79
Cowpea										
Pod shell	98.35	9.73	9.13	6.55	23.48	71.95	9.72	89.22	nd	4.31
Haulms	93.33	12.28	10.22	11.97	27.36	nd	40.01	73.11	nd	nd
Whole cotton seed										
Brown seeded	96.80	25.91	3.24	23.83	37.75	51.15	42.11	93.56	nd	5.63
White seeded	91.15	20.38	5.00	21.14	28.55	40.99	49.45	86.15	nd	4.68
Undelinted CSC	92.56	25.94	2.92	8.38	36.06	33.03	50.31	89.61	nd	5.51
Poultry litter										
Broilers	91.27	26.41	16.63	7.01	21.67	32.03	51.36	88.44	nd	4.21
Layers	91.36	19.57	18.00	7.05	17.46	19.19	44.06	73.36	nd	4.08
Chick	96.45	18.65	28.29	7.36	18.25	19.74	46.55	68.16	nd	3.57

nd= not determined

Table 1b. Mineral composition of some non-conventional feed resources.

Feed sources	P (%)	Ca (%)	Cu (%)	K (%)	Mn (ppm)	Fe (ppm)	Zn (ppm)	Mo (ppm)
Sorghum								
Panicle	nd	0.724	74	2.18	422	1820	40	9.0
Leaves	nd	1.86	75.0	2.89	373	8.91	533	8.0
Maize								
Husk		0.713	65	2.65	493	417	65	7.0
Offal	0.50	1.52	80	2.69	549	1790	105	8.0
Sweet potatoe	nd	4.40	101	5057	431	1010	74	10.0
Whole plant (red)	nd	7.52	94	1.80	325	1870	54	8.0
Whole plant (white)	nd	0.94	76	2.21	329	522	66	11.0
Irish potatoe								
Peels	nd	0.795	79.6	3.26	418	2250	56	10.0
Whole plant	nd	1.22	79	5.21	422	1510	72	98.0
Yam (white)								
Peels	nd	1.22	1.22	3.66	519	2600	64	9.0
Whole plant	nd	0.795	104	3.67	519	473	61	11.0
Whole cotton seed								
White seeded	0.426	1.45	96	4.72	385	974	118	9.8
Undeilinted CSC	0.529	8.93	74	4.04	360	651	75	7.0
Poultry litter								
Layer	2.43	6.10	72	0.84	275	4000	215	7.2
Broilers	1.15	6.72	76	0.90	288	4160	238	7.0
Chick	1.52	2.89	69	0.92	286	4120	251	6.9

nd = Not determined

4.2.0 Experiment Two: Replacement value of sun-dried layer litter (SDLL) for cotton seed cake in fattening diets for bulls.

4.2.1. Chemical composition of the experimental diets

Table 2a showed the chemical composition of the feed ingredients:- Sorghum stover, maize offal and cotton seed cake. The ingredient chemical composition of the fattening diets are presented in Table 2b. The dry matter content of the diets ranged from 91.56% - 94.76%. The CP contents increased with increase in the level of SDLL up to 50% inclusion then declined. The range was between 15.97% and 21.50%. In contrast, the levels of acid detergent fibre and neutral detergent fibre decreased with decrease in levels of SDLL in the diets while the gross energy content of the diets decreased with increasing levels of SDLL in the diets.

4.2.2. Dry matter and nutrient intake of experimental diets

Mean dry matter intakes of the feed and of the calculated nutrient intake of the bulls are presented in Table 3. The dry matter intake of concentrate were similar ($P>0.05$) for diets containing 0, 25, 50 and 75% SDLL but were significantly ($P<0.05$) higher than those containing 100% SDLL, (Quadratic component. $P=0.005$). The range was between 2.55 and 4.74kg/day for diets containing 100% and 50% replacement by SDLL respectively. Dry matter intake of sorghum stover did not differ significantly ($P>0.05$) with increase in the level of SDLL replacement in the diets but increased with level of SDLL up to 75% replacement. Total dry matter intake (DMI Kg/day) of the diets were similar ($P>0.05$) for diets containing 0, 25, 50 and 75% SDLL. The total dry matter intake of the diet containing 100% replacement by SDLL was significantly ($P<0.05$) lower than those of others, (Quadratic component ($P= 0.005$). When dry matter intake was expressed on metabolic body weight ($kg/W^{0.75}$) and on percent body weight basis, there were no differences ($P>0.05$) between the diets.

Table 2a: Nutrient composition (%) of sorghum stover, layer liter, maize offal and cotton seed cake.

	Sorghum stover	Layer litter	Maize Offal	Cotton seed cake
Dry matter	94.40	90.78	92.32	92.56
Crude Protein	6.63	19.58	11.98	24.98
Crude fiber	30.77	17.21	15.78	38.02
Ether Extract	8.31	7.00	9.24	8.06
Organic matter	86.97	75.22	82.25	87.68
NDF	57.13	44.23	24.98	51.23
ADF	46.94	20.14	21.64	36.33
Ash	7.43	28.16	5.04	2.90
GE (Mcal/kg)	3.69	4.08	3.47	5.48

Table 2b. Ingredient and Chemical composition (%) of the fattening diets.

	Levels of replacement of CSC with SDLL (%)				
INGREDIENTS	0	25	50	75	100
Maize Offal	60	60	60	60	60
Cotton seed cake	40	30	20	10	0
Sundried layer litter	0	10	20	30	40
CHEMICAL COMPOSITION					
Dry matter	91.56	94.76	94.03	92.59	93.52
Crude protein	17.53	19.00	21.50	19.28	15.97
Crude fibre	24.18	22.33	20.47	18.61	16.74
Ether extract	8.91	8.78	8.63	8.52	9.26
Organic matter	87.42	89.73	87.70	87.72	81.58
Acid Detergent fibre	35.94	35.32	34.69	34.07	33.44
Neutral Detergent fibre	24.90	25.60	24.30	22.99	20.69
Ash	4.14	5.03	6.33	5.87	8.58
Gross Energy (Mcal/kg)	4.60	4.40	4.19	3.99	3.79

Table 3. Dry matter and nutrient intake of Bunaji bulls fed fattening diets containing sun-dried layer litter

Parameters	Levels of replacement of CSC with SDLL (%) 0	25	50	75	100	SEM	Contrast
Dry Matter Intake (Kg)							
Concentrate	4.31[a]	4.51[a]	4.74[a]	3.90[a]	2.55[b]	0.41*	Q (P= 0.009)
Sorghum stover	0.97	0.92	1.21	1.36	1.15	0.18ns	
Total	5.27[a]	5.44[a]	5.96[a]	5.26[a]	3.73[b]	0.56*	Q (P=0.0445)
DMI (% of body weight)	1.80	1.74	1.87	1.73	1.32	0.19ns	
DMI (g/KgW$^{0.75}$)	75.81	74.47	80.07	73.27	55.14	7.87ns	
Nutrient Intake per day							
Crude protein (g)	89.00[b]	97.00[b]	117.00[a]	90.00[b]	53.50[c]	0.10*	Q (P= 0.0019)
Organic matter (Kg)	5.00	5.12	5.54	4.91	3.39	0.53ns	
Ether extract (g)	502.50[b]	500.00[b]	592.50[a]	475.00[c]	337.50[d]	53.15*	
NDF (kg)	2.27	2.24	2.49	2.24	1.65	0.25ns	
ADF (kg)	1.75[b]	2.14[a]	1.83[b]	1.63[b]	1.17[c]	0.20*	L (P=0.00186)
Crude fibre (Kg)	1.45[a]	1.37[a]	1.43[a]	1.22[a]	0.85[b]	0.15*	

[abc] Means with different superscripts along the row differ significantly (P<0.05)
L = linear trend
Q= quadratic trend
ns= not significant
* = significant 5% level
** = Significant 1% level

Crude protein intake increased as the level of SDLL increased in the diets up to 50% level of replacements then decline quadratically. The CP intake was significantly higher ($P<0.05$) on diet containing 50% SDLL replacement while those containing 0. 25 and 75% SDLL were similar ($P>0.05$). The CP intake of the bulls on diet containing 100% SDLL replacement was significantly ($P<0.05$) lower than those on other diets. Although, organic matter intake increased marginally with increase in SDLL replacement in the diet up to 50% before it declined, the differences were not significant ($P>0.05$) between the treatments. While there were no significant differences ($P>0.05$) in intake of ether extract and neutral detergent fibre, intake of acid detergent fibre was significantly ($P<0.05$) higher on diet containing 25% SDLL replacement. Intake of crude fibre were similar between diets containing 0, 25, 50 and 75% SDLL but diet containing 100% SDLL had significantly ($P<0.05$) lower crude fibre intake.

4.2.3. Liveweight changes

Mean daily liveweight change, feed efficiency, dry matter intake and body condition score are presented in Table 4. Total liveweight gain and daily liveweight gains of bulls fed diets containing 25, 50 and 75% of SDLL replacement were similar ($P>0.05$) but differed significantly ($P<0.05$) from those containing 0 and 100% SDLL replacement of CSC in a quadratic manner ($P= 0.0001$). The average daily live weight gains ranged from 0.570 to 0.873kg for bulls on diets containing 100 and 50% replacement of SDLL respectively. At the end of the fattening trial, the initial liveweight of the bulls on diets in which CSC was replaced at 0, 25, 50, 75 and 100% by SDLL were improved by 20.12, 25.95, 30.19, 27.92 and 19.62% respectively and the cost of feed was reduced by 11.97, 17.01, 38.09 and 62.48% for diets containing 25, 50, 75 and 100% SDLL replacement respectively compared to the diet containing 0% SDLL.

Table 4: Mean daily live weight change, feed efficiency and body condition score of Bunaji bulls fattened on diet containing sun-dried layer litter (SDLL)

Parameters	Levels of replacement of CSC with SDLL (%) 0	25	50	75	100	SEM	Contrast
Liveweight changes (kg)							
Initial weight	266.00	263.00	260.00	265.00	260.00	6.20	
Final weight	319.25	331.25	338.50	325.75	311.00	7.54	
Weight Changes	53.25 [b]	68.25 [a]	78.50 [a]	60.75 [a]	51.00 [b]	2.88**	Q P=(0.001)
ADG	0.593 [b]	0.758 [a]	0.873 [a]	0.678 [a]	0.570 [b]	0.03**	Q (P=0.001)
FCE (kg Feed/kg gain)	9.69 [b]	7.55 [b]	7.27 [a]	8.25 [b]	7.15 [a]	0.03**	
Body condition score							
Initial	2.45	2.68	2.50	2.60	2.45	0.10ns	
Final	4.58	4.75	4.88	4.75	4.63	0.13ns	

[abc] Mean with different superscripts along the row differ significantly (P<0.05)
FCE= Feed conversion efficiency
L = linear trend
Q= quadratic trend
ns= not significant
* = significant 5% level
** = Significant 1% level
ADG= Average daily weight gain

Polynomial analysis was conducted to show the trend of weight response to graded levels of SDLL in addition to establishing the optimum level of SDLL replacement for maximum weight gain since the result of analysis indicated that the relationship between SDLL levels and weight gain was quadratic. i.e. the weight gain increased to a maximum and declined with increased levels of SDLL in the diet.

$$Y = 0.59686 + 0.00927X - 0.0000977143X^2$$

Where Y= daily weight gain, X= level of SDLL replacing CSC in the diet

From this equation, the optimum level of SDLL replacement for CSC in the diet for maximum weight gain in fattening Bunaji bulls is 47.44% which is close to the 50% replacement.

Feed efficiency (kg Feed/kg gain)

The Feed was most efficiently utilized by the on the diet in which all the CSC was replaced by SDLL. This was however not significantly different from those on diet in which 50% of the CSC was replaced by SDLL. The feed efficiency on the diets containing 0, 25 and 75% SDLL replacement were similar ($P>0.05$).

Body condition score

Body condition score of the bulls taken at the beginning of the trial ranged from 2.45 to 2.68. At the end of the trial, the condition scores were not different ($P>0.05$) between treatments. The range was between 4.58 and 4.88.

4.2.4. Rumen ammonia nitrogen (RAN, mg/100ml) and pH

Rumen ammonia nitrogen taken at the beginning of the trial ranged between 6.65 and 7.30 mg/100ml (Table 5). However, RAN taken at the end of the trial showed a significant ($P<0.05$) increase with increasing level of SDLL in the diet. The RAN of bulls on diets containing 100 and

75% SDLL replacement were similar (P>0.05) while those on other treatments differ significantly (P<0.05). Rumen pH values of the bulls fed diets containing different levels of SDLL ranged between 6.34 and 6.88 at the end of the study. There were no differences (P>0.05) in the rumen pH between the diets either at the beginning or after the feeding trial, (Table 5).

4.2 5. Nutrient digestibility and nitrogen retention

Mean values for the digestibility of nutrients are presented in Table 6. Dry matter digestibility (DMD) of the diets decreased as the level of SDLL increased in the diets. The DMD of diets containing 50 and 25% SDLL replacement were similar (P>0.05) and differed significantly (P<0.05) from the diets containing 0, 75 and 100% SDLL replacement. Digestibility of crude protein (CPD) significantly (P<0.05) increased as the level of SDLL increased in the diets up to 50% replacement, then declined (Table 6). The CPD of the diet containing 75% SDLL replacement was the least (P<0.05) among the diets.

Digestibility of ether extract increased as the levels of SDLL increased in the diets, the range was between 53.49% and 67.12% for the diets containing 0 and 100% SDLL replacement, respectively. The differences in the digestibility of ether extract between in the diets were significant (P<0.05). Organic matter digestibility also increased with increase in the level of SDLL in the diets, the differences were however not significant (P>0.05). The digestibility of ADF and NDF were not significantly (P>0.05) affected by the levels of SDLL in the diets.

Nitrogen balance

Total nitrogen intake increased (P>0.05) with increase in the proportion of SDLL in the diet up to 50% replacement then declined (quadratic component). Total nitrogen loss increased significantly (P<0.05) with increase in the level of SDLL in the diets.

Table 5. Rumen ammonia nitrogen and rumen PH of Bunaji bulls fattened on diets containing sun-dried layer litter (SDLL)

	Levels of replacement of CSC with SDLL (%)					
Parameters	0	25	50	75	100	SEM
Rumen ammonia nitrogen(mg/100ml)						
Before trial commenced	7.30	7.08	7.00	6.70	6.65	0.64ns
At the end of the trial	8.13[d]	9.68[c]	11.40[b]	14.08[a]	14.10[a]	0.68**
Rumen PH						
Before trial commenced	6.34	6.40	6.75	6.95	6.40	0.65ns
At the end of the trial	6.43	6.38	6.53	6.88	6.48	0.21ns

[abc] Means with different superscripts along the row differ significantly (P<0.05)
ns= not significant
* = significant 5% level
** = Significant 1% level

Table 6. Apparent digestibility (%) of nutrient and nitrogen balance by Bunaji bulls fattened on diets containing sun-dried layer litter (SDLL)

Parameters	Levels of replacement of CSC with SDLL (%) 0	25	50	75	100	SEM	Contrast
Nutrients digestibility (%)							
Dry Matter	71.01[a]	68.70[b]	68.83[b]	67.78[c]	62.00[d]	1.73**	L (P=0.001)
Crude Protein	65.52[c]	78.45[b]	85.37[a]	40.13[e]	49.48[d]	1.40**	Q (P=0.006)
Crude Fibre	54.41	54.14	62.37	63.48	66.41	2.83ns	
Organic Matter	65.19	66.63	70.42	70.29	70.22	1.72ns	
Ether extract	53.49[d]	56.18[c]	62.44[b]	66.50[a]	67.12[a]	2.06*	
Neutral detergent fibre	58.16	49.62	63.49	69.37	59.28	2.60ns	
Acid detergent fibre	44.28	43.97	49.48	57.13	49.05	3.56ns	
Nitrogen Balance (g/day)							
Nitrogen intake	143.33[c]	156.67[b]	180.00[a]	173.33[a]	130.00[d]	11.55*	
Urinary – N	30.00[d]	26.67[c]	36.67[b]	53.33[a]	56.00[a]	6.83**	
Faecal – N	20.67[c]	40.00[a]	30.00[b]	33.33[b]	33.33[b]	5.16**	
Total-N loss	50.67[d]	66.67[c]	66.67[c]	103.33[a]	89.33[b]	9.55**	Q (P=0.001)
N-Retained	80.33[c]	90.00[b]	116.67[a]	70.00[d]	54.00[c]	7.15**	Q (P=0.001)
N-Retained (% N-intake)	61.79[a]	57.45[b]	64.82[a]	40.39[c]	37.68[c]	4.50**	Q (P=0.001)

[abc] Means with different superscripts along the row differ significantly (P<0.05)
L = linear trend
Q= quadratic trend
ns= not significant
* = significant 5% level
** = Significant 1% level

Bulls on the diets containing 75% SDLL replacement lost the highest quantity of nitrogen while bulls on diet containing 0% SDLL lost the least nitrogen (Table 6).

The quantity of nitrogen retained by the bulls increased significantly ($P<0.05$) with increasing levels of SDLL up to 50%, and then declined (quadratic component $P= 0.001$). The amount of nitrogen retained on diets containing 75 and 100% SDLL replacement were similar ($P>0.05$) while those on the diets containing 100% SDLL replacement was least (Table 6). When the quantity of nitrogen retained was expressed as percent of nitrogen intake, bulls on the diet containing 50% SDLL replacement had the highest nitrogen retained, and this was similar ($P>0.05$) to those of bulls on the diet without SDLL. Bulls on diets containing 75 and 100% SDLL replacement had the least ($P<0.05$) nitrogen retention.

4.2.6. Carcass Evaluation

Mean values of dressing percentage and weights (kg) of offals are presented in Table 7. Inclusion of SDLL had no significant ($P>0.05$) effect on the dressing percentage of the bulls. The dressing percentage ranged from 49.49 for bulls on diet containing 100% SDLL replacement to 50.57% for bulls on diet containing 50% SDLL diet. The quantity of dissectible beef realized from the bulls ranged from 88.88 kg for bulls on diet containing 100% SDLL replacement to 99.19 kg for bulls on diet containing 50% SDLL replacement. There were no significant ($P>0.05$) differences between the bulls on the different diets. However, when the quantity of dissectible beef was expressed as percent of carcass weight, the bulls on the diets containing 0 and 75% SDLL replacement had the highest dissectible beef ($P<0.05$) compared to bulls on the other treatments. Meat to bone ratio of the bulls ranged from 4.80 to 4.96. The differences were not significant ($P>0.05$), although bulls on the diet containing 75% SDLL replacement had the highest meat to bone ratio.

Weight of the various external (head, legs, hides) and internal (liver, heart, kidney, stomach and intestine) offals were similar (P>0.05), irrespective of the levels of SDLL in the diets.

4.2.7. Economic evaluation

Table 8 shows the total cost of feed consumed, value of gain and the income over feed cost of the bulls fattened on diets containing SDLL. Inclusion of SDLL in the fattening diets showed a significant (P<0.05) reduction in feed cost. The value of gain (total liveweight x ₦150 (cost /kg liveweight) increased significantly (P<0.001) as the level of SDLL increased and reached the maximum on the diet containing 50% level of inclusion, then declined (Quadratic component). The bulls on the diets containing 25 and 50% SDLL gave the highest value of gain which differed (P<0.01) from those on other treatments. Bulls on 75 and 100% SDLL replacement diets were similar in their value of gain. Feed cost per kilogram liveweight gain decreased linearly as the level of SDLL increased in the diets. Diets containing 25, 50 and 75% SDLL replacement had similar feed cost per gain. The lowest feed cost per gain was recorded on the diet containing 100% SDLL replacement.

Income over feed cost increased significantly (P<0.05) with increase in the level of SDLL and was highest at 50% SDLL replacement, then declined. The lowest income over feed cost was recorded on diet containing 0% SDLL.

Table 7. Dressing percent, weight of hot carcass and edible offal of Bunaji bulls fattened on diets containing sun-dried layer litter (SDLL)

	Levels of replacement of CSC with SDLL %)					
Parameters	0	25	50	75	100	SEM
Live weight (Kg)	315.50	338.50	350.00	327.50	314.00	4.90
Shrunk body weight (Kg)	276.50	289.50	304.50	293.00	274.00	15.28ns
Hot Carcass weight (kg)	138.00	145.50	154.20	145.00	137.00	8.30ns
Dressing Percent	50.38	50.26	50.57	49.50	49.49	0.56ns
Weight of dissectible beef (kg)	90.57	94.50	99.19	96.10	88.87	5.12ns
Beef yield (% of carcass weight)	65.63[a]	64.95[b]	64.43[b]	66.26[a]	64.90[b]	0.44*
Bone yield (kg)	17.43	17.65	17.75	18.60	18.23	1.43ns
Meat: bone ration	4.92	4.85	4.80	4.96	4.88	0.78ns
Legs (kg)	6.35	7.20	7.25	6.75	6.60	0.35ns
Hide (kg)	21.30	21.95	21.86	21.76	22.15	0.77ns
Head (kg)	16.97	18.24	18.87	18.32	16.53	1.09ns
Liver (kg)	3.50	3.60	3.90	3.90	3.50	0.28
Spleen (kg)	0.78	0.82	0.88	0.86	0.79	0.04ns
Heart (kg)	0.97	1.01	1.06	1.21	0.99	0.13ns
Kidney (kg)	0.95	0.90	0.92	1.16	0.94	0.06ns
Empty Stomach (kg)	9.50	10.00	10.50	10.05	9.40	0.60ns
Empty Intestine (kg)	8.00	8.20	8.50	8.40	7.85	0.38ns

[ab] Means with different superscripts along the row differ significantly (P<0.05)
ns= not significant

- = significant 5% level

Table 8. Economic evaluation of Bunaji bulls fattened on diet containing sun-dried layer litter (SDLL)

	Levels of replacement of CSC with SDLL (%)						
PARAMETERS	0	25	50	75	100	SEM	CONTRAST
Total Conc. Intake (kg).	422.55 [a]	428.40 [a]	453.83 [a]	375028 [a]	257.63 [b]	39.56**	
Total stover Intake (kg).	92.25	88.20	115.65	129.60	109.35	17.11ns	
Total feed Intake (kg).	514.80	516.60	569.58	504.88	366.78	53.98ns	
Cost of feed Consumed (₦)	6684.15[a]	5884.08 [a]	5547.00 [ab]	4138.08 [b]	2508.19 [c]	561.61**	L (P=0.001)
Weight gain (kg)	53.25	68.25	78.50	60.75	51.00	2.88**	
Value of gain (₦)	7987.50 [c]	10237.42 [a]	11775.00 [a]	9112.50 [b]	7650.00 [c]	431.82**	Q (P=0.001)
Overall income over feed cost (₦)	1303.35 [c]	4553.42 [b]	6228.00 [a]	4974.42 [b]	5141.84 b	71.94**	

[abc] Means with different superscripts along the row differ significantly (P<0.05)
L = linear trend
Q= quadratic trend
ns= not significant
* = significant 5% level
** = Significant 1% level
Cost of cotton seed cake= N 20,000.00/ton
Cost of Maize offal = N 15,000.00/ton
Cost of Poultry manure = N 6200/ton
Value of gain = Weight gain x ₦150 (cost of live animal per kg)

4.3.0 Experiment 3:

Replacement value of sun-dried broiler litter (SDBL) for cotton seed cake in the fattening diets for Bulls

4.3.1. Chemical composition of the feed ingredients and experimental diets

Chemical composition of the ingredients and experimental diets are presented in Tables 9a and b. The crude protein content of the broiler litter was highest followed by the cotton seed cake and maize offal. The crude protein content of bracharia hay was least. The GE content was highest for CSC followed by bracharia hay then maize offal. The GE of broiler litter was the lowest. The DM, CF, EE and GE of the experimental diets decreased while ADF content increased with increasing levels of SDBL in the diets. Crude protein content of the diets increased with increase in the level of SDBL in the diets up to 25% then declined. Organic matter, ash and NDF did not show any particular trend as the level of SDBL increased in the diets..

4.3.2. Voluntary dry matter and nutrient intakes

Table 10 shows the dry matter and nutrient intake of the diets. The level of SDBL in the diets had no significant ($P>0.05$) effect on the concentrate, hay and total feed intake of the bulls, though, the bulls on the 0% SDBL tended to consume more of the diet. In absolute terms, total intake of the diets ranged from 6.26kg/day for bulls on diets in which 50% of the CSC was replaced by SDBL to 6.45kg/day for bulls fed diet containing 0% SDBL. Dry matter intake expressed as percent body weight increased ($P>0.05$) with increase in the level of SDBL in the diets, averaging 2.23, 2.35, 2.29, 2.47 and 2.49% for bulls on diets containing 0, 25, 50, 75 and 100% SDBL replacement respectively. Intake of CP, OM, EE, ADF and NDF were not significantly ($P>0.05$) affected by level of SDBL in the diets. Intake of the diets in terms of metabolic body weight of the bulls were significantly different ($P<0.05$) between the diets

Table 9a: Nutrient composition (%) of Bracharia hay and feed ingredients.

	Bracharia hay	SDBL	Maize Offal	Cotton seed cake
Dry matter	98.84	91.24	91.35	91.84
Crude Protein	4.62	26.33	11.25	24.63
Crude fiber	44.84	21.54	14.75	37.94
Ether Extract	6.85	7.01	9.57	7.97
Organic matter	90.75	88.44	80.35	86.57
NDF	47.23	50.42	22.75	54.28
ADF	48.75	32.58	20.28	34.42
Ash	6.23	16.20	5.84	3.01
GE (Mcal/kg)	3.25	2.21	3.54	5.25

Table 9b: Ingredient and chemical composition of the fattening diets.

	Levels of replacement of CSC with SDBL (%)				
INGREDIENTS	0	25	50	75	100
Maize Offal	60	60	60	60	60
Cotton seed cake	40	30	20	10	0
Sundried broiler litter	0	10	20	30	40
CHEMICAL COMPOSITION					
Dry matter	94.24	90.68	90.26	89.90	89.16
Crude protein	19.00	22.91	20.34	17.66	15.94
Crude fibre	24.18	22.75	21.30	19.87	15.94
Ether extract	8.91	8.77	8.64	8.50	8.38
Organic matter	87.42	82.97	84.44	82.83	81.58
Acid Detergent fibre	35.94	36.05	36.05	36.26	36.36
Neutral Detergent fibre	24.90	27.40	27.91	28.40	20.69
Ash	7.84	7.71	5.82	7.07	8.58
Gross Energy (Mcal/kg)	4.60	4.47	4.34	4.21	4.08

Table 10. Daily dry matter and nutrient intake of Bunaji bulls fed diets containing sun-dried broiler litter

Parameters	Levels of replacement of CSC with SDBL (%)						
	0	25	50	75	100	SEM	Contrast
Dry Matter Intake							
Concentrate (kg)	3.98	3.85	3.84	3.82	3.82	0.35ns	
Bracharia hay (kg)	2.47	2.52	2.42	2.60	2.55	0.14ns	
Total (kg)	6.45	6.37	6.26	6.42	6.37	0.34ns	
DMI (% of body weight)	2.23	2.35	2.29	2.47	2.49	0.12ns	
DMI ($g/kgW^{0.75}$)	92.67 [c]	96.64 [b]	94.50 [b]	100.50 [a]	100.95 [a]	2.95**	
Nutrient Intake per day							
Crude protein (kg)	0.96	1.13	1.03	0.92	0.88	0.07ns	
Organic matter (kg)	5.97	5.89	5.86	6.00	5.89	0.31ns	
Ether extract (kg)	0.55	0.55	0.54	0.55	0.54	0.03ns	
NDF (kg)	2.45	2.44	2.45	2.52	2.50	0.31ns	
ADF (kg)	2.60	2.66	2.62	2.75	2.74	0.12ns	
Crude fibre (Kg)	152.50	180.00	165.00	147.50	140.00	10.84ns	

ns= not significant

4.3.3. Liveweight changes

Table 11 shows the mean daily liveweight gains, feed efficiency and body condition score of bulls fattened on diets containing SDBL. Daily liveweight gains of the bulls decreased linearly as the level of SDBL increased in the diets; averaging 0.914, 0.853, 0.823, 0.689 and 0.531 kg/day for bulls on diets containing 0, 25, 50, 75 and 100% SDBL replacement respectively. The liveweight gain of the bulls fed diets containing 0, 25 and 50% SDBL replacement were similar ($P>0.05$) and differed significantly ($P<0.05$) from those of bulls on diets containing 75 and 100% SDBL replacement. The liveweights of bulls fed diets containing 0, 25, 50, 75 and 100% SDBL replacement were improved by 27.23%, 25.97%, 25.13%, 21.91% and 17.22% respectively during the period of the experiment. The feed cost of fattening bulls on diets containing 25, 50, 75 and 100% SDBL were reduced by 9.59, 20.82, 29.69 and 40.21% when compared to those on diet not containing any SDBL.

Feed efficiency (feed/gain): Feed efficiency decreased as the level of SDBL increased in the diets. There were no significant differences ($P>0.05$) in feed efficiency between diets containing 0, 25, and 50% SDBL replacement but they were different ($P<0.05$) from those containing 75 and 100% SDBL, replacement. The feed efficiency of the diet containing 75% SDBL replacement also differed significantly ($P<0.05$) from that containing 100% SDBL replacement. The diet containing 100% SDBL was least efficient.

***Body condition score*:** The body condition scores taken at the start of the trial showed no difference ($P>0.05$) between the animals, but at the end of the trial, the condition score of the bulls on diets containing 0, 25, and 50% SDBL replacement were similar ($P>0.05$), but differed significantly ($P<0.05$) from those on diets containing 75 and 100% SDBL replacement (table 11).

Table 11. Mean daily liveweight change, feed efficiency and body condition score of Bunaji bulls fattened on diets containing sun-dried broiler litter (SDBL)

	Levels of replacement of CSC with SDBL (%)						
Parameters	0	25	50	75	100	SEM	Contrast
Liveweight changes (kg)							
Initial weight	220.50	218.75	220.50	221.50	229.50	25.627ns	
Final weight	302.00	295.50	294.50	283.00	277.25	27.456ns	
Weight Changes	82.24 [a]	76.75 [a]	74.00 [a]	62.00 [b]	47.75 [c]	4.271**	L (P=0.001)
Av. Daily weight gain	0.914 [a]	0.853 [a]	0.823 [a]	0.689 [b]	0.531 [c]	0.047**	L (P=0.001)
FCF (kg Feed/kg gain)	7.39 [a]	8.00 [a]	8.00 [a]	9.89 [b]	12.88 [c]	0.759**	
Body condition score							
Initial	3.38	3.38	3.24	3.25	3.25	0.15ns	
Final	4.88 [a]	4.75 [a]	4.75 [a]	4.25 [b]	4.25 [b]	0.14*	

[abc] Means with different superscript along the column differ significantly (P<0.05)
L = linear trend
Q= quadratic trend
_ns= not significant
* = significant 5% level
** = Significant 1% level
FCE= Feed conversion efficiency

4.3.4. Rumen ammonia concentration and blood metabolites.

Rumen ammonia nitrogen concentration (RAN)

Rumen ammonia nitrogen concentrations, Packed cell volume and blood protein and blood urea nitrogen levels of the bulls fed diets containing SDBL are shown in Table 12. RAN (mg/100ml) of the bulls were similar (P>0.05) irrespective of the treatments at the beginning of the study. However, at the end of the study the RAN increased as the level of SDBL increased in the diets. The RAN of the bulls on diets containing 0% SDBL was the least, and this was significantly (P<0.05) lower than the RAN in other treatments. The RAN of bulls fed diets containing 25, 50, 75 and 100% SDBL replacement were also different significantly (P<0.05) among each other. The highest RAN was recorded on diet containing 100% SDBL replacement.

Packed cell volume (%):

At the beginning of the study the PCV ranged from 28.00% to 32.75% and at end of the study it ranged from 34.75% for bulls on diets containing 75 and 100% SDBL replacement to 38.00% for bulls on diet containing 0% SDBL. There were no significant difference (P>0.05) in PCV values between the bulls on diets containing 0 and 25% SDBL. Bulls on diets containing 50, 75 and 100% SDBL replacement had similar PCV values. Bulls on diet containing 0% SDBL had the highest PCV value while the lowest was recorded from bulls on the diet containing 75% and 100% SDBL.

Serum total protein

Serum total protein (TP) values of the bulls fed diets containing SDBL at the end of the study are similar for bulls on the diets containing 0, 25 and 50% SDBL but showed significant (P<0.01) depression as the level of SDBL increased up to 75% and after ward in the diet. The range was between 7.98mg/dl for bulls on diets containing 50% SDBL replacement and 7.43mg/dl for the

diet containing 100% SDBL replacement.

Blood urea nitrogen (BUN mg/100ml):

The BUN increased within treatments from the beginning to the end of the study and between treatments as the level of SDBL increased in the diet(Table 12). At the end of the study, the BUN of bulls on the diet containing 100% SDBL replacement had the highest ($P<0.05$) BUN level. BUN of bulls on the diet containing 0% SDBL was the least and similar ($P>0.05$) to those on 25% SDBL replacement diet. Bulls fed diets containing 50 and 75% SDBL replacement had similar ($P>0.05$) BUN.

4.3.5. Nutrient digestibility and nitrogen balance

Dry matter intake and digestibility of nutrients are presented in Table 13. Intake of gamba hay ranged from 2.85 kg/day for bulls on diet containing 100% SDBL replacement to 2.53kg/day for bulls fed diet containing 0% SDBL. There were no significant ($P>0.05$) differences between the treatments. There were also no significant ($P>0.05$) differences between treatments in the intake of the concentrate and the total dry matter. The total dry matter intake ranged from 6.99kg/day for diet containing 75% SDBL replacement to 7.48kg/day for diet containing 50% SDBL replacement.

Dry matter digestibility (DMD) decreased linearly ($P<0.05$) with increase in the level of SDBL in the diets. The range was between 58.27 for the diet containing 100% SDBL replacement and 64.10% for the diet containing 0% SDBL. The DMD of the diets containing 0 and 25 were similar ($P<0.05$). The DMD of the diets containing 25 and 50% SDBL replacement were also similar ($P>0.05$) and different ($P<0.05$) from those containing 75% and 100% SDBL.

Table 12. Blood parameters and rumen ammonia nitrogen of Bunaji bulls fed fattening diets containing sun-dried broiler litter (SDBL)

	Levels of replacement of CSC with SDBL (%)					
Parameters	0	25	50	75	100	SEM
Rumen Ammonia Nitrogen (mg/100ml)						
BF	8.35	7.93	8.01	7.85	8.20	0.66
ND	9.70 [e]	12.63 [d]	13.53 [c]	14.45 [b]	16.88 [a]	0.66**
Packed Cell Volume (%)						
BF	28.00	28.50	31.50	32.75	29.75	2.31ns
ND	38.00 [a]	36.75 [a]	36.00 [b]	34.75 [b]	34.75 [b]	1.73**
Serum total Protein (%)						
BF	7.28	7.50	7.40	7.25	7.15	0.40ns
ND	7.95 [a]	7.89 [a]	7.98 [a]	7.88 [b]	7.43 [b]	0.18*
Blood Urea Nitrogen (mg/100ml)						
BF	8.63	8.60	8.50	8.75	8.93	0.12ns
MD	11.85 [b]	12.38 [b]	14.05 [a]	14.13 [a]	14.33 [a]	0.67**
ND	12.85 [c]	13.58 [c]	15.18 [b]	15.13 [b]	15.83 [a]	0.41**

[abc] Means with different superscripts along the row differ significantly (P<0.05)
ns= not significant
* = significant 5% level
** = Significant 1% level
BF= Before the trial commenced
MD= Mid stage into the trial
ND= End of the trial

Crude protein digestibility (CPD) of the diet containing 50% SDBL replacement was significantly ($P<0.05$) higher than those of other treatments. The CPD of diets containing 25 and 100% SDBL replacement were similar. The diet containing 75% SDBL replacement of CSC had the least crude protein digestibility.

Organic matter digestibility was highest on diet containing 0% SDBL and decreased as the level of SDBL increased in the diets. The differences were not significant ($P>0.05$). The digestibility of ADF was not affected significantly ($P>0.05$) by the level of SDBL in the diets but digestibility of ether extract and NDF showed significant ($P<0.05$) depression as the level of SDBL increased in the diets. Digestibilities of crude fibre were similar for diets containing 25, 50 and 75% SDBL replacement but differed form those containing 0 and 100% SDBL replacement which were similar.

Mean daily nitrogen intake on diets containing 25 and 50% SDBL were higher and significantly ($P<0.05$) different from those containing 0, 75 and 100% SDBL which were similar (Table 13). Daily N- intake was highest on the containing 25% SDBL. The urinary nitrogen loss ranged from 30.00 l/day to 64.33 l/day for the diets containing 0 and 100% SDBL respectively. The differences were not significant ($P>0.05$) between treatments. The faecal nitrogen loss were higher on diets containing 25 and 50% SDBL and were also significantly ($P<0.05$) different from those containing 0, 75 and 100% SDBL. Amount of nitrogen loss ranged between 80.00g/day for 0% SDBL diet and 114..00g/day for 100% SDBL replacement diet. Total nitrogen loss were similar ($P<0.05$) on diets containing 25, 50, 75 and 100% SDBL. Diet containing 0% SDBL had the least nitrogen loss (Table 13).

The amount of nitrogen retained by the bulls ranged from 40.00 to 93.35g/day and it was significantly ($P<0.05$) affected by the level of SDBL in the diets. The amount of nitrogen

retained were similar (P>0.05) for bulls fed diets containing 25 and 50% SDBL. Diets containing 0 and 50% SDBL had similar (P>0.05) nitrogen balance. Bulls on diets containing 75 and 100% SDBL had the least (P<0.05) nitrogen retained. Nitrogen retained expressed as percent of nitrogen intake was similar (P>0.05) between diets containing 0, 25 and 50%. Diet containing 75% SDBL also differed (P<0.05) from the diet containing 100% SDBL.

4.3.6. Carcass evaluation

Hot carcass weight, dressing percentage, and weight of the organs of bulls fattened on SDBL are presented in Table 14 The carcass weight of the bulls varied between 134.30 and 156.39 kg, there were no differences (P>0.05) between bulls on the diets containing 0, 25, 50 and 75% SDBL. Bulls on the diet containing 100% SDBL had significantly (P<0.05) lower carcass weight. The dressing percentages of the bulls ranged between 50.21% and 51.44% for bulls on 75 and 0% SDBL replacement diets respectively. There were no differences (P>0.05) in the dressing percentage between the treatments. The quantity of dissectible beef from the bulls was highest on diet containing 0% SDBL, this was similar (P>0.05) to those on diets containing 25 and 50% SDBL. Diets containing 25, 50, 75 and 100% SDBL also gave similar (P<0.05) quantity of dissectible beef. Meat to bone ratio ranged from 3.24 to 3.84 for bulls on diets containing 100 and 50% SDBL replacement. The differences in the meat: bone ratio were not affected (P>0.05) by the level of SDBL in the diets. The quantity of boneless beef expressed as percent of carcass weight ranged from 69.65% for bulls on 0% SDBL diet to 71.30% for bulls on 50% SDBL diet. There were no differences (P>0.05) between the bulls.

The weight of external offals (head, legs, tail and hides) and the internal offals (liver, spleen, heart and kidney) and the empty stomach and intestine were not affected (P>0.05) by the treatments.

Table 13. Feed intake and apparent digestibility (%) of nutrient and nitrogen balance by Bunaji bulls fattened on diets containing sun-dried broiler litter (SDBL)

Parameters	Levels of replacement of CSC with SDBL (%) 0	25	50	75	100	SEM	Contrast
Dry Matter Intake (kg/day)							
Gamba Hay	2.53	2.60	2.61	2.62	2.85	0.44ns	
Concentrate	4.55	4.78	4.87	4.37	4.34	0.15ns	
Total intake	7.08	7.38	7.48	6.99	7.19	0.53ns	
Nutrient Digestibility (%)							
Dry Matter	64.10 ^{a}	62.20 ^{ab}	61.27 ^{b}	58.42 ^{c}	58.27 ^{c}	1.83**	L (P=0.001)
Crude Protein	68.67 ^{b}	66.74 ^{c}	70.53 ^{a}	64.84 ^{d}	65.25 ^{c}	1.48**	Q (P=0.001)
Crude Fibre	52.60 ^{b}	56.68 ^{a}	58.17 ^{a}	56.89 ^{a}	50.81 ^{c}	3.44**	L (P=0.001)
Organic Matter	65.40	65.05	64.55	62.04	60.53	1.74ns	
Ether extract	66.41 ^{a}	47.91 ^{b}	48.59 ^{b}	41.06 ^{c}	39.99 ^{c}	2.22**	L(P=0.001)
Neutral detergent fibre	60.11 ^{a}	59.21 ^{a}	52.58 ^{b}	54.96 ^{b}	48.46 ^{c}	2.23**	L (P=0.006)
Acid detergent fibre	46.78	45.98	46.89	41.14	47.21	3.04ns	
Nitrogen Balance							
Nitrogen intake(g/day)	160.00 ^{b}	206.6 ^{a}	186.67 ^{a}	150.00 ^{b}	146.67 ^{b}	14.61**	
Urinary - N (g/day)	30.00	43.33	36.67	63.33	64.33	8.30ns	
Faecal – N (g/day)	50.00 ^{b}	70.00 ^{a}	63.33 ^{a}	46.67 ^{b}	50.00 ^{b}	4.94*	
Total-N output (g/day)	80.00 ^{b}	113.33 ^{a}	100.00 ^{a}	110.00 ^{a}	114.33 ^{a}	12.22**	
N-retained (g/day)	80.00 ^{b}	93.35 ^{a}	86.68 $^{a\,b}$	40.00 ^{c}	32.34 ^{c}	10.11**	
N-retained (% N-intake)	49.96 ^{a}	45.17 ^{a}	46.43 ^{a}	33.33 ^{b}	20.05 ^{c}	5.34**	

^{abc} Means with different superscripts along the row differ significantly (P<0.05)
L = linear trend, Q= quadratic trend, ns= not significant
* = significant 5% level, ** = Significant 1% level

Table 14. Dressing percent, weight of carcass and edible offal (kg) of Bunaji bulls fattened on diets containing sun-dried broiler litter (SDBL)

	Levels of replacement of CSC with SDBL (%)					
Parameters	0	25	50	75	100	SEM
Live weight (kg)	340.50	340.00	331.50	325.50	302.00	28.61
Fasted body weight	304.35[a]	300.33[a]	289.48[a]	289.55[a]	265.68[b]	23.34*
Hot Carcass weight	156.39[a]	151.03[a]	146.26[a]	148.30[a]	134.30[b]	11.43*
Dressing Percent	51.44	50.32	50.51	51.21	50.55	0.43
Weight of dissectible beef	108.75[a]	105.33[ab]	104.22[ab]	100.42[b]	94.50[b]	5.94*
Beef (% of carcass weight)	69.55	69.91	71.30	67.93	70.37	1.58
Bone yield	31.21	30.54	29.62	27.22	29.26	3.88
Meat: bone ratio	3.47	3.44	3.84	3.69	3.24	0.63
Legs	8.22	8.10	7.66	7.74	7.17	0.64
Hide	24.86	23.98	22.64	21.30	22.67	3.23
Head	19.50[a]	19.17[a]	17.90[a]	18.35[a]	16.47[b]	1.38*
Liver	3.61	3.69	3.39	3.55	3.24	0.27
Spleen	1.18	1.04	0.96	1.30	1.16	0.11
Heart	0.98	0.96	0.95	0.92	0.90	0.13
Kidney	0.88	0.82	0.81	0.84	0.87	0.11
Empty Stomach	11.70	11.80	10.89	11.31	10.80	0.44
Empty Intestine	7.14	7.65	7.57	6.89	6.83	0.30

[abc]Means with different superscripts along the row differ significantly (P<0.05)
* = Significant at 5% level

4.3.7. Economic evaluation

Table 15 shows the total cost of feed consumed, value of gain, feed cost per gain and the income over feed cost of the bulls fattened on diets containing SDBL. Total feed cost of fattening the bulls decreased linearly (P=0.001) as the level of SDBL in the diets increased. The differences were significant (P<0.05). The diet which contained 0% of SDBL was the most expensive and the least expensive was the diet containing 100% SDBL replacement.

The value of gain (total liveweight x ₦150 (cost /kg liveweight) showed a linear (P=0.001) decrease as the level of SDBL increased in the diet. The bulls on the diet containing 0% SDBL gave the highest value which differed significantly (P<0.05) from those on diets containing 25 and 50% SDBL. Bulls on diets containing 75% and 100% SDBL replacement were also different (P<0.05) in their value of gain.

Feed cost per kilogram liveweight gain (₦/kg) was significantly (P<0.05) lowest on diet containing 50% SDBL replacement, followed by the diets containing 75% SDBL replacement. The feed cost per kilogram gain were also significantly different (P<0.05) between all the treatments. The diet containing 100% SDBL replacement had the highest feed cost per kilogram gain.

Income over feed cost was highest on the diets containing 0, 25 and 50% SDBL replacement, these were different (P<0.05) from income realized on bulls on diets containing 75 and 100% SDBL replacement. The least income was recorded on diet containing 100% SDBL.

Table 15 . Economic evaluation of Bunaji bulls fattened on diets containing sun-dried broiler litter (SDBL)

	Levels of replacement of CSC with SDBL (%)						
PARAMETERS	0	25	50	75	100	SEM	CONTRAST
Total Conc. Intake (kg).	380.03	382.10	382.15	382.50	382.50	34.70	
Total stover intake (kg).	225.00	229.50	220.50	236.25	231.75	12.59	
Total feed intake (kg).	605.03	611.60	602.65	618.75	614.25	33.17	
Av. Cost of feed Consumed/ animal (N).	7194.60 [a]	6504.58 [b]	5696.48 [c]	5058.34 [d]	4301.98 [f]	347.99**	L (P=0.001)
Weight gain (kg)	82.24	76.75	74.00	62.00	47.75	4.27**	L (P=0.001)
Value of gain (N)	12336.00 [a]	11512.50 [b]	11100.00 [b]	9300.00 [c]	7162.50 [d]	645.90**	L (P=0.001)
Income over feed Cost (N)	5141.03 [a]	5007.93 [a]	5403.52 [a]	4241.67 [b]	2860.52 [c]	616.12**	

[abc]Mean with different superscripts along the row differ significantly (P<0.05)
L = linear trend
Q= quadratic trend
* = significant 5% level
** = Significant 1% level
Cost of cotton seed cake= N 20,000.00/ton
Cost of Maize offal = N 15,000.00/ton
Cost of Poultry manure = N 6200/ton
Value of gain = Weight gain x ₦150 (cost of live animal per kg)

4.4.0. Experiment 4:
The effect of feeding graded levels of maize offal and whole cotton seed (WCS) on the feedlot performance of Bunaji bulls

4.4.1. Nutrient composition of the experimental diets

The chemical composition of the feed ingredients and the diets are presented in Table 16 a and b. The CP content of the diets decreased as the level of WCS decreased. The composition of the other nutrients also decreased with increase in level of WCS in the diet.

4.4.2. Voluntary dry matter and nutrient intake

Table 17 shows the mean daily dry matter intake. The concentrate consumed decreased as the proportions of WCS increased in the diets and became significantly lower ($P<0.05$) on the diet containing 80% WCS. The intake of the concentrates containing 20, 40 and 60% WCS were similar ($P<0.05$). Intake of gamba hay was similar ($P>0.05$) on diets containing 20, 40 and 60% WCS. Diet containing 80% WCS had significantly lower hay intake. Total intake were also similar ($P>0.05$) for diets containing 20, 40 and 60% WCS. The diet containing 80% WCS had significantly ($P<0.05$) lower total dry matter intake. Total dry matter intake decreased by 23.94%, 4.36 and 1.76% as the level of WCS decreased from 80-60%, 60-40% and 40-20% respectively. When the dry matter intake was expressed on metabolic body weight basis diet containing 20% WCS had significantly higher DMI, this was similar ($P>0.05$) to the diet containing 60% WCS. Diet containing 60 WCS was also similar ($P>0.05$) to the diet containing 40% WCS. Diet containing 80% WCS had the lowest DMI when expressed as percent body weight. Dry matter intake expressed as percentage body weight were similar on diets containing 20, 40 and 60% WCS. Diet containing 80% WCS had the least ($P<0.05$) DMI when expressed as percent body weight.

Table 16a : Mean chemical composition (%) of WCS, maize offal, gamba hay

	Whole cottonseed	Maize offal	Gamba hay
Dry matter	91.15	92.10	98.84
Crude protein	20.38	11.3	4.50
Crude fibre	28.55	16.27	44.81
Ether extract	21.14	9.27	6.92
Organic matter	86.15	86.91	92.79
NDF	49.45	26.37	37.20
ADF	40.99	22.8	48.88
Ash	5.00	5.19	6.05
GE (Mcal/kg)	4.68	3.99	Na

Na= not analyzed

Table 16b

Mean chemical composition (%) the fattening diets containing graded levels of whole cotton seed (WCS) and maize offal.

	Proportions of Maize offal and WCS in the concentrate			
	80:20	60:40	40:60	20:80
Dry matter	91.09	90.63	91.18	91.28
Crude protein	18.19	16.06	14.53	13.28
Crude fibre	26.09	23.64	21.18	18.73
Ether extract	18.76	16.39	14.02	11.65
Organic matter	86.83	86.61	86.89	86.92
NDF	44.83	40.19	35.60	30.99
ADF	39.33	33.70	30.07	26.44
Ash	4.26	4.02	4.29	4.36
Gross energy(Kcal/kg)	4.55	4.40	4.27	4.13

Intake of crude protein increased significantly (P<0.05) as the proportion of WCS increased in the diets. Maximum CP intake was recorded on the diet containing 60% WCS. This was similar (P>0.05) to the diet containing 40% WCS. Diets containing 40 and 20 % WCS were similar (P>0.05).. The diet containing 80% WCS had the least CP intake, this was however similar (P>0.05) to the diet containing 20% WCS. Intakes of organic matter, ash were similar between the diets. Intake of acid detergent fibre and neutral detergent fibre increased as the proportions of WCS decreased in the diet up to 60%, then declined. The differences were not significant (P>0.05) for diets containing 40 and 60% WCS. Diet containing 80%WCS had the least intakes of ADF and NDF.

The quantity of gossypol consumed increased significantly (P<0.05) as the levels of WCS increased in the diets. Gossypol intake as a result of consumption of WCS ranged between 0.012% and 0.032% for free gossypol and between 0.013 and 0.036% for total gossypol. Intake of both the free and total gossypol were similar (P>0.05) on diets containing 80 and 60% WCS. The intake of free and total gossypol from diet containing 40% WCS was different from that of the diet containing 20% WCS. Bulls fed diet containing 20% WCS consumed the least (P<0.05) amount of both free and total gossypol.

4.4.3. Liveweight changes

Average liveweight gain of the bulls increased significantly (P<0.01) with increase in the level of WCS in the diet up to 40 % in the concentrate and then declined (Table 18). Average daily weight gains also increased significantly (P<0.01) up to a maximum at 40% WCS in the concentrate diet and then declined. The final liveweights of the bulls were improved by 16.97%, 20.50%, 28.63% and 22.65% for the diets containing 20, 40, 60 and 80 % WCS over their initial liveweights during the 90 day experimental period.

Table 17.
Mean dry matter, nutrients and gossypol (calculated) intake by Bunaji bulls fed fattening diets containing graded levels of whole cotton seed (WCS) and maize offal

Parameters	Proportions of Maize offal and WCS in the concentrate 80:20	60:40	40:60	20:80	SEM
Dry matter intake(Kg)					
Concentrate	3.00 [b]	4.03 [a]	4.28 [a]	4.33 [a]	0.34**
Gamba hay	2.18 [b]	2.40 [a]	2.42 [a]	2.50 [a]	0.09**
Total	5.18 [b]	6.42 [a]	6.70 [a]	6.82 [a]	0.35**
DMI (% of body weight)	1.93 [c]	2.31 [ab]	2.24 [b]	2.37 [a]	0.13**
DMI (g/kgW$^{0.75}$)	77.83 [b]	95.66 [a]	94.40 [a]	91.57 [a]	5.69**
Nutrient intake					
Crude Protein (g)	737.20 [c]	866.16 [a]	835.68 [ab]	787.71 [bc]	56.29*
Organic Matter (kg)	5.95	6.45	6.37	6.42	0.46ns
Ether Extract (g)	959.04 [a]	946.88 [a]	827.08 [b]	726.36 [c]	78.24**
NDF (kg)	2.77 [c]	3.21 [a]	3.11 [a]	2.95 [b]	0.16**
ADF (kg)	2.52 [c]	2.92 [a]	2.85 [a]	2.73 [b]	0.14*
Calculated gossypol intake (%)					
Free	0.032 [a]	0.032 [a]	0.023 [b]	0.012 [c]	0.002**
Total	0.036 [a]	0.036 [a]	0.025 [b]	0.013 [c]	0.002**

Total and free gossypol was calculated from values presented by Airier and Fetuga (1984).
[abcd] Means with different superscripts along the row differ significantly (P<0.05)
* = significant 5% level
** = Significant 1% level

Feed conversion efficiency *(feed/gain):* The diet containing 40% WCS had the best feed efficiency which differed (P<0.05) significantly from those of other treatments. Although, the diet containing 80% WCS was least efficient, it was similar to diets containing 60 and 20% WCS (Table 18).

Body condition score

Body condition scores were similar between treatments (P>0.05) at the commencement and at the end of the trial. The final body condition score of the bulls on different treatments were not affected (P>0.05) by the levels of WCS in the diets, although, the condition score of bulls on diets containing 40 and 20% WCS were higher compared to others. Bulls on the diet containing 80% WCS had the least condition score.

4.4.4. Rumen pH and Rumen ammonia nitrogen concentration (RAN)

Rumen pH, rumen ammonia concentration and blood metabolites of the bulls fattened on diets containing WCS are presented in Table 19. Rumen pH of the bulls ranged from 6.49 to 6.67 at the beginning of the trial. The differences were not significant. There were significant differences (P<0.05) in the rumen pH between all the treatments. Bulls fed the diet containing 40% WCS had the highest pH and the lowest was recorded for bulls fed the diet containing 20% WCS .

Rumen ammonia nitrogen concentration (mg/100ml rumen fluid) was similar (P>0.05) between treatments at the start of the trial. The range was between 6.36 and 7.23 (mg/100ml). However, at the end of the trial, RAN increased significantly (P<0.05) as the level of WCS decreased in the diets. The range was between 11.35 and 21.95mg/100ml). Bulls on the diet containing 80% WCS had the highest RAN, which was statistically (P<0.05) different from the RAN of the diets containing 60, 40, and 20% WCS. Bulls on the diet containing 20%WCS had the least RAN .

Table 18: Mean daily live weight change (kg), feed efficiency and body condition score of Bunaji bulls fattened on diets containing whole cotton seed (WCS) and maize offal

Parameters	Proportions of Maize offal and WCS in the concentrate 80:20	60:40	40:60	20:80	SEM
Liveweight changes (kg)					
Initial liveweight	249.00	250.00	248.00	250.50	22.28
Final Liveweight	291.25	301.25	319.00	307.25	22.66
Weight gain	42.25 [c]	51.05 [b]	71.00 [a]	56.75 [b]	0.938**
Average daily gain	0.470 [c]	0.570 [b]	0.789 [a]	0.631 [b]	0.01***
FCE (kg feed/kg gain)	11.70 [b]	12.05 [b]	9.03 [a]	11.47 [b]	1.35*
Body condition score					
Initial	2.58	2.65	2.38	2.33	0.39ns
Final	4.70	4.88	4.95	4.95	0.90ns

[abcd] Means with different superscripts along the row differ significantly (P<0.05)
* = significant 5% level
** = Significant 1% level
FCE = Feed conversion efficiency

4.4.5. Blood Metabolites

Packed cell volume

There was no difference (P>0.05) in the PCV of the bulls on the different treatments at the beginning of the trial (Table 19). However, at the mid stage and the end of the trial, there were differences (P<0.05) in PCV due to the levels of WCS in the diets. During the mid stage of the trial, the PCV values differed significantly (P<0.05) among bulls on different treatments. Bulls on the diet containing 40% WCS had the highest PCV. However, during the last stage of the trial, the PCV of bulls on diets containing 60 and 40% WCS were similar (P>0.05) and different from those on 80 and 20% WCS diets. The PCV of bulls on 80 and 20 % diets also differed significantly (P<0.05) from each other.

Total serum protein (g/dl)

The total protein (g/dl) of bulls fed different levels of WCS ranged between 6.20 and 6.63g/dl at the start of the trial and between 7.65 and 7.85 g/dl at the end of the trial. There were no differences (P>0.05) in total protein across the treatments during the two periods. However, the total protein show some increase within the treatments as the trial progressed due to feeding WCS .

Blood urea nitrogen (BUN mg/100ml):

Blood urea nitrogen level ranged from 7.33 to 7.58mg100ml before the trial started and between 11.33 and 12.40 mg/100ml during the mid stage of the trial. There were no significant differences (P>0.05) in the BUN between the treatments at the start and mid stage of the trial. However, at the end of the trial, the BUN of bulls on diets containing 60, 40 and 20% WCS were similar but different (P<0.05) from those on the diet containing 80% WCS.

4.4.6. Nutrient digestibility and nitrogen balance

Feed intake values during the metabolism trial, digestibility coefficient of nutrients and metabolizable energy content are presented in Table 20. Intake of Gamba hay ranged from 1.70kg/day for the diet containing 20% WCS to 2.21 kg/day for the diet containing 80% WCS. The levels of WCS in the diets did not affect ($P>0.05$) the intake of Gamba hay (Table 20). However, intake of the concentrate increased significantly ($P<0.05$) as the proportions of WCS decreased in the concentrate. The range was between 2.50 kg and 4.33 kg for the diets containing 80 and 20% WCS respectively. Total feed intake (concentrate and hay) increased ($P<0.05$) by 5.95%, 15.07% and 28.03% as the level of WCS decreased from 80 to 60, 40 and 20% in the diets.

DMD decreased as the level of WCS increased increases in the diets, ranged was between 57.55 and 67.03%. There were no significantly differences ($P<0.05$) in DMD between diets containing 20, 40 and 60% WCS. DMD of the diet containing 80% WCS was significantly lower. The highest DMD was recorded on the diet containing 20% WCS. Crude protein digestibility increased significantly ($P<0.05$) with decrease in the proportions of WCS in the diets up to 40% level of inclusion, then declined. The CP digestibility of the diets containing 40 and 60% WCS were similar ($P>0.05$) but differed significantly ($P<0.05$) from those containing 20 and 80% WCS. CP digestibility of the diet containing 80% WCS was the lowest. Although the digestibility of crude fibre, ADF, NDF and ether extract decreased with decreasing proportions of WCS in the diets, the differences were however not significant ($P>0.05$). Digestibility of organic matter did not also differ between the treatments.

Table 19 . Rumen pH, rumen ammonia nitrogen and blood metabolites of Bunaji bulls fattened on diets containing whole cotton seed (WCS) and maize offal

Parameters	Proportions of Maize offal and WCS in the concentrate 80:20	60:40	40:60	20:80	SEM
Rumen PH					
BE	6.58	6.67	6.65	6.49	0.16ns
ND	6.59 [c]	6.75 [b]	6.88 [a]	6.38 [d]	0.04ns
Rumen Ammonia Nitrogen (mg/100ml)					
BE	6.80	6.36	7.23	7.05	0.29ns
ND	21.95 [a]	17.50 [b]	13.48 [c]	11.35 [d]	0.51**
Packed Cell Volume (%)					
BE	23.00	24.00	23.50	23.75	0.35ns
MD	29.00 [d]	31.00 [c]	34.50 [a]	33.25 [b]	0.75*
ND	30.25 [c]	34.25 [a]	34.75 [a]	33.00 [b]	0.62**
Total Serum Protein (g/dl)					
BE	6.20	6.63	6.50	6.23	0.19ns
ND	7.65	7.70	7.76	7.85	0.12ns
Blood Urea nitrogen (mg/100ml)					
BE	7.35	7.58	7.33	7.53	0.33 ns
MD	12.40	11.50	11.85	11.33	0.38ns
ND	15.20 [b]	13.03 [a]	12.70 [a]	12.68 [a]	0.42**

[abc] Means with different superscripts along the row differ significantly (P<0.05)
ns= not significant, * = significant 5% level, ** = Significant 1% level
BF= before the trial commenced, MD= mid stage into the trial, ND= end of the trial

Metabolizable energy contents of the diets ranged between 8.95 and 9.85MJ/kg for diets containing 80 and 20% WCS respectively. Although the ME content of the diets increased with decrease in the proportions of WCS in the diets, the differences were not significant (P>0.05). Metabolizable energy intake (MJ/head/day) was higher (P<0.05) on the diet containing 20% WCS. Diets containing 60 and 40% WCS were similar (P>0.05) and different (P<0.05) from diet containing 80% WCS in ME intake. ME intake was least for the diet containing 80% WCS.

***Nitrogen balance**:*

Mean daily nitrogen intake (g/day) ranged between 95.33 and 110.06g/day. There were no differences (P>0.05) between the treatments. The least nitrogen intake was recorded on the diet containing 60% WCS (Table 20). Increasing level of WCS in the diet resulted in increasing urinary nitrogen, although, the differences were not significant (P>0.05). Bulls on the diet containing 80% WCS had the highest urinary nitrogen loss (Table 20). Feacal nitrogen loss were also similar (P>0.05) between treatments. Bulls on the diet containing 20% WCS lost the highest quantity of nitrogen through the faeces. Total nitrogen loss from the bulls generally showed a decrease with decrease in WCS in the diet, the differences were not significant (P>0.05).

The quantity of nitrogen retained by the bulls ranged between 13.71g/day and 40.53g/day. There were no significant differences (P<0.05) in the quantity of nitrogen retained between diets containing 20 and 40% WCS. The diets containing 40 and 60% WCS also had similar (P>0.05) nitrogen retention. Bulls on the diet containing 80% WCS had the lowest (P<0.05) nitrogen retention. Nitrogen retained expressed as percent nitrogen intake increased with decrease in the proportions of WCS in the diet up to 40% level of WCS in the diet, then declined. Nitrogen retained as percent nitrogen intake were similar (P>0.05) for diets containing 60, 40, and 20% WCS but different (P<0.05) from that of the diet containing 80% WCS (Table 20).

Table 20. Mean daily feed intake and apparent digestibility (%) of nutrient by Bunaji bulls fattened on diets containing whole cotton seed (WCS) and maize offal

Parameters	Proportions of Maize offal and WCS in the concentrate 80:20	60:40	40:60	20:80	SEM
Dry matter intake (Kg/day)					
Gamba hay	2.21	2.20	2.02	1.70	0.34ns
Concentrate	2.50 [d]	2.79 [c]	3.40 [b]	4.33 [a]	0.32**
Total intake	4.71 [c]	4.99 [c]	5.42 [b]	6.03 [a]	0.31**
Nutrient digestibility (%)					
Dry matter	57.55 [b]	66.2 [a]	67.03 [a]	68.16 [a]	3.48**
Crude Protein	52.18 [c]	66.86 [a]	67.58 [a]	57.17 [b]	3.76*
Crude Fibre	65.09	60.15	55.05	53.13	3.88
Ether Extract	86.61	78.21	76.72	72.89	13.87
Organic Matter	65.52	67.35	64.64	69.27	3.14
Neutral Detergent Fibre	56.60	51.94	42.58	51.93	4.96
Acid Detergent Fibre	57.89	57.53	54.05	52.38	4.08
ME content (MJ/kg)	8.95	9.66	9.25	9.85	0.45
ME intake (MJ/kg/head/day)	39.62 [c]	44.90 [b]	46.78 [b]	55.13 [a]	4.33*
Nitrogen Balance					
Nitrogen Intake (g/day)	96.43	95.33	100.49	110.06	8.88ns
Urinary nitrogen (g/day)	36.73	29.70	30.39	22.15	4.07ns
Faecal nitrogen (g/day)	46.00	32.00	32.78	47.37	5.34ns
Total nitrogen output (g/day)	82.73	61.71	63.18	69.56	6.72ns
Nitrogen retained (g/day)	13.71 [c]	33.63 [b]	37.32 [ab]	40.53 [a]	5.06 **
Nitrogen retained (% N-Intake)	14.35 [b]	34.39 [a]	37.52 [a]	36.64 [a]	3.73 **

[abc] Means with different superscripts along the row differ significantly (P<0.05)

* = significant 5% level, ** = Significant 1% level, Metabolizable = DE x 0.82 (ARC 1980)

4.4.7. Carcass evaluation

Dressing percentage, weight of external and internal offals and meat to bone ratio are presented in Table 22. The dressing percentage of the bulls ranged from 50.43% for bulls on diet containing 60% WCS to 52.13% for bulls fed diet containing 20% WCS. The levels of WCS in the diets had no significant (P>0.05) effect on the dressing percentage of the bulls. All the parameters measured, except meat: bone ratio, and the weights of empty stomach and intestine were similar (P>0.05) between treatments. The weight of the empty stomach were similar (P>0.05) for the bulls on the diets containing 20 and 40% WCS. Diets containing 60 and 80% WCS also had similar empty stomach. The weight of empty intestine was different between all the treatments. Percentage of dissectible beef in the carcass ranged between 60.89% and 63.95% for bulls on diets containing 80% and 40% WCS. The differences were not significant (P>0.05) between the treatments.

4.4.8. Economic evaluation

Total cost of feed for fattening the bulls was significantly (P<0.05) affected by level of WCS in the diets (Table 23). The lowest cost of feed consumed was recorded on the diets containing 20% level of WCS. Cost of the diets containing 60 and 40% WCS were similar (P>0.05) but significantly different (P<0.05) from the cost of the diet containing 20 and 80% WCS (Table 25). Cost of feed per kilogram live weight gain were higher (P<0.05) for diets containing 80 and 60% WCS, this is closely followed by the diet containing 20% WCS. The diet containing 40% WCS had the least (P>0.05) cost per kilogram live weight gain (Table 23).Value of liveweight gains (₦ 150.00 x kg liveweight) were significantly (P<0.05) affected by the level of WCS in the diets. There were significant (P<0.05) differences in value of gain among treatments. The highest value of gain was recorded on the diet containing 40% WCS while the least value of gain was recorded

on the diet containing 80% WCS (Table 23). Income over feed cost decreased significantly ($P<0.01$) as the level of WCS increased in the diet up to 40% level of WCS inclusion, then declined. Diets containing 80 and 60% WCS had the least income over feed cost which differed ($P<0.05$) from those of the diet containing 20% WCS (table 23).

Table 21. Dressing percent, weight of internal and external offal (kg) of Bunaji bulls fattened on diets containing whole cotton seed (WCS) and Maize offal

Parameters	Proportions of Maize offal and WCS in the concentrate 80:20	60:40	40:60	20:80	SEM
Average Liveweight	249.00	250.00	248.00	250.00	22.28
Shrunk body Weight	245.75	245.52	242.00	246.50	16.86
Hot Carcass Weight	124.00	124.50	129.00	129.00	7.13
Dressing Percent	50.51	50.43	50.99	52.13	0.93
Weight of dissectible beef	75.50	76.00	82.50	81.50	3.46
Meat : bone ratio	5.20 [a]	4.01 [c]	4.63 [b]	4.89 [a]	0.02*
Beef yield (% of carcass weight)	60.89	61.04	63.95	63.18	5.68
Legs	7.10	7.25	7.70	6.85	0.44
Hide	20.50	19.30	20.25	20.40	0.87
Head	15.25	14.75	15.45	15.10	1.00
Liver	3.79	3.80	3.85	3.83	0.08
Spleen	0.88	0.82	0.90	0.88	0.11
Heart	1.03	1.06	1.09	1.09	0.21
Kidney	0.93	0.93	0.96	0.95	0.24
Empty Stomach	9.95 [b]	9.94 [b]	11.40 [a]	11.15 [a]	0.19**
Empty Intestine	6.95 [d]	7.15 [c]	7.40 [b]	7.70 [a]	0.11*

[abcd] Means with different superscripts along the row differ significantly (P<0.05)
* = significant 5% level
** = Significant 1% level

Table 22. Value of liveweight gains and income over feed cost of Bunaji bulls fattened on diets containing whole cotton seed (WCS) and Maize offal

Parameters	Proportions of Maize offal and WCS in the concentrate				
	80:20	60:40	40:60	20:80	SEM
Total Conc. Intake (kg)	296.55 [b]	400.05 [a]	422.23 [a]	246.38 [c]	33.41**
Total Hay consumed (kg)	198.00	218.25	220.50	227.25	8.27
Total feed consumed (kg)	494.55 [c]	618.30 [a]	642.83 [a]	573.63 [b]	37.13*
Cost of feed consumed (N)	5325.14	6535.95	6565.46	4613.11	402.42
Weight Gain (kg)	42.25	51.25	71.00	56.75	0.94*
Feed cost /gain (N)	125.96 [a]	127.33 [a]	92.34 [c]	113.03 [b]	5.76*
Value of gain (N)	6337.50 [d]	7687.50 [c]	10,650.00 [a]	8512.50 [b]	140.73**
Income Over Feed cost (N)	1012.36 [c]	1161.50 [c]	4084.53 [a]	2094.00 [b]	345.26**

[abcd] Means with different superscripts along the row differ significantly (P<0.05)
* = significant 5% level
** = Significant 1% level
Cost of WCS at time of the trial =₦10,000/ton
Cost of Maize offal at the of the trial = ₦ 15,000.00
Value of gain = Weight gain x ₦150 (cost of live animal per kg)

CHAPTER FIVE

DISCUSSION

5.1.0. Experiment one: Nutrient composition of some non-conventional feed resources

5.1.1. Plant by-products

Sorghum by-products:

Sorghum stover*:* This is the remains of sorghum plant after grain harvest. The crude protein content of the stovers reported in this trial (6.63%) is slightly higher than 5.1-5.8% reported by Alhassan *et al.* (1987). Crude protein content of cereal crop residue has been found to decline with time after grain harvest (Alhassan *et al.* (1987). It has therefore been advised that crop residue should not be left on the field longer than 28 days after grain harvest to prevent loss of quality (Alhassan, et al., 1987). Thus, sorghum leaves, if harvested at the right time and properly stored could serve as good quality roughage for ruminants during the period of feed scarcity.

Sorghum trashed panicle*:*

This is the remains of the panicle after grain threshing. The quantity of grain that remains on the panicle depends on the efficiency of threshing. The CP content of this waste is very low. The value reported in this trial (2.41%) is lower than the 3.5% reported by Alhassan *et al.* (1987). The amount of grain left after threshing may be the reason for this difference. Sorghum panicle is already in use by livestock farmers in the sorghum producing zones in the country. However, proper harnessing for feeding will ensure its maximum utilization.

Roots and tubers

Fresh roots and tubers contain from 30-90% water (Coursey and Haynes, 1970) and are succulent feedstuffs. The dry matter is very low in fibre and is highly digestible.

Yam peeling: The CP content (10.25%) reported in this study is slightly lower than 11.7% reported by Bo Gohl (1975) for water yam The CF, ash and NFE reported for this study were also lower. The differences could be due to differences in the variety of yam used.

Irish potatoes plant and peelings: The dry matter content of Irish potatoe tuber and peeling are similar to what Umoh, 1982 reported. The CP content reported in the present study is similar to the values reported by Umoh, (1982) and McDonald, (1988). The differences could be due to varietals differences. Potatoes are generally poor sources of mineral except for potassium McDonald, (1988). The Calcium content of 1.22% reported for Irish potatoes tuber in this study is higher than 0.10% reported by Umoh, (1982). Although, the tubers and their peelings are not yet used in large quantity in ruminant feeding, the peels could be fed to ruminant either wholly or in-combination with maize offal to serve as source of fermentable energy to ruminants. Feeding tubers to ruminants is not very economical.

Sweet potatoes (Ipomea batatas) **:** The CP contents of the white variety of sweet potatoes tuber and the peelings are higher than the red variety. The CP contents of the tuber (5.06%) and peelings (6.38%) of the red variety of sweet potatoes are similar to 5.4% for tuber and 6.3% for peelings reported by BO Gohl, (1975) but lower than 13.31% and 11.06% reported for the peelings and tuber of the white variety reported in this study.

Maize by-products

Maize husk* (*Cob shell): The maize husk is abundant farm products of maize crop during threshing of maize. The DM and CP content of maize husk in this trial is 94.60 and 3.06%. Alhassan, *et al.,* 1883 reported that the CP content of maize husk is similar to that of maize stover. Although, the husk is high in cell wall and it is bulkier, it can serve as source of roughage to the ruminants if it is properly preserved as soon as grains are threshed.

Maize offal.

This is a known feed resource in the main cattle producing area of the country. It is a by-product of a popular stable food in Northern Nigeria. The maize offal (collected from local mills) has its CP content of about 10.93%, this is lower than the 11.26 to 12.19% reported by Fadugha (1990). Maize offal has been used to replace completely the maize component of fattening diets in NAPRI. Although, there is high competition between ruminant and monogastric animals, increased grain production is the only solution to its availability for use in livestock production. The mineral contents of maize offal are shown in table 1a.

Whole cotton seed

The cotton seed analyzed in this study were white and brown seeded. The brown seeded variety had higher CP and energy content than the white seeded type. The brown seeded variety has CP content similar to 25.4% reported by Millers (1964) while the CP value reported by Fadugba (1990) is similar to the CP content of the white seeded whole cotton seed investigated in the present study. The use of whole cotton seed as a protein source for ruminants has become more important because of the high cost of most conventional protein sources. Although, the production of cotton is declining in the country making the seed more expensive, increase in production of cotton is the only solution to increased availability of cotton seed to both the oil millers and to serve as protein source for cattle. Mineral composition of cotton seed is also presented in the Table 1a.

Cowpea by-product

Cowpea Pod shell: The CP content of cowpea pod shell in this study was about 9.73%. Alhassan

et al. (1987) reported values ranging from 6.9 to 7.1%. This feed resource is readily used by farmers and ruminants readily accept it (Alhassan *et al.,* 1987). The cowpea pod shell has the potential to be used with other feed resources to develop complete diets for fattening cattle.

5.1.2. Animal waste

Poultry litter: The use of poultry litter has been recognized as one of the ways to dispose of or recycle the otherwise waste products of the poultry industry. The CP content of poultry litter (18.65- 26.41%) reported in this study is higher than CP content of most forage (Millers, 1973; Blair Rains 1975). It is also higher than most of the crop residues of leguminous origin. The CP, CF, ADF and NDF of the poultry litter reported in this study are similar to the values reported by Adu and Lakpini (1984), Lamidi, (1995); Belewu and Adeneye (1996) and Fontenot, (1996) and The CP content reported in this study is comparable to those of whole cotton seed. However, the energy content of the litter is lower than what obtains in most conventional feedstuffs, probably because of the high ash content of the manure (Lowman and knight, 1971). The litter is also high in phosphorus, calcium and magnesium.

It is clear that there is a lot of potential for use of non-conventional feed resources both as protein and energy sources. This information and a lot more in the literature will form base line information for feed millers, scientists and individuals for more efficient utilization of these feedstuffs.

5.2.0. Experiment two:

Replacement value of sun-dried layer litter for cotton seed cake in the fattening diets for bulls

5.2.1. Nutritive value of the concentrates and the sorghum stover

The CP value of sorghum stover fed to the bulls is higher than the values reported by Alhassan *et al.* (1983) (3.8- 5.0 % CP) and Hena *et al.* (1991) (3.98%). The main reason for the difference in CP might be the differences in length of storage after grain harvest (Alhassan *et al.,* 1987). The values of ADF and NDF reported by Hena, *et al.* (1991) and Alhassan *et al.* (1987) for sorghum stover is higher than the value recorded in this trial. The nutritive value of maize offal used for this study is within the range reported previously (Fadugba, 1990). The CP content of sun-dried layer liter reported in this trial (19.58%) is within the range (16-21) reported by Fontenot, (1996). The DM content of the diets ranged from 90.16 to 94.76. Although the CP content of the diets was expected to decrease as the level of CSC was decreasing in the diets, poor laboratory analysis may be responsible for this observation. The decreasing energy content associated with increasing SDLL in the diets was due to increasing ash content of the diets as SDLL increased in the diets (Table1).

5.2.2. Dry matter and nutrient intake

The results of the feeding trial showed that total dry matter and concentrate intake were similar for diets containing 0, 25, 50 and 75% SDLL. This observation is consistent with those of Oliphant (1974); Denisov (1973); Adu and Lakpini (1983) and Lamidi (1995). The declining DMI observed on diets containing 100% SDLL replacement may be associated with grittiness and unpalatable nature of layer litter (Holzer and Levy, 1976). As a result, higher litter level in the diet will lead to the less palatable diet. The dry matter intake also follow the trend of the CP

contents of the diets. This apparent effect of crude protein on DMI agreed with the earlier reports of Horton, (1979) and is responsible lowered liveweight gain reported on diets containing more than 50% SDLL.. Dry matter intake expressed as percent body weight was lower than the 3.00% reported by NRC, (1980), indicating less acceptance of the concentrate containing higher proportions of SDLL.

The DMI expressed as percent body weigh reported for the diet containing 50% SDLL replacement was similar to 1.88% reported by Okorie *et al.* (1977) when he fed layer litter to cattle.

5.2.3. Liveweight changes

The average liveweight gains of bulls on the diet containing 50% SDLL replacement is similar to 0.87kg/day reported by Olayiwole *et al.* (1981) for Bunaji bulls fattened on conventional diets. However, the average daily weight gains of Bunaji bulls reported by Ikhatua and Olayiwole (1982); Olayiwole and Fulani (1980) and Olayiwole *et al.* (1975) were higher than those reported in this study. The differences between the present results and those of earlier trials cited here could be due to the type of concentrate (Maize, ground nut cake and cotton seed cake) and forages types (maize silage) used in those studies. The average daily weight gain reported in this study is lower than 1.10kg/day reported by Cullison *et al.* (1976) for steers fattened on diets containing dried poultry litter and soybean cake. The differences could be due to differences in the concentrate fed and genetic make up of the bulls. The reasons one can put forward as being responsible for the type of response observed on liveweight gains in the present trial is that poultry litter can supply enough ammonia for the growth of bacteria provided other nutrients (fermentable energy) are present (Elias 1971; Bryant and Robinson 1973). There is the need to provide some quantity of preformed protein (Belgado, *et al.* 1978). This is because some of the

rumen bacteria require amino acids and peptides (Hungate, 1966 and Orskov 1986) and volatile fatty acids for growth. However, since the levels of ammonia reported for all the treatments in the present study are above the 5mg/100ml required for maximum bacterial growth (Satter and Slyter, 1974), ammonia could not have been a limiting factor for feed utilization by the bulls on the diets. The major factors that could have influenced performance of bulls on treatments containing 0, 25 and 50% SDLL replacements and those containing 75 and 100% SDLL replacement in the present trial may be the fermentable energy content of the diets which reduced as the quantity of SDLL increased in the diets. This affects both intake and feed efficiency of the diets adversely (Oliphant, 1974; Smith and Calvert, 1976; Cullison *et al.* 1976 and Okorie *et al.* 1977) and dietary protein that might have escaped degradation in the rumen (by- pass protein) made available to the abomasum for host animal digestion (Minson, 1975; Johnson, 1976; Belewu and Adeneye, 1996). Consequently the diet containing 50% SDLL replacement appeared to give the best combination of maize offal, cotton seed cake and SDLL that gave the best live weight gain. This diet had the highest CP, DM and CP intake which resulted in the highest CP digestibility and nitrogen retention compared to the other treatments. The lower average daily liveweight gains of bulls on the diet containing higher SDLL i.e. 80% and 100%, could be due to lower energy content of the diet, reduced dry matter and CP intake, reduced CP digestibility and nitrogen retention of bulls on these diets. Similar observations have been made by Bhattacharya and Fontenot (1966); Tinnimit *et al.* (1972), Bastman (1973); Belgado, *et al.* (1978) and Belewu and Adeneye, (1996). However, contrary observation was made by Cullision *et al.* (1976) and Cooper *et al.* (1974). They observed no differences in daily weight gains when layer litter was fed at 0, 50, and 100% to replace soybean cake in diets containing maize grain and molasses**.** However, the type of poultry litter fed was not specified in

those studies.

Feed cost per kg liveweight gain which was observed to decline with increasing SDLL in the diet was as a result of the lower cost of SDLL compared with CSC. However, since the cheapest feed did not give the highest liveweight gains, this factor was not used in arriving at the best diet.

Body condition score

The improvement in the body condition score noticed at the end of the study is indication of improved feed utilization by the bulls. Although there were no differences in the condition scores between bulls on the different treatments at the end of the study, bulls on the treatment containing 50% SDLL replacement had the best body condition scores. This is because of better feed intake and feed utilization by the bulls on this treatment as compared to others. Feeding SDLL dose not adversely affect body condition score of the bulls.

5.2.4. Rumen ammonia nitrogen concentration (RAN) and rumen pH.

The RAN reported in this study is higher than 5mg/100ml required for maximum bacterial synthesis (Satter and Slyter 1974), but within the range 5-20mg/100ml reported by Leng and Nolan (1984) as the optimum rumen ammonia concentration required for maximum rumen functions. The higher level of RAN on diets containing higher SDLL (80 and 100%) replacements in the diets could be due to inefficient ammonia utilization due to lower fermentable energy content in the diets or higher evolution of RAN on these diets since SDLL levels were higher on those diets. The rumen pH reported in this study is higher than (6.0) the value below which cellulolytic digestion in the rumen could be inhibited, (Mould and Orskov 1984). It is therefore expected that adequate cellulolytic activities was taken place in the rumen of the bulls fed the experimental diets. Thus, RAN and rumen pH could not have been a limitation to the utilization of the diets.

5.2.5. Nutrients digestibility and nitrogen retention

Although there were no differences in the quantity of faeces produced by the bulls on the different diets, bulls fed the diet containing higher levels (75 and 100%) of SDLL replacement produced more faeces, this may have resulted in lower CP digestibility and nitrogen retention on those diets.

Water intake followed the trend of SDLL in the diets leading to increased urine output as the level of SDLL increased in the diets. This observation confirms those of McDonald, (1954) and Wohlt *et al.* (1973), who observed increase in water intake and urine excretion with increase in the levels of non protein nitrogen in diets. This is probably because additional water is required to get rid of excess end products of nitrogen metabolism accumulating in the blood.

Increase in proportions of SDLL in the diets resulted in increased water intake and urinary nitrogen loss especially when more than 50% of the CSC was replaced by the SDLL 50% in the diets. This observation is in conformity with earlier works reported by Annison, (1975); Tinnimit *et al.* (1972); Umunna and Woods, 1975; Smith and Calvert (1976); Oltjen and Dinius (1976) and Ikhatua and Olayiwole (1982). The implication of these results is that replacing CSC with more than 50% SDLL in fattening diets could lead to higher evolution of RAN, increased water intake and urinary nitrogen losses which could reduce animal performance.

All the bulls had positive nitrogen balance irrespective of the level of SDLL replacement in the diets. However, the drop in nitrogen retained observed on diets containing 75% and 100% SDLL replacement could be as a result of less efficient utilization of protein especially in view of the observation of Tinnimit *et al.* (1972); Smith and Calvert, (1976) and El-Sabban *et al*. (1970). They all observed decreased nitrogen retention when poultry litter made up more that half of the

nitrogen in the diet. Umunna *et. al*., (1982) also reported that sheep fed soybean meal had higher nitrogen retention than those fed urea alone. Nitrogen retained expressed as percent nitrogen intake was highest on the diet containing 50% SDLL replacement.

The decrease in digestibility co-efficient of dry matter and CP at the high levels of SDLL confirms the observations of Bhattacharya and Fontenot (1966); Lowman and Knight (1970); Tinnimit *et al.* (1972) and Okorie *et al.* (1977). Umunna *et al.* (1982) who reported similar decrease in CP and DM digestibility when lamb diets were supplemented with corn gluten meal plus urea. The crude protein digestibility of 49.48% reported on the diet in which the poultry litter was the sole source of nitrogen is slightly lower than 55% reported by Tinnimit *et al.* (1972). However, Smith and Calvert (1976) reported no difference in DM and CP digestibility when sheep were fed diets containing 0, 50 and 100% dried layer litter. The increase in digestibility of crude fibre, ADF, NDF ($P>0.05$) and ether extract ($P<0.05$) with increase in the level of SDLL in the diet follows the trend of crude protein intake in the diets. This observation corroborates the report of Smith and Calvert (1976) where soybean meal in sheep diet was substituted for dry poultry litter at 0, 50 and 100%. Digestibility of organic matter which tended to increase with increase in the level of SDLL in the diets, is in contrast to the observation of El-Sabban, *et al.* (1970) who reported exponential decline in the rate of organic matter digestibility from 67-76% as the level of poultry litter increased from 20% to 80%.

5.2.6. Carcass evaluation

The dressing percentages of the bulls in this study are lower than the 52.50% reported by Buvanendran *et al.* (1983) for Bunaji bulls. This might be due to lower feed quality and the consequent lower feed utilization, both of which resulted in lower weight gains of the bulls. However, the dressing percentages fall within the range (50—53.60%) reported by Olayiwole

and Fulani (1980). The weight of external offals is similar to the values reported by Olayowole and Fulani (1980) for legs (6.3-7.0kg), head (13.8 – 15.5kg) and for hide (21.8-24.6kg). The weights of the liver, heart and empty rumen are within the range reported for liver (3.6-4.9), heart (1.0-1.3kg) and empty rumen (3.4- 11.00kg) by Olayiwole and Fulani (1980) for Bunaji bulls fattened on conventional protein and energy sources. However, the value for empty intestine in the present study is lower than those reported by Olayiwole and Fulani (1980). The results of this study indicate that fattening bulls for 90 days on diets containing sun-dried layer litter may not have any negative effects on the organs of the animals.

Dissectible beef yield expressed as percent of carcass weight of the bulls in this study ranged from 64.43 to 66.26%, and is lower than the 69.4% reported by Buvanendran *et al.* (1983). The differences might be due to methods of dissecting the meat. In the present study all the meat could not be removed from the bones because of the local tools knives and axe) used leading to less beef yield. Meat to bone ratio of the bulls in the present study ranged from 4.80 to 4.96. This is slightly higher than the value of 4.1 reported by Buvanendran *et al.* (1983). Meat to bone ratio is an index of carcass merit in beef cattle (Berg and Butterfield, 1976), and the higher the ratio the higher the economic value of the carcass.

5.2.7. Economic Evaluation

Feed cost constitute more than 80% of the total cost of fattening cattle, therefore we consider only feed cost as an indices for calculating income since other costs are fixed. The income over expenditure which is the excess cash available after sales of the fattened bulls was highest on the diet containing 50% SDLL and it indicates that the farmer who fattened his bulls on this diet could gain N6228.00 within 90 days.

5.2.8. Conclusion

The result of this study indicates that Bunaji bulls can be fattened on diets containing sun-dried layer litter. The diet in which 50% of the cotton seed cake was replaced by the SDLL gave higher live weight gain of about 0.873kg and had improved the initial live weight of the bulls by about 23.19% and at a reduced cost of about 17.01% when compared to the diet containing 0% SDLL over a 90-day period. The bulls on this diet had higher DMI, DM and CP digestibility, nitrogen retention and feed efficiency when compared to bulls on other diets. The carcass of the bulls were heavier and meat to bone ratio was better, the income over feed cost was also highest. At higher levels (80% and 100%) of SDLL inclusion in the diets, liveweight gain decreased, DMI, DM and CP digestibility and nitrogen retention decreased. ~~The bulls on these treatments drank more water and had higher urinary nitrogen loss which contributed tothat resulted in lower daily weight gain~~. Although bulls can also be fattened on diets containing 80 and 100% SDLL, such bulls will have to be fattened longer than 90days and the farmer may make less profit.

There was no any visible detrimental effect of feeding SDLL on the bulls, probably because the litter was fed for a short period and substances such as arsenic, hormones and copper based drugs were not fed to the birds. Even in areas were these drugs are used for disease control in poultry Webb *et al.* (1980) has reported no deleterious effects in cattle fed the litter over a period of 150days. Martin and McCann (1996) concluded from their work that poultry litter does not appear to be a source of harmful micro-organisms when fed to beef cattle. Drugs such as antibiotics, nicabazin and amprolium may be the only source of concern to cattle fed poultry litter since some of these drugs are heavily used for disease prevention and control. However, Webb and Fontenot (1975) reported that these drugs do not accumulate in tissues of cattle after 5 days withdrawal from the feed.

5.3.0. Experiment three: Replacement value of sun-dried broiler litter for cotton seed cake in the fattening diets for Bunaji bulls

5.3.1. Nutritive value of the concentrates and Bracharia hay

The crude protein, DM, CF, EE, OM, and gross energy contents of the sun-dried broiler litter (SDBL) used in this trial are slightly higher than the values reported for autoclaved broiler litter (Belewu and Adeneye 1996). The differences might be due to differences in the methods of preserving the litter. Heating has been identified to reduce nitrogen content of litter (Harmon *et al.*, 1974 and Calvert, 1979). The CP value reported by Lamidi, (1995) is higher than the value obtained in this study. However, the CP content of broiler litter used for this study was within the range (25.43-31.53%) reported by Fontenot (1996) for broiler litter.

The CP value of Bracharia hay fed to the bulls is higher than the 3.8- 5.0% reported by Alhassan *et al.* (1987) and the 3.98% reported by Hena *et al.* (1991). The difference in CP content might be due to time of cutting and baling and length of stay on the field after bailing (Alhassan *et al.*, 1987). The values of ADF and NDF reported by Hena, *et al.* (1991) and Alhassan *et al.* (1987) is higher than what was reported in this trial, because of differences in the length of stay on the field.

The CP content of the diets is expected to increase with increasing SDBL in the diets; however the increase was only up to 25% SDBL inclusion thereafter it declined. Poor laboratory analysis might be responsible. The increasing levels of ADF and NDF observed with increasing levels of SDBL in the diets can be associated with higher levels of the nutrient in the SDBL. The decreasing gross energy content of the diets observed with increasing SDBL in the diets is due to

higher ash content associated with increasing SDBL in the diets (Lowman and Knight, 1971)..

5.3.2. Dry matter and nutrient intake

The lack of significant differences in the intake of the concentrate and total DM is consistent with the findings of Smith (1973); Cooper, *et al.* (1974); Smith and Calvert (1976); Kayongo and Irungu (1986); Odhuba, (1989) and Lamidi.,(1995). This may be attributed to good aroma and better palatability associated with broiler manure. Dry matter intake expressed as percent of body weight reported in this study (2.23% -2.49%) is close to the 3.0% reported by ARC (1980) This indicate that the fattening diets were accepted by the bulls.

5.3.3. Liveweight Changes

The daily liveweight gains (0.513kg/day to 0.914kg/day) obtained in this study are lower than the 1.07kg reported by Ikhatua and Olayiwole (1982) and Olayiwole and Fulani (1980) when they fattened bulls on conventional feedstuffs. However, the average liveweight gains of bulls on diets containing 0, 25 and 50% SDBL replacement were higher than the values of 0.87kg reported by Olayiwole *et al.* (1981) for Bunaji bulls. The better performance of the bulls on diets containing 0, 25 and 50% SDBL replacement could be as result of better feed intake and better feed utilization, which resulted in better feed efficiency and nitrogen retention, as compared to those on diets containing 75 and 100% SDBL replacement. Bulls on diets containing 75 and 100% SDBL lost higher proportions of nitrogen through the urine, and hence lower nitrogen retention and lower liveweight gains. Lower energy contents of the diets containing 75 and 100% were also responsible for the poorer performance of the bulls. Lowman and Knight (1970) had attributed the lower daily gains of cattle on dry poultry litter to lower energy content of the diet. This observation is similar to those of Oliphant (1974) and Cullision *et al.* (1976) when broiler

litter was fed to steers.

Feed efficiency.

The Lower feed efficiency observed at higher (75 and 100%) levels of SDBL in the diets could be as a result of inefficient feed utilization on these diets. These diets contained higher proportions of the SDBL and resulted in higher loss of nitrogen.

The lowest feed cost per kilogram liveweight gain observed on the diet containing 50% SDBL also indicates better feed utilization which resulted in better liveweight gain.

Body condition score

The improvement in condition score of the bulls between treatments observed at the end of the trial is due to better feed utilization of bulls on diets containing 0, 25 and 50% SDBL compared to the bulls on other treatments. This fed provided both preformed protein and non-protein nitrogen compound which led to better feed conversion and condition.

5.3.4. Rumen ammonia nitrogen concentration (RAN mg/100ml)

Rumen ammonia nitrogen concentration recorded in this trial ranged from 8.01 to 16.88mg/100ml. Optimum range (5 to 20mg/100ml) for effective rumen functions has been reported by Leng and Nolan (1984). The increasing RAN concentration as the level of SDBL increased in the diet is because SDBL is more soluble in the rumen than cotton seed cake and as it is more rapidly converted to ammonia Dinius (1976) and Wohlt *et al.* (1975).

Rumen ammonia nitrogen concentrations reported in this study are higher than 5mg/100ml reported by Satter and Slyter (1974) for optimum microbial production *in vitro*. It is also higher than 8.5mg/100ml reported for optimum bacterial yield (Okorie, 1977) and 8mg/100ml reported by Leng and Nolan (1984) as the critical ammonia nitrogen required for rumen function.

Therefore, differences in RAN concentration cannot be the limitation for the difference noticed on the performance of the bulls, since intensive microbial activities which will enhance better feed utilization was expected in the rumen of all the bulls.

5.3.5. Blood metabolites

Packed cell volume (PCV)

The packed cell volume reported in this trial is within the range (24-46%) reported by Coles 1974) for cattle. Olalokun and Oyenuga (1975) reported PCV values of 29.5 to 32.8% for White Fulani cattle in Nigeria, whereas Smith (1959) and Fiennes (1953) reported PCV values of 32.88 to 38.00% for Zebu cattle in the East Africa. The decreasing levels of PCV as the level of SDBL increased in the diets reflect the level of crude protein of the diets and CP intake by the bulls. This observation is in close agreement with those of Manston *et al.* (1975) and Oyedipe *et al.* (1984), who reported increase in PCV with increase in protein intake. Saror and Coles (1973) also reported a high association between protein intake and PCV level in Zebu cattle. It is therefore clear from the results that feeding SDBL up 100% to fattening bulls has no negative effects on the PCV of the bulls.

Total Protein (TP)

Value of total protein reported in this study falls within the range of 6- to 8mg/dl reported by Oyedipe *et al.* (1984). An increased level of blood protein with increased protein intake has also been reported by Oyedipe *et al.* (1984).

Blood serum urea nitrogen level

Blood serum urea nitrogen (BUN) level reported in this study is within the range of 6.3-25mg/100ml blood reported by Orskov *et al.* (1986) for animals on diets containing adequate

protein. The amount of urea nitrogen in the blood is a reflection of intake of effective rumen degradable protein and its balance with fermentable metabolizable energy (Orskov 1982). When higher blood serum urea nitrogen is noticed, there is an excess of effective rumen degradable protein to fermentable metabolizable energy in the diets (FAO, 1980). The increasing level of BUN observed with increasing SDBL in this study is an indication of inefficient utilization of ammonia nitrogen in bulls fed diets containing the higher level (75-80%) of SDBL (Utley *et al.*, 1970 and Ikhatua *et al.*, 1985). This can also be seen as reflected by the higher rumen ammonia nitrogen concentration on those treatments.

5.3.6. Nutrient digestibility and nitrogen balance

Apparent digestibility coefficient of DM was observed to decrease with the high levels of SDBL in the diets. This could due to decrease in the dietary crude protein intake. Similar observations were reported by Bhattacharya and Fontenot (1966); Lowman and Knight (1970); Tinnimit *et al.* (1972) with cattle; and Smith and Calvert (1972); Okorie *et al.* (1977) and Adu and Lakpini ((1983) with sheep

Nitrogen balance

Water intake tended to increase with increasing levels of SDBL in diets. This was required to eliminate the nitrogenous end products of metabolism which accumulated in the blood as a result of increased level of SDBL (Ikhatua and Olayiwole, 1982 and Ikhatua *et al.*, 1985).

Nitrogen balance was positive for bulls on all the treatments. This indicates that all the nitrogen absorbed was well tolerated and utilized, however, the lower level of nitrogen retained on diets containing 75% and 100% SDBL may be due to SDBL being hydrolyzed into ammonia more rapidly than the ammonia could be fixed into microbial protein. The excess ruminal ammonia could be lost as urea through the urine. This could account for the greater urinary N loss and the

higher blood urea nitrogen on the diets containing 75 and 100% SDBL. This observation is in agreement with those of Bhattacharya and Fontenot (1966) and Smith and Calvert (1976) when they fed poultry litter to sheep and those of Adegbola et al. (1990 when they fed urea to sheep.

5.3.7. Carcass evaluation

Dressing percentage of the bulls is within the range of 50.00 to 53.00% reported by Olayiwole and Fulani (1980) for Bunaji bulls fattened on conventional diets. However, higher dressing percentages (60.00%-61.00%) were reported by Cullision *et al.* (1976) for steers fattened on poultry litter, maize grain and soybean cake diets. The differences in dressing percentage between what is reported in the present study and those cited above could be due to high quality of the concentrate (maize grain and soybean cake) fed in those studies as compared to maize offal, cotton seed cake and bracharia hay offered to the bulls in the present study.

The weights of various internal and external offals reported in this study are within the weight range reported by Olayiwole and Fulani (1980). This indicates that there were no detrimental effects of feeding sun-dried broiler litter to the bulls.

5.3.8. Conclusion

Sun-dried broiler litter can replace up to 50% of the cotton seed cake in fattening diets without any significant reduction in the performance of bulls. The bulls on this diet had their initial weights improved by 25.13% and feed cost per gain was also least on the diet. The income over feed cost which was the most important economic factor for the farmers is also highest on the diet containing 50% SDBL. Bulls on diets containing 75 and 100% SDBL replacement had lower liveweight gain, feed efficiency, nitrogen retention and value of gain. Feeding of SDBL to bulls did not result in any visible detrimental effect on the health of the bulls with the 90 days trial. All the organs of the bulls fattened on the diets containing various proportions of SDBL did

not have any abnormality to indicate any negative effects of feeding SDBL.

5.4.0 Experiment four:
The effect of feeding graded levels of maize offal and whole cotton seed on the feedlot performance of Bunaji bulls

5.4.1. Nutrient content of whole cotton seed (WCS) and gamba hay

The crude protein content of WCS used in this study falls within the range (20-25%) reported by Ikurior and Fetuga (1984); Haggar, (1974) and Millers *et al.* (1964) for most of the cotton seed in the country. The CP content of Gamba hay used for this study falls within the value reported by Haggar, (1974) and Zemmelink *et al.* (1972) for gamba cut in October. In general the CP content of grasses tends to decline as the season progresses (Blair Rains,1963; de leeuw, and Brinkman, 1974.)

5.4.2. Voluntary dry matter and nutrient intake

The gradual decrease in the crude protein content of the diets as the level of WCS decreased in the diet was due to the reduction in the proportions of WCS in the diet. The WCS has higher protein content than maize offal. The decreased intake of concentrate and total dry matter with increasing WCS in the diets is probably because cattle tend not to eat large quantity of WCS because of the fluff nature of the seed (Coppock, et al 1985). Similar observations have been reported (Smith *et al.,* 1981 using Holstein cattle; Coppock *et al.,* 1985, using Jerssy, Lubis *et al.,* 1990 and Lanham *et al.,* 1992 using Holstein cattle). In the present study, feed intake was not affected up to 40% WCS level in the diets, contrary to the findings of Smith *et al.* (1981), who reported negative effect on DMI at 30% WCS inclusion in the diet.

There has been conflicting reports on intake of WCS. While Coppock *et al,* (1985) and Lanham *et al.* (1992) reported a decrease in DMI with increase in WCS in a trial conducted during the hot

season, Belibasskis and Tsirgogianni (1995) reported that feeding WCS in diets whose fibre content was similar to the control diet did not induce a reduction in DMI. In another trial conducted in a mild weather condition, Wilka *et al.* (1991) reported an increase in DMI when WCS was fed. Therefore, DMI response to inclusion of WCS in a diet is a function of both climatic and dietary factors.

5.4.3. Liveweight changes

Mean daily liveweight gains reported in this study (0.470kg- 0.789kg/day) were lower than the 0.88kg reported by Olayiwole *et al.* (1981) for Bunaji bulls and the 1.10kg/day reported by Olayiwole *et al.* (1975) for steers fed groundnut cake, undelinted CSC and guinea corn plus gamba hay. The reasons that may be attributed to the differences in liveweight gain is the concentrate (maize or sorghum grains, groundnut cake and CSC plus maize silage) offered in the trials sited above, as compared to maize offal and WCS offered in the present trial.

At the end of the fattening period of 90days, the bulls on the diet containing 40% WCS had their initial weights improved by 28.63%. This level of improvement is however lower than the range of 30-40% reported by Olayiwole, *et al.* (1981.) when bulls were fattened on conventional fattening diets of maize grain and cotton seed cake. The lower daily liveweight gains recorded on the diets containing 60 and 80% WCS might be as of a result of lower concentrate and total feed intake, lower DM digestibility and lower feed utilization of the bulls on those diets as reflected in lower nitrogen retention (Table 20).

There was no evidence that bulls on the highest level of WCS could have consumed enough WCS to cause gossypol toxicity, going by the recommendation of Coppock *et al.* (1987). The calculated gossypol intake level in the present study ranged from 0.012 to 0.023% and 0.013 to 0.036% for free and bounded gossypol respectively. These levels are lower than the 0.084% free

gossypol fed to adult cattle with functional rumen without any form of toxicity (Lindsey *et al.*, 1980). Apart from the fact that the quantity of WCS offered to the bulls was small ruminant animals also have the ability to tolerate gossypol because of their ability to detoxify gossypol by binding it with epsilon amino group of lysine (Raiser and Fu, 1962, and Risco *et al.*, 1992) to form a complex which is excreted in the faeces as bound gossypol. Despite these, some level of toxicity has been reported by Lindsey *et al.* (1980) in adult Holstein injected with gossypol. Adult ruminants with functional rumen have been considered relatively tolerant to gossypol (Smith and Collar, 1981).

Feed efficiency (feed/gain): Feed efficiency of 9.04 recorded on diet the containing 40% WCS compares well with what Olayiwole *et al.* (1981) reported for bulls fattened for 110 days. The diet containing 40% WCS was most efficiently utilized as reflected by its high crude protein and DM digestibility and better nitrogen retention.

Body condition scores**:** Although, there were no differences in the body condition score between bulls on the various test diets, bulls on the diets containing 40 and 20 % WCS had better condition score. This is due to better utilization of the feed resulting in higher liveweight gain.

5.4.4. Rumen ammonia nitrogen concentration and rumen pH.

The rumen pH reported in this study is higher than the values of 6.0 reported to inhibit cellulolytic digestion in the rumen Mould and Orskov (1984). The pH also falls within the range of 6.5-6.8 reported by Mould *et al.* (1983) and Ndlovn, *et al.* (1985) to be the optimum for cellulosis. Therefore adequate cellulolytic activities are expected in the rumen of all the bulls on the various dietary treatments.

Rumen ammonia nitrogen concentration (11.35-21.95mg/100ml) reported in this study is higher than 5mg/100ml reported by Satter and Slyter (1974) as the minimum for optimum microbial

production *in vitro.* The rumen ammonia nitrogen concentration in the present study is therefore, not a limiting factor in the digestion of the feed since optimum bacteria activities are expected in the rumen of all the bulls irrespective of the WCS level in the diet.

5.4.5. Blood Metabolites

Total protein (TP) and blood urea nitrogen (BUN). The levels of TP and BUN reported in this study are within the range of (7.45 to 7.67mg/dl total protein) and (13.3 to 18.5mg/dl blood urea nitrogen) reported by Coppock *et al.* (1985) for cattle with normal renal function. The increasing BUN with increase in WCS in the diet reported in this study is consistent with the observation of Coppock *et al.* (1985) and it is a reflection of the quantity of WCS in the diets. The concentration of BUN is regulated not only by renal excretion but also by the quantity of protein consumed and /or ruminally degradable protein, provided that there is enough energy for the micro organisms in the rumen (Castelli, *et al.,* 1993). In the present study, the higher BUN observed with increasing WCS level in the diet may also be as a result of lower level of energy source (maize offal) in the diet containing 80% WCS, hence rumen microbes cannot efficiently utilize the rumen ammonia resulting from degradation of WCS. This is reflected by the higher rumen ammonia concentration observed on the treatment containing 80% WCS.

Packed cell volume (PCV)

The observed increase in PCV associated with increase in the level of WCS up to 60% in the diet is in line with the observations of Coppock *et al.* (1985); Saror and Cole (1973) and Oyedipe *et al.* (1984). They all showed that reduction in crude protein intake resulted in depressed PCV and TP in Zebu cattle. The values for BUN (12.68 – 15.20mg/dl), PCV (30.25- 34.75%) and TP (7.65 – 7.85 mg/dl) reported in this study are within the normal range reported for healthy cattle (Coppock *et al.,* 1985 and Oyedipe *et al.,* 1984). Therefore, there is no indication of any

gossypol toxicity from the parameters measured on these bulls as a result WCS feeding, although the study was for a short period.

5.4.6. Nutrient digestibility and nitrogen balance

Nutrient digestibility

Lower dry matter digestibility (DMD) observed on diet containing 80% WCS conform to the observation of Coppock *et al.* (1985) and this might be due to increase CP intake of the animals. Steen (1989) has also reported increased DMD as a result of increased protein intake. The level of dietary CP intake also influence CP digestibility (Haggar and Ahmed 1970., Adu, 1982., Hassan and Bryant, 1986 and Sahlu *et al.* 1993). The better CP digestibility on the diet containing 40% WCS among other factors resulted in better average daily weight gains. Similar result has been reported by Palmquist and Jenkins (1980) and Coppock *et al.* (1985) when they fed WCS to cattle.

The increased CF, ADF and NDF digestibility observed with increase in the level of WCS in the diet is in agreement with the findings of Palmquist and Jenkins (1980) and Coppock *et al.* (1985). Addition of fat to ruminant diets is known to depress fibre digestibility, because of inhibitory effect of oil on rumen microbial activities (Palmquist and Jenkins, 1980). However, it appears from the work of Smith *et al.* (1981) and Keele and Roffler (1982) that excessive reaction with lipid occur within the rumen and that the response from feeding WCS differ greatly from feeding the component parts, especially the oil. This is because the processes of regurgitation, mastication and re in-salivation and the fact that the oil is encapsulated probably causes a slow release of fat from WCS into the rumen milieu

The increase in the digestibility of ether extract with increasing levels of WCS in the diets is consistent with the findings of Anderson *et al.* (1982), Coppock *et al.* (1985), Coppock *et al.*

(1987) and Zinn (1995) and it is attributed to the formation of feacal soap that are insoluble in ether. If the fatty acid combined in feacal soap are not detected, lipid digestibility co-efficient will be artificially high.

Nitrogen retention

Increased water intake observed with increasing WCS in the diets could be due to the need to eliminate by products of excess protein digestion in the rumen (e.g. BUN). This also is responsible for the copiously excreted urine by the bulls on the diet containing 80% WCS. Bulls on the diet containing 80% WCS had frequent scouring; this may also have contributed to the low digestibility of nutrients noticed on this diet. Olayiwole *et al.* (1975) and Marion *et al.* (1976) also reported scouring in cattle fed WCS above 50%.

Daily urinary and faecal - N loss indicated that more nitrogen was lost at higher levels of WCS. Mean daily nitrogen retention showed that all the bulls were in positive nitrogen balance. The decreasing nitrogen retention associated with increasing WCS in the diets is as a result of lower CP intake and lower metabolizable energy content and inefficient utilization of in the diet due to scoring effect of WCS on the animals and higher blood urea nitrogen level. Murphy *et al.* (1994) and Hassan and Bryant, (1986) made similar observation when they fed WCS to lactating cows. The lower CP digestibility, N-intake and lower nitrogen retention recorded on the diet containing the highest (80%) level of WCS is in agreement with the findings of Olayiwole *et al.* (1975), Marion *et al.* (1976) and Mosi and Butherworth (1985).

.5.4.7 Carcass evaluation

The dressing percentage reported in this study is slightly lower than 52.50 to 53.98% reported by Olayiwole *et al.* (1975) for Bunaji steers fed high energy rations. However, the values are comparable to 50.2 to 53.6% reported by Olayiwole and Fulani (1980) using intact Bunaji bulls.

The weights of other parts (external and internal) and offals reported in this study are within the range reported by Olayiwole and Fulani (1980) for Bunaji bulls fattened on high energy diets. These results indicate that fattening bulls for 90 days on diets containing WCS had no negative affect on the organs and parts of the bulls. Gossypol has been reported to accumulate mainly in the liver followed by the kidney and heart of sheep, goats (Nikokyris *et al.* (1991) and cows (Hawkins *et al.,* 1985.) fed free gossypol at high concentrations for a period of above one year. From the work of Nikokyris *et al.* (1991), the concentration of free gossypol in all the organs examined were much lower than the maximum free gossypol level of 450mg kg^{-1} in cotton seed based protein products for human consumption {as established by the Food and Drug Administration and Control of United States (Jones, 1988)}. Despite the fact the that gossypol was fed at very high level and for over a year. It is therefore safe to say that it is not likely that gossypol will accumulate in the liver, kidney and heart of the bulls fattened in this study that may result in any adverse effect on the consumers, because the level of WCS fed to the bulls were not up to the 3-4kg WCS /day recommended by Arieli (1998) and Coppock *et al.* (1987) as safe for cattle. In addition the trial was conducted for only 90 days. Also the level of gossypol in the diet is low. In Nigeria meat and other food are properly cooked in most communities before eating. Therefore, any free gossypol that may be found in the organs will be destroyed by heat (i.e. changed to bounded form) and be excreted in the faeces.

5.4.8. Economic evaluation

The cost of producing 1kg of liveweight in the study was lowest on diet containing 40% WCS. This is due to efficient feed utilization leading to high liveweight gain of bulls on this diet. Feed account for about 70-80% of the total cost of fattening bulls (Powel, 1975, Olayiwole *et al.,* 1981); and since feed cost was the major cost monitored during the study; the economic returns

were based on this. The calculations of other cost such as capital required for pens, depreciation, and purchase of stock and labour were not considered. The income over feed cost was highest on the diet containing 40% WCS. The implication is that the farmer can make up to ₦4084.50 or more on bulls fattened on a diet containing 40%WCS and 60% maize offal when sold on hooves or when the bulls are slaughtered.

5.4.9. Conclusion

It can be concluded from this study that Bunaji bulls can be fattened on diets containing maize offal and WCS. Bulls on diets containing 40% WCS and 60% maize offal had the highest liveweight gain of 0.789kg/day. This diet was most efficiently utilized with, high crude protein digestibility and nitrogen retention. Inclusion of WCS at higher level (60-80%) led to lower intake of DM, CP, Organic matter, ADF and NDF. The animals on such diets had increased urine and faecal output with frequent scouring, higher nitrogen loss, low nitrogen retention and low nutrient digestibility, and consequently reduced liveweight gain.

Results of blood metabolites (PCV and total protein) and carcass evaluation did not indicate any sign of toxicity from feeding WCS, although, there has been report of gossypol accumulation in liver, kidney and heart in cattle fed WCS (Nikokyris *et al.,* 1991). It is not likely that the bulls fattened in the present study will have any gossypol toxicity because the amount of WCS fed was lower than the safe recommended level of 3-4kg WCS /day for cattle (Arieli 1998 and Coppock *et al.* 1987). The trial also lasted for a short period of 90 days. Adult ruminants with functional rumen can also tolerate gossypol, because of their ability to detoxify it by binding it with epsilon amino group of lysine to form a complex which is excreted in the faeces as bound gossypol.

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6.0 Summary and general conclusion

Feedlot fattening of Bunaji bulls using non-conventional feed sources were investigated. Four different experiments were conducted.

Experiment I: Determined the nutrient compositions of some non-conventional feed sources.

Experiment II : Determined the replacement value of sun-dried layer liter (SDLL) for cotton seed cake in the fattening diets for Bunaji bulls.

Experiment III: Determined the replacement value of sun-dried broiler litter (SDBL) for cotton seed cake in the fattening diets for Bunaji bulls.

Experiment IV: Determined the effects of graded levels of maize offal and whole cotton seed on the fattening performance of Bunaji bulls.

The result of the first experiment showed that feed sources like cowpea haulms, cowpea pod shell, whole cotton seed and poultry litter have high crude protein content which range from 9.73% for cowpea pod shell to 26.41% for broiler litter. They can replace the conventional protein sources like the oil seed cakes as good protein source for fattening cattle. The peel of tubers and the whole plants and the maize offal can also serve as sources of energy for ruminants. The maize husk, sorghum stover, and panicle can also serve as good roughages if collected as soon as the grains are harvested.

The results of the second experiment showed that Bunaji bulls can be fattened on diet containing sun-dried layer litter using sorghum stover as the basal ration. SDLL should not replace more than 50% of the CSC (weight for weight) otherwise intake will decrease. Diet in which 50% of the CSC in the diet was replaced by SDLL gave highest average daily liveweight gain of 0.873kg/head. This represented an increase of about 23.19% liveweight at a reduction of about

17.01% in feed cost compared to diet without SDLL. Fattening of bulls on diet in which higher level (75 and 100%) of SDLL replacing CSC will result in lower concentrate intake and weight gain. Such bulls will be fattened for longer time. The economic returns from fattening a bull on this diet is ₦ 6228.00 as compared to ₦ 1303.35 for bulls fattened on diet without SDLL.

The result of the third experiment showed that bulls can be fattened on diet containing 60% maize offal, 20% CSC and 20% SDBL without any detrimental effects on concentrate intake and weight gain. The bulls on this diet had their liveweight improved by 25.13% as compared to 27.23% for bulls on diets without SDBL and at 20.82% reduction in feed cost. A farmer can make about ₦ 5403.52 or more on each bull as compare to ₦ 5141.03 for bull on diet without SDBL. There was no any noticeable detrimental effect of feeding poultry litter to bulls on the two experiments.

The result of the fourth experiment showed that fattening concentrate diet should not contain more than 40% whole cotton seed other wise intake of the concentrate will be negatively affected. Bulls can be fattened on concentrate diet containing 40% whole cotton seed and 60% maize offal. This diet was most efficiently utilized and gave liveweight gain of about 0.789kg/head/day which represented about 28% improvement over the initial liveweight of the bulls. Diet containing higher (80%) levels of whole cotton seed resulted in lower dry matter intake of the concentrate, crude protein digestibility and liveweight gain. The diet containing 40% WCS had the least cost per kilogram live weight gain. The mean daily liveweight of the bulls on diets containing 40% WCS were improved by 40.49, 28.10 and 20.07% when compared with those on the diet containing 80, 60 and 20% WCS. Farmer may gain about N4084.53 or more when bulls are fattened for 90days on diet containing 40% whole cottonseed and 60% maize offal. No sign of toxicity was observed on any of the bulls fed different levels of whole

cotton seed during the experimental period.

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APPENDICES

APPENDIX I.

Summary of ANOVA for dry matter intake, crude protein, intake as percent body weight, live weight changes, feed efficiency of bulls fattened on diet containing sun dried layer litter (SDLL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Concentrate intake	4	15	19	2.923	0.678	4.32**
Sorghum stover intake	4	15	19	0.128	0.129	1.00ns
DMI	4	15	19	2.770	1.267	2.91ns
DMI as % body weight	4	15	19	0.186	0.138	14.86ns
Crude protein intake	4	15	19	0.211	0.037	5.63**
Live weight changes	4	15	19	0.0618	0.004	15.38***
Feed efficiency	4	15	19	0.00048	0.00041	1.18ns

** Significant at 5% level, *** Significant at 1% level, ns= not significant
DF= Degree of freedom

APPENDIX II.
Summary of ANOVA for digestibility of nutrient by bulls fattened on diet containing sun dried layer litter (SDLL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
DMD	4	10	14	38.747	10.074	3.85**
CPD	4	10	14	770.62	5.84	131.95***
OMD	4	10	14	20.246	8.850	2.29ns
ADFD	4	10	14	85.247	38.116	2.24ns
NDFD	4	10	14	158.70	2.227	7.85**
DOMD	4	10	14	12.29	7.32	1.68**
DCPI	4	10	14	2290.05	145.15	14.86**

** Significant at 5% level, *** Significant at 1% level,ns= not significant
DF= Degree of freedom
DMD = Dry matter digestibility,
CPD= Crude protein digestibility
OMD = Organic matter digestibility
ADFD Acid detergent fibre digestibility
NDFD = Neutral detergent fibre digestibility

APPENDIX III.

Summary of ANOVA for urine output, water intake, nitrogen intake and nitrogen balance of bulls fattened on diet containing sun dried layer litter (SDLL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Water intake	2	10	12	18.96	18.78	1.01ns
Urine output	2	10	12	5.71	3.85	1.48ns
Faecal output	2	10	12	0.053	0.159	0.34ns
Urinary nitrogen	2	10	12	0.0003	0.0001	2.31ns
Faecal nitrogen	2	10	12	0.001	0.00008	14.04**
Nitrogen intake	2	10	12	0.001	0.0004	3.06ns
Nitrogen output	2	10	12	0.002	0.0003	5.89***
Nitrogen retention	2	10	12	0.004	0.0001	30.57***

** Significant at 5% level
*** Significant at 1% level
ns= not significant
DF= Degree of freedom

APPENDIX IV.
Summary of ANOVA for rumen ammonia nitrogen level, rumen pH value of bulls fattened on diet containing sun dried layer litter (SDLL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Initial RAN	4	15	19	0.29	0.33	0.90ns
Final RAN	4	15	19	28.12	1.85	15.17***
Initial pH	4	15	19	1.019	0.091	11.22ns
Final pH	4	15	19	0.448	0.200	2.24ns

** Significant at 5% level
*** Significant at 1% level
ns= not significant
DF= Degree of freedom

APPENDIX V.
Summary of ANOVA for total feed cost, values of gain and income over feed cost of bulls fattened on diet containing sun dried layer litter (SDLL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Total cost of feed	4	15	19	1085731	125716	8.64**
Consumed per animal						
Value of gain per animal	4	15	19	11471063	745875	15.38***
Income over feed cost	4	15	19	13813242	2073059	6.66**

** Significant at 5% level
*** Significant at 1% level
ns= not significant
DF= Degree of freedom

APPENDIX V I
Summary of ANOVA for dressing percentage, weight of various organs of bulls fattened on diet containing sun dried layer litter (SDLL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Dressing percentage	1	3	4	0.36	0.17	2.11
Meat :bone ratio	1	3	4	0.16	0.37	0.43ns
Dissectible beef	1	3	4	34.72	52.46	0.66ns
Liver	1	3	4	0.084	0.160	0.53ns
Heart	1	3	4	0.018	0.022	0.84ns
Quantity of beef as %						
carcass weight	1	3	4	1.048	0.392	2.68ns

ns= not significant
DF= Degree of freedom

APPENDIX VII.

Summary of ANOVA for dry matter intake, crude protein, intake as percent body weight, live weight changes, feed efficiency of bulls fattened on diet containing sun dried broiler litter (SDBL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Concentrate intake	4	15	19	0.019	0.492	0.04ns
Digitaria hay intake	4	15	19	0.017	0.077	0.23ns
DMI	4	15	19	0.021	0.453	0.05ns
DMI as % body weight	4	15	19	0.0455	0.055	0.83ns
Crude protein intake	4	15	19	0.001	0.0005	2.11ns
Live weight changes	4	15	19	0.094	0.0089	10.44**
Feed efficiency	4	15	19	0.006	0.0002	9.16***

** Significant at 5% level
*** Significant at 1% level
ns= not significant
DF= Degree of freedom

APPENDIX VIII

Summary of ANOVA for Summary of ANOVA for digestibility of nutrient by bulls fattened on diet containing of bulls fattened on diet containing sun dried broiler litter (SDBL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
DMD	4	10	14	11.76	8.56	1.37ns
CPD	4	10	14	12.38	5.61	2.21ns
OMD	4	10	14	8.88	7.76	1.14ns
ADFD	4	10	14	16.07	23.82	0.67ns
NDFD	4	10	14	54.37	16.46	3.30**

** Significant at 5% level
*** Significant at 1% level
ns= not significant
DF= Degree of freedom

DMD = Dry matter digestibility
CPD = Crude protein digestibility
OMD = Organic matter digestibility

ADFD Acid detergent fibre digestibility
NDFD = Neutral detergent fibre digestibility

APPENDIX IX.

Summary of ANOVA for urine output, water intake, nitrogen intake and nitrogen balance of bulls fattened on diet containing sun dried broiler litter (SDBL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Water intake	2	10	12	18.956	18.777	0.48ns
Urine output	2	10	12	5.706	3.853	4.52ns
Faecal output	2	10	12	0.162	0.135	1.20ns
Urinary nitrogen	2	10	12	0.0003	0.0001	2.55ns
Faecal nitrogen	2	10	12	0.0003	0.0001	4.18**
Nitrogen intake	2	10	12	0.0023	0.0008	2.84ns
Nitrogen output	2	10	12	0.0006	0.0004	1.38ns
Nitrogen retention	2	10	12	0.00435	0.00015	4.51***

** Significant at 5% level
*** Significant at 1% level
ns= not significant
DF= Degree of freedom

APPENDIX X.

Summary of ANOVA for rumen ammonia nitrogen level, rumen pH value, Blood urea level and Packed cell volume of bulls fattened on diet containing sun dried broiler litter (SDBL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Initial RAN	4	15	19	0.159	1.445	0.11ns
Final RAN	4	15	19	24.47	1.72	15.94***
Initial BUN	4	15	19	0.070	0.062	1.15ns
Final BUN	4	15	19	2.740	0.676	4.05**
Initial PCV	4	15	19	16.08	21.30	0.75ns
Final PCV	4	15	19	77.37	12.02	6.44**
Initial TP	4	15	19	0.58	0.11	5.20ns
Final TP	4	15	19	0.419	0.135	3.12ns

** Significant at 5% level
*** Significant at 1% level
ns= not significant

DF= Degree of freedom

BUN= Blood urea nitrogen, PVC= Packed cell volume, TP= Total protein, RAN= Rumen ammonia nitrogen level

APPENDIX XI
Summary of ANOVA for total feed cost, values of gain and income over feed cost of bulls fattened on diet containing sun dried broiler litter (SDBL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Total cost of feed Consumed per animal	4	15	19	641.74	59.81	10.73**
Value of gain per animal	4	15	19	17902688	1668750	10.73**
Income over feed cost	4	15	19	4513099	1689960	2.67**

** Significant at 5% level
DF= Degree of freedom

APPENDIX XII
Summary of ANOVA for dressing percentage, ad weight of various organs of bulls fattened on diet containing sun dried broiler litter (SDBL)

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Dressing percentage	1	3	4	0.479	0.376	1.27ns
Meat :bone ratio	1	3	4	0.008	0.026	0.32ns
Dissectible beef	1	3	4	59.09	70.65	0.84ms
Liver	1	3	4	0.065	0.141	0.46ns
Heart	1	3	4	0.004	0.036	0.11ns
Quantity of beef as % carcass weight	1	3	4	3.04	5.00	0.61ns

ns= not significant
DF= Degree of freedom

APPENDIX XIII.

Summary of ANOVA for dry matter intake, crude protein, intake as percent body weight, live weight changes, feed efficiency of bulls fattened on diet containing graded levels of maize offal and whole cotton seed

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Concentrate intake	3	12	15	1.83	0.55	3.33**
Digitaria hay intake	3	12	15	0.078	0.034	2.32ns
DMI	3	12	15	2.28	0.58	3.95**
DMI as % body weight	3	12	15	0.147	0.065	2.27ns
Crude protein intake	3	12	15	11201.04	23337.66	0.48ns
Live weight changes	3	12	15	0.0716	0.0004	164.78*
Feed efficiency	3	12	15	7.53	1.14	6.64**
Free gossypol intake	3	12	15	0.00038	0.000013	30.45***
Total gossypol intake	3	12	15	0.00046	0.000016	29.03***

** Significant at 5% level, *** Significant at 1% level, ns= not significant
DF= Degree of freedom

APPENDIX XIV

Summary of ANOVA for Summary of ANOVA for digestibility of nutrient by bulls fattened on diet containing of bulls fattened on diet containing graded level of maize offal and whole cotton seed

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
DMD	3	8	11	64.54	36.34	1.78ns
CPD	3	8	11	170.54	42.41	4.02**
OMD	3	8	11	26.49	29.57	0.90ns
ADFD	3	8	11	21.68	49.90	0.43n
NDFD	3	8	11	103.80	73.78	1.41ns

** Significant at 5% level
ns= not significant
DF= Degree of freedom

DMD = Dry matter digestibility
CPD = Crude protein digestibility
OMD = Organic matter digestibility

ADFD Acid detergent fibre digestibility
NDFD = Neutral detergent fibre digestibility

APPENDIX . XV

Summary of ANOVA for urine output, water intake, nitrogen intake and nitrogen balance of bulls fattened on diet containing sun dry graded levels of maize offal and whole cotton seed.

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Water intake	3	8	11	4.98	10.83	0..46ns
Urine output	3	8	11	2.97	0.78	3.78**
Faecal output	3	8	11	0.06	0.19	0.30ns
Urinary nitrogen	3	8	11	106.79	49.79	2.14ns
Faecal nitrogen	3	8	11	205.44	85.69	2.40ns
Nitrogen intake	3	8	11	134.60	236.44	0.57ns
Nitrogen output	3	8	11	275.57	135.57	2.03ns
Nitrogen retention	3	8	11	436.37	76.83	5.68**

** Significant at 5% level
*** Significant at 1% level
ns= not significant

APPENDIX . XVI

Summary of ANOVA for rumen ammonia nitrogen level, rumen pH value, Blood urea level and Packed cell volume of bulls fattened on diet containing graded level of maize offal and whole cotton seed.

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Initial RAN	3	12	15	0.56	0.33	1.69ns
Final RAN	3	12	15	87.40	1.05	83.16**
Initial BUN	3	12	15	0.809	0.245	3.25*
Final BUN	3	12	15	5.813	0.515	1128**
Initial PCV	3	12	15	0.73	0.47	1.52ns
Final PCV	3	12	15	12.91	2.08	6.20ns
Initial TP	3	12	15	0.174	0.142	1.22ns
Final TP	3	12	15	0.068	0.024	2.77ns
Initial pH	3	12	15	0.042	0.012	3.52**
Final pH	3	12	15	0.18	0.007	24.23***

** Significant at 5% level
*** Significant at 1% level
ns= not significant

DF= Degree of freedom

BUN= Blood urea nitrogen, PVC= Packed cell volume, TP= Total protein, RAN= Rumen ammonia nitrogen level

APPENDIX XVII

Summary of ANOVA for total feed cost, values of gain and income over feed cost of bulls fattened on diet containing graded levels of maize offal and whole cotton seed

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Total cost of feed Consumed per animal	3	12	15	1409095.5	647783.3	2.18ns
Value of gain per animal	3	12	15	13058906	79219	164.85***
Income over feed cost	3	12	15	8026990	476810	16.83***

*** Significant at 5% level

DF= Degree of freedom

APPENDIX XVIII

Summary of ANOVA for dressing percentage, ad weight of various organs of bulls fattened on diet containing graded levels of maize offal and whole cotton seed.

	SOURCE OF VARIATION					
	Treatment	Error	Corrected total	MEAN SQUARE		F-VALUE
SOURCE	DF	DF	DF	Treatment	Error	Treatment
Dressing percentage	1	3	4	1.22	1.71	0.71ns
Meat :bone ratio	1	3	4	0.515	0.156	3.29ns
Dissectible beef	1	3	4	26.45	23.87	1.11ns
Liver	1	3	4	0.0014	0.0046	0.31ns
Heart	1	3	4	0.0019	0.0004	4.63ns

ns= not significant

DF= Degree of freedom

APPENDIX XIX Urease Nesslerization Method for Determining Blood Urea (Archer and Robb,1925).

The method is based on the principle that urea is converted into ammonium carbonate by the action or urease. The solution is treated with Nessler's reagent and its esinction (Optical Density) is compared with that of a nesslerized ammonium chloride solution of known strength. Nearly all the ammonia in the final test is derived from urea.

Method

2ml of distilled water was put into a centrifuge tube

0.20ml of blood already preserved with 20% potassium oxalate and kept at $4^{o}C$ was added to the centrifuge tube.

0.20ml of freshly shaken urease suspension was added and the mixture mixed.. The tube was stoppered and incubated in water bath maintained at $50^{o}C$ for 30 minutes.

After this, 0.30ml of diluted sulphoric acid (0.67N H_2SO_4) was added and the mixture mixed.

0.30ml of sodium tungstate, $Na_2WO_4.2H_2O$ solution was added and the mixture mixed.

4.0ml of distilled water was measured into the test tube.

5.0ml of supernatant liquid after centrifuging was added to the test tube.

2.0ml of Nessler regent was also added and mixed thoroughly.

9.0ml of standard solution 2 (see above) was measured into another test tube and 2.0ml of Nessler's reagent was added and mixed thoroughly. This represented a blood urea concentration of 50mg/100ml.

The percent transmittance of the two solutions ere immediately read from spectrophotometer (spectronic 20, Bausch and lomb) at wave length of 430nm. Blank was prepared by putting 9ml

of distilled water and 2ml of nessler reagent in centrifuge tube. The blank was used to set the spectrophotometer scale to zero before reading the percent transmittance of the samples and standards.

Blood urea)mg/100ml) was calculated as Blood urea mg/100ml = 50 x T/S

Where T and S are spectrophotometer reading of the samples and standard solutions

Preparations of standard (as described by Tarnoky, 1958)

1. **Stock standard solution:** 1.4985g of ammonium chloride A.R (dried in *vacuo* over H_2SO_4 **)** was dissolved in 500ml of distilled water and kept at 4^oC.
2. **Dilute Standard solution:** 4.70ml of the stock standard solution was added to 1.0 liter of distilled water and kept at 4^oC .

Preparation of Reagents (as described by Tarnoky, 1958)

1. **Ethanol, 30% (v/v).** 30ml of absolute ethanol or industrial methylated spirit was added to 100ml of distilled water.
2. **Urease suspension.** One tablet of urease BDH was crushed in a glass- stoppered test tube. 5ml of 30% ethanol was added to dissolve it. The suspension was kept at room temperature. The suspension was shaken each time before measuring out0.2ml
3. **Sodium tungstate solution:** 100g of $Na_2WO_4.2H_2O$, A.R was dissolved in 1.0liter of distilled water. The solution is alkaline to phenolphthalelin.
4. **Sulphoric acid 0.67N**: 19ml of conc. H_2SO_4 A.R s.g 1.840 was dissolved in 1 liter of distilled water.
5. **Preparation of nessler's reagent**:
    a. Saturated sodium hydroxide solution was first prepared by adding 240g of NaOh

pellets A.R to 400ml of distilled water. The flask was stoppered and left for two days at room temperature with occasional mixing. Therefore the clear supernatant liquid was decanted.

b. The second step was preparation of sodium hydroxide 10% 9 (w/v) in water by adding 45ml of distilled water for every 10ml of reagent (a) (Saturated solution of sodium hydroxide). 10ml of the resulting solution was further diluted to about 25ml with distilled water and titrated with N HCl to give titer values of between 9.5 and 10.5

c. The third step was preparation of Nessler's double iodide solution. 15g of Potassium iodide A.R. was dissolved in 10ml of distilled water. 20g of Mercuric iodide was added and completely dissolved. The solution was further diluted to 100ml with distilled water, filtered and the filtrate diluted to 200ml with water.

Nessler's reagent. 350ml of reagent b. 75ml of reagent c and 75ml of distilled water were mixed. The solid was allowed to settle and the clear supernatant liquid used.