THE POTENTIAL USE OF DEEP-STACKED BROILER LITTER AS A RUMINANT FEED

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بسم ا   الرحمن الرحيم

DEDICATION

Dedicated to

The soul of my aunt

Late Attica

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ABSTRACT

The objective of this research was to study the effect of feeding diets of deep-stacked broiler litter (DBL) on growth, dry matter intake, feed conversion ratio and carcass composition in Baggara cattle raised for 14 weeks. The effect of such diets on dry matter intake of sheep and goats was also studied. Further more the nutritive value of such diets was also studied.

Thirty six Baggara intact bulls with 166.7±9.71 kg initial body weight were assigned in a randomized complete design to one of four dietary treatment groups that differed in DBL as a percentage of concentrate diet. The percentages in concentrate diet were 0%, 20%, 40% and 60%. Growth in term of total gain and daily gain was not affected by inclusion of processed litter in concentrate diet up to 40%. At higher inclusion rate (60%) both total gain and daily gain dropped ($P<0.01$). Dry matter intake was not affected by feeding processed litter ($P>0.05$) and so palatability. Feed conversion ratio deteriorated with increasing inclusion rate of DBL and became significantly lower at ($P<0.05$) at 60% inclusion rate. Dressing percentage was not affected by dietary treatments. Non carcass components as a percentage of empty body weight was affected differently by dietary treatments but generally tended to be heavier in slaughtered bulls fed poultry litter and that was reflected in that carcass weight in kg in term of empty body weight either hot or cold was lighter ($P<0.001$) in those bulls. The fat reservoir in body tissues tended to be lower in animal fed DBL than others and that resulted in less insulation of carcass and higher chiller shrinkage percentages. Whole sale cuts from bulls fed different levels of DBL as a percent of cold side weight were not affected by different dietary treatments. The same was true for the composition of the whole sale cut (sirloin) as a percent of the cut weight.

Although the color of fresh meat of bulls fed DBL recorded by Hunter lab. Tristimulus Colorimeter was less light and more reddish ($P<0.001$), subjective evaluation of cooked meat by the semi trained panelist did not support that assumption and produced no odd odour or color of that meat.

Digestibility study revealed no significant difference in organic matter digestibility. Crude protein digestibility decreased gradually as the inclusion rate of DBL increased in the experimental diets. In addition to that all of the experimental diets degraded extensively and quickly in the rumen of the fistulated bulls decreasing the percentage of by bass protein.

Dry matter intake of dietary treatments by sheep and goats was not affected by inclusion of DBL in their diets and they experienced no palatability problems.

The previously mentioned results indicate that DBL could be safely used as a feed ingredient for bulls without any effect on animal health or people consuming meat from such animals. DBL as a feed ingredient for sheep and goats was also acceptable. Inclusion of DBL in concentrate diets produced acceptable growth rates of bulls with compromisable prices. Digestibility results rated the experimental diets as low to high quality hay in term of organic matter digestibility and metabolizable energy contents. That reasonable growth rate achieved in this study coupled with moderate organic matter digestibility and high degradation of the experimental diets suggest that fattening mature Baggara bulls do not need high energy diets and a very small amount of bypass protein produces a reasonable growth; saving high quality protein for other types of production.

بسم الله الرحمن الرحيم

ملـخص الاطروحـة

أجريت هذه التجارب البحثية بهدف دراسة أثر استخدام أعلاف تحتوي على فرشة الدجاج اللاحم المطمورة على معدل النمو، المادة الجافة المأكولة، كفاءة تحويل الغذاء و خصائص الذبيح لأبقار البقارة المسمنة لمدة 14 أسبوع. أيضا تمت دراسة القيمة الغذائية لهذه الأعلاف و كذلك أثر تلك الأعلاف على كمية الطعام المتناول منها بواسطة الماعز و الضأن قد تمت دراسته ايضا.

تم استخدام 36 عجل من أبقار البقارة غير المخصية بوزن أبتدائي 9.71±166.7 لاجراء التجربة و ذلك بتوزيعهم حسب نظام التصميم العشوائي الكامل لأحد من المعاملات الغذائية الأربعة التي تختلف في نسبة احتوائها على فرشة الدجاج اللاحم المطمورة في الأعلاف المركزة. نسبة فرشة الدجاج اللاحم المطمورة في الأعلاف المركزة كانت 0 %، 20 %، 40 % و 60 %. معدل النمو في صورة الوزن المكتسب الكلي خلال فترة التجربة و معدل النمو اليومي (كجم) لم يتاثر ($P>0.05$) بادخال فرشة الدجاج اللاحم المطمورة في عليقة المولاس المركزة و ذلك حتى نسبة 40 % احلال. و لكن عند نسبة 60 % احلال فرشة دواجن فان كل من الوزن المكتسب الكلي و معدل النمو اليومي شهد تدهورا ملحوظا ($P<0.01$). المادة الجافة المأكولة بواسطة حيوانات التجربة لم تتاثر ($P>0.05$) باحلال فرشة الدجاج اللاحم المطمورة احلالا جزئيا لعليقة المولاس المركزة و كذلك استساغة الحيوان للأعلاف المختبرة. المكونات غير الذبيحية كنسبة من وزن الحيوان الفارغ (بدون محتوى القناة الهضمية) أظهرت تفاعلا مختلفا مع المعاملات المختلفة و لكنها عموما كانت أثقل في الابقار المذبوحة المغذاة على مخلفات الدواجن، و قد انعكس ذلك على وزن الذبيح (كجم) باردا كان أم حارا. حيث وجد أنه أخف وزنا في الابقار المغذاة على فرشة الدواجن ($P<0.001$). عموما نسبة التصافي لم تتاثر ($P>0.05$) بالمعاملات المختلفة. المخزون الدهني في أنسجة العجول المذبوحة أظهر ميلا للانخفاض في الحيوانات المغذاة على فرشة الدواجن و نتج عن ذلك ان قل معدل عزل الذبيح و أرتفعت تبعا لذلك نسبة التقلص التجميدي. كما وجد أن قطع الذبيح لم تتأثر بالمعاملات الغذائية المختلفة. كذلك مكونات القطعة القطنية (sirloin) كنسبة من القطعة المذكورة. بالرغم من أن لون اللحم الطازج لذبيح العجول المغذاة بفرشة الدواجن المسجلة بواسطة جهاز تحليل الطيف الضوئي (Hunter lab. Tristimulus Colorimeter) قد كان أقل ضوءا و داكنا أكثر ($P<0.001$)، التذوق الحسي

لهذه اللحوم مطبوخة بواسطة ذواقة شبه متدربين لم يساعد ذلك الأفتراض كما لم يلاحظ أي رائحة أو لون غير مرغوب به بذلك اللحم.

تجارب معامل الهضم للمعاملات المختلفة أوضحت أن ليس هناك أي فروقات معنوية ($P>0.05$) لمعامل الهضم للمادة العضوية للمعاملات المختلفة. أما معامل الهضم للبروتين الخام فقد أنخفض تدريجيا مع أرتفاع نسبة احلال فرشة الدواجن لعليقة المولاس. بالاضافة لذلك فان كل المعاملات الغذائية قد تم تكسيرها بدرجة كبيرة و بسرعة عالية في كرش العجل و أدى ذلك لأنخفاض نسبة البروتين غير المتكسر في الكرش و المتنقل الى المعدة الحقيقية و الجهاز الهضمي السفلي.

كمية الطعام المتناول من المعاملات المختلفة بواسطة الضأن و الماعز لم يتاثر بادخال فرشة الدواجن في علائقهم و لم يعانوا من أي مشاكل في استساغة الاعلاف المختبرة.

كل النتائج المذكورة سابقا توضح ان فرشة الدجاج اللاحم المطمورة يمكن استعمالها بسلاسة كأحد المكونات العلفية في علائق العجول من غير أي أثر سالب على صحة هذه العجول أو الانسان المستهلك للحوم هذه الحيوانات. أيضا استعمال فرشة الدجاج اللاحم المطمورة كغذاء للمجترات الصغيرة أعطى نتائج مقبولة. كما أن احلال فرشة الدجاج اللاحم المطمورة احلالا جزئيا لعليقة المولاس المركزة نتج عنه معدل نمو معقول للعجول و تكلفة أعلاف معقولة و مناسبة. نتائج تجارب الهضم أدرجت الأعلاف المختبرة كعلف أخضر مجفف منخفض الى عالي القيمة الغذائية و ذلك حسب معامل هضم المادة العضوية و محتوى الطاقة التمثيلية. معدل نمو العجول المعتدل الذي سجل في هذه الدراسة بالاضافة الى معامل هضم المواد العضوية المتوسط و ارتفاع معدل التكسر في الكرش للمعاملات المختلفة، تدل على أن تسمين عجول البقارة لا يحتاج الى أعلاف ذات طاقة عالية و أن كمية صغيرة من البروتين المحمي نتج عنه معدل نمو معقول و بالتالي يمكن حفظ البروتين عالي القيمة الغذائية لأنواع أخرى من الانتاج الحيواني في المجترات.

CHAPTRE ONE

INTRODUCTION

It is well known that intensive animal production creates a large amount of wastes. The wastes are generally considered to be of little economic value. However these wastes contain nutrients that could be substituted for more costly nutrients used in animal production. In addition to that environmental constraint concerned with the management of animal wastes may limit their use in agricultural production systems. So more attention has been drawn towards the potential resource value of these wastes. Poultry wastes namely poultry manure contain higher concentration of nitrogen, calcium and phosphorus than the waste of other animal species. Broiler litter is known as solid or semisolid waste composed of bedding material, excreta, wasted feed and feathers. Although broiler litter can be used effectively and efficiently as a fertilizer, its greatest potential impact is a feed ingredient for ruminants when processed by acceptable method. The main nutritional constitution of broiler litter for ruminant feeding are high level of protein (average 25% crude protein, 45% real protein and 55% NPN), minerals (25%, especially Ca and P), metabolizable energy (8.77-10.02 MJ/kg DM) and high crude fiber (Rankins, 1995).

Public perception of beef has to be taken into account considering using waste material as feed. There is an apparent reluctance on the part of the public, as well as of some beef producers, to accept broiler litter as cattle feed. However the public readily accepts organically grown vegetables on composted broiler litter. The process by which a plant assimilates food into its tissues is much less complicated than the process by which a cow does the same thing; a cow's food is broken down and processed much more completely.

Ruminants have the ability to digest low-cost feedstuffs that are not normally utilized by other livestock. However protein is typically the most expensive ingredient in ruminant diets. Feeding poultry litter is a means of disposing of a waste in environmentally sound manner while concurrently supplying a low-cost protein feed to ruminants. In Sudan poultry manure or litter is traditionally used as a fertilizer, its use as a feed ingredient in ruminant diets is recent and not very frequent (El Hag and El Hag, 1981; Abdalla *et al*., 1989; Z/Alabedein, 1998 Abdalla *et al*., 2003 and Mahmoud, 2005). This little involvement of poultry litter as a feed could be due to religious or health constraints. Poultry industry or especially poultry production was growing rapidly during the last years. The most recent survey of poultry farms in Khartoum state was done by Ministry of Agriculture, Animal resources and Irrigation (2005). The survey revealed that about 612 poultry farms are located in Khartoum state raising about 8,197,690 broiler chicken and 1,313,549 layers .These large numbers of growing chicks implies large amounts of poultry wastes viz poultry manure. Storage and proper disposal of poultry wastes is not well managed in Sudan.

The objective of this study is to evaluate the feeding value of broiler litter as a feed for growing bulls. Also to initiate an applicably environmentaly safe method to get rid of this poultry waste and turn in into meat. The palatability and acceptability of this deep stacked litter as small ruminants feed is also demonstrated.

CHAPTER TWO
LITERATURE REVIEW

2.1. Poultry farms surveys:

Statistics for food and agriculture are very important. Detailed analysis based on objective, quantitative data of the food, agriculture and rural sectors is necessary in formulating sector polices, and preparing and evaluating development and projects relating to food, agriculture, agrarian reform and rural development (WCA 2000, 1995). These statistic goals could be achieved through census including surveys studies. Census was defined in publication WCA 2000, page 21 as "An agriculture census may be conducted through complete enumeration, or sampling or a combination of both". Beside enumeration poultry farms surveys could also be used to collect more information for example information about farm management practices (Coffey *et al*., 1998 and Mopate and Lony, 1999), or incidence and prevalence of microorganisms in wastes from poultry farms (Witter *et al*., 2005 and Hermans *et al*., 2006).

2.2. Efficient use of alternative feed stuffs in beef cattle diets:

Utilization of alternative feedstuffs may provide a mean to reduce diet cost and cost of feedlots. However, some principles must be kept in mind when considering utilization of alternative feedstuffs. Some of these are obvious, such as price per unit of energy or protein provided by the feedstuff, while other considerations are not so obvious. These include the impersistance in nutrient contents from batch to batch, spoilage and subsequent mold growth, toxicity, supplemental mineral or vitamin needs and more importantly basic diet ingredients that feedstuff may naturally complement, blending rates and blending limits.

The subject of the efficient use of alternative feedstuffs; due to its importance in modern farming system and for the reason stated above; was reviewed well by DiCostanzo and Meiske (1994). Those scientists concluded the follows:

2.2.1. Factors Affecting Nutritional Value of Feedstuffs:

For ruminants, the microbial population existing in the rumen breaks down feed ingredients that ingested by the animal. This population must be healthy and viable to permit maximum utilization of these ingredients. Because ruminants evolved mainly as forage feeders, factors that disturb cellulytic microorganisms will result in reduced utilization of nutrients primarily energy and protein, but also reduced production of vitamins and utilization of minerals. These factors affecting nutritional value of feedstuffs are:

2.2.1.1. Nutritional variation:

Variation in batches of alternative feedstuffs is dependent mainly on the processes that produce that feedstuff. Although purchasing the feedstuff from the same source may reduce some of this variation, changes in processing occur due to changes in demand of main processed product. Thus, as for many feedstuff used in feedlots, chemical analysis of alternative feedstuffs for different batches is strongly encouraged.

2.2.1.2. Spoilage and toxicity:

Chemical analysis of feedstuffs must include moisture contents, which determine whether a feedstuff may be safely stored for any length of time. Moisture contents more than 15% may reduce storage time and increase probability of mold growth and fungi production. Other potential toxicity problem associated with the use of alternative feedstuffs is the occurrence of pesticides (especially with fruit and vegetable processing wastes). Heavy metals or other minerals contamination may occur with some poultry litter (Mthiyane *et al*., 2001; Deshck *et al*., 1998; Chaudhry *et al*. 1996). Also salmonellosis is very frequent in some alternative feedstuffs (Chaudhry *et al*. 1996).

2.2.1.3. Supplemental needs:

Utilization of certain feedstuffs may increase the supplemental need for various minerals or vitamins. Utilization of poultry litter may disturb the utilization of iron and molybdenum. Also corn gluten feed contains high levels of phosphorus so will require additional supplementation with calcium. As reported earlier by church (1979a) that diets with calcium phosphorus ratio lower than 1.1 may induce lower performance in calves and nutrient conversion were markedly decreased. High sulphur contents of some feed stuffs obtained from extraction procedures may reduce thiamine utilization leading to polioencephalomalicia (PEM) (church, 1979b). Generally observing limits on feeding alternative feeds, and carefully testing limits have to be thoroughly researched especially when these alternative feedstuffs are practiced in a feeding program. Additionally gradual incorporation of the commonly known or any new feedstuff, in the diet to adapt cattle and ruminal microbes is a sound procedure justifies the additional efforts.

2.3. Non protein nitrogen:

NPN includes any compounds that contain nitrogen (N) but not present in the polypeptide form of protein, which can be precipitated from a solution (Church, 1986a). Organic NPN compounds include ammonia, urea, amides, amines, amino acids and some peptides. Inorganic NPN compounds include a variety of salts such as ammonium chloride and ammonium sulphate. NPN, especially urea is primary of interest for feeding to ruminants (Fig. 1). The reason for this is that urea is hydrolyzed rapidly to ammonia and carbon dioxide and the ammonia is then incorporated into amino acids and proteins by rumen bacteria, which are utilized later by the host (Charmley, 1995). Urea toxicity is not very frequent. The toxicity occurs because urea is hydrolyzed rapidly in the rumen to ammonia and carbon dioxide. If the rumen fluid is alkaline (pH above 7), ammonia will be absorbed rapidly resulting in overload on the liver, which would normally remove most of it (Huntington and Archibeque, 1999). If enough starch or molasses is fed to the animal to reduce the pH of the rumen, then utilization of urea is very satisfactory (Church, 1986b). The same author claimed that in practical rations, it is recommended not more than one-third of the total nitrogen be supplied by urea or other NPN compounds. Furthermore in complete feeds, urea should be restricted to 2% or less. More than this may be unpalatable and caused reduced feed intake. Many workers hypothesized that the abundant amounts of non-protein nitrogen in broiler litter could impair the reproductive function as a result of elevated concentration of ammonia. However, Fatima (personal communication) claimed that heifers fed diets containing poultry litter had better reproductive performance than those fed the control diets. Rankins (1995) reported that heifers could adapt to the non-protein nitrogen in diets containing up to 35% poultry litter.

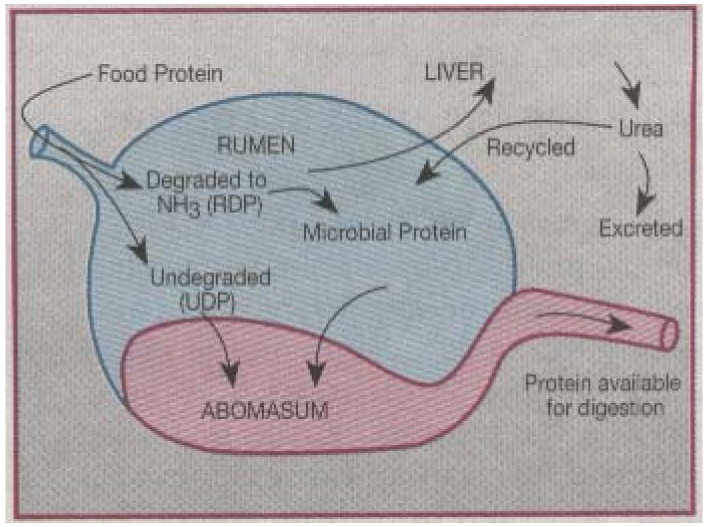

Figure (1) Fate of soluble and insoluble crude protein in the rumen (Charmley, 1995)

2.4. Recycling animal wastes as a feedstuff:

In the Sudan the disposal of animal wastes onto the land has been a traditional practice. This practice remained attractive for a long time because of the benefit of maintaining soil fertility, securing a convenient channel of manure disposal and harvesting nutrients in food and feed crops. In recent years, the problem of animal waste disposal in concentrated areas has been augmented by confined feeding operation. In addition, increased public consciousness of the environmental pollution has challenged the animal scientists and others to expand and to improve the disposal system, recycling the waste nutrients most effectively whenever feasible. From the standpoint of cost and return however, the handling and disposing of animal waste for crop production has been economically handicapped by the relatively convenience and availability of low cost inorganic fertilizer. For this reason, together with increasing demand for feedstuff, the possibility of reclaiming the nutrients contained in animal wastes for animal production purposes has been extensively investigated as alternative sources of feed. For example Fontenot (1981) investigated the relative nutritive value of animal wastes for ruminants in descending order is: excreta of broiler litter, caged layer, swine feces and lastly beef dairy cattle manure.

2.4.1. Poultry farm waste management:

Waste from poultry farms and poultry processing plants has to be disposed off regularly and efficiently so that the premises are kept clean and the birds protected from infections. Waste from poultry farms consists mostly of droppings of birds and used litter, beside dead birds. Poultry slaughter houses and hatcheries have additional types of wastes like offal, feet, feathers, intestines ect.. As stated by Saxena and Ketelaars (2000) most poultry waste constitutes manure, which has a large number of uses. There are four ways to deal with poultry manure:

i- Utilize it as a fertilizer

ii- Utilize it as an ingredient in ruminant feeds

iii- Use it for aquatic bioconversion (fertilizing fish pond)

iv- Convert it into biogas

2.4.2. Nutritive value of poultry litter for ruminants:

The possibility of using poultry litter as a cheap dietary ingredient for ruminants has been considered over a long period (Noland et al., 1955), the strongest interest in its use being for fattening cattle (Tagari et al., 1976). From time to time during this period there have been surges of interest in this possibility (Battacharya and Tylor, 1975; McCaskey and Anthony, 1979; Roothaert and Mathewman, 1992; Silanikove and Tiomkin, 1992; Rankins *et al*., 1993; Rude *et al*., 1994). In Sudan using poultry litter as ruminant feed is recent and not frequent (El Hag and El Hag, 1981; Abdalla *et al*., 1989; Abdalla *et al*. 2003 and Mahmoud, 2004). Broiler litter is used most efficiently as a crude protein (CP) supplement. Properties of broiler litter possibly restricting use of dietary levels greater than required as a CP supplement include rapid and extensive microbial degradation of nitrogenous compounds to ammonia in the rumen and low to moderate digestible or available energy concentration.

2.4.3. Broiler litter characteristics:

2.4.3.1. Moisture

The moisture concentration in broiler litter ranges between 15 and 30% (Ruffin and McCaskey, 1990). This moisture contents is influenced mainly by water management systems in broiler houses. Bedding material could also influence the moisture contents of broiler litter as they differ in their water-holding capacity (Muller, 1984). Nutritionally moisture contents of broiler litter is of no value except that if it exceeds 25% that suggests difficulty in handling and litter with less than 12% moisture is often dusty and unpalatable (Ruffin and McCaskey, 1990). In addition to that moisture concentration in litter influence temperatures achieved in processed litter by deep stacking method.

2.4.3.2. Crude protein

Broiler litter is high in CP (N x 6.25) ranging 19.4 –34.6% on dry matter basis (Deshck *et al*., 1998). The crude protein in litter consists of both true protein nitrogen and non-nitrogen protein (NPN) with uric acid forms the main NPN component. According to Van Ryssen (2000) the proportion of true protein in litter varies between 40-60% of the crude protein. Commonly nitrogenous compounds in broiler litter are very soluble and rapidly degraded to ammonia in the rumen. The quantity of indigestible nitrogen in broiler litter is extremely variable, affected mostly by the processing method used for processing broiler litter namely deep stacking (Park et al., 1995; Wang et al., 1996).

2.4.3.3. Crude fiber

Concentration of neutral detergent fiber (NDF) in broiler litter is quite variable (30-60%). It is affected by number of growing periods before harvest (Wang and Goetsch, 1998), also the extent of heat damage. Generally fiber in broiler litter is relatively of high ruminal digestibility (Park et al., 1995).

2.4.3.4. Available energy

The available energy in broiler litter varies greatly. Ruffin and McCaskey (1990) reported an average TDN concentration in broiler litter used for feeding cattle in Alabama of 50 ranged from 36% to 64% TDN for broiler litter. Thus the energy value is similar to or higher than good quality legume hay.

2.4.3.5. Ash

Ash contents are one of the important measures of the quality of litter. It is made of minerals from feed, broiler excrement, bedding material and soil. A wide range in ash concentration (10 to 54%, average 25%) of broiler litter was reported by Stephenson et al. (1990) High ash contents of broiler litter suggests soil contamination. Most soil enters litter during removal from the broiler house and during loading on trucks for transportation. In conclusion Ruffin and McCaskey (1990) suggested that ash levels greater than 28% reflect insufficient energy availability for efficient feeding of ruminants and thus animal performance.

2.4.3.6. Minerals

The high ash contents in broiler as referred to previously suggest that the byproduct can be an excellent source of minerals such as calcium, phosphorus, potassium, magnesium, and sulfur, lessening need for other supplemental minerals.

Excessive macro minerals in broiler litter generally have not caused production problems. However, Pough et al. (1994) reported that lactating beef cows consuming broiler litter *ad libitum* suffered from a milk hypocalcemia, and Ruffin and McCaskey (1990) suggested removing brood cows from broiler litter diets at least 20 days before calving. Copper contents of broiler litter are high (123 mg/kg) as reported by Deshck *et al*. (1998) in Jordan. Higher values were also reported by Rankins *et al*. (1993) and Stephenson *et al*. (1990) as 270 mg/kg DM and 473 mg/kg DM respectively. Copper toxicities in cattle have not occurred as long as animals are not continually fed high levels of litter yearlong. However sheep do not have the ability to eliminate copper from the liver and will die if fed broiler litter for periods longer than 90 to 120 days especially young sheep (Hill, 1977a ,b). Bloat has only been a problem with weanling steers and heifers on diets containing equal amounts of broiler litter and grain or some other energy source (Doctorian and Evers, 1996). A bloat preservative could be added to the diet.

2.4.4. Processing and storage of broiler litter

Broiler litter like any other feed ingredient, hold potential hazards. Pesticide residues, mycotoxins such as aflatoxins and even nitrite toxicity, can affect many common feed ingredients. Other potential hazards are associated with pathogenic bacteria such as Salmonella and other coliform bacteria, and residues from medicated poultry rations, such as antibiotics, coccidiostats, copper and arsenic. All litter, regardless of its source, should be processed to eliminate disease-causing organisms. Ruffin and McCaskey (2001) reported that processing of broiler litter as a feed ingredient can be accomplished by any one of several methods:

1- Mixing litter with other feed ingredients and ensiled to encourage acid production.
2- Direct acidification of litter could also be done to achieve essentially the same effect.
3- Heat treatment of litter. This would occur during mechanical drying or pelleting of feeds.
4- Deep stacking of litter. This method is the most economical and by far the practical method of processing litter (Chaudhry *et al.*, 1996). Deep stacking refers to the process of stock piling litter for further use. After stacking, the litter undergoes a combined composting-ensiling process.

2.4.4.1. Processing litter by deep stacking:

Processing litter by deep stacking is the method of preference and the causes were stated earlier. Moreover deep stacking typically processes broiler litter used as a ruminant feedstuff in the USA.

For proper deep stacking the moisture content of broiler litter should be 20 to 25%, although levels slightly outside this range have been used with resultant litter of acceptable feeding value (Goetsch and Aiken, 2000). Further more deep stacking improves palatability and eliminates potential hazards from pathogenic bacteria such as salmonella and clostridium (Chaudhry *et al*., 1996; McCaskey and Anthony, 1979 and Fontenot and Webb, 1975). For proper elimination of known pathogens, internal stack temperature should reach 55 to 60^{o} C, and the stacking process should be 20days before feeding (Ruffin and McCaskey, 1990). The common nitrogen compound in litter (uric acid and urea) during deep stacking degrades to ammonia which also kills pathogenic organisms. Heat is the one thing that reduces the quality of broiler litter in the stack. Excessive heating (>60^{o} C) reduces availability of nitrogen through allowing the complete sequence of Millard reactions, with irreversible binding of nitrogen and carbohydrates thus reducing the digestibility (Goetsch and Aiken, 2000). To control excessive heating (>60^{o} C), limit the moisture contents of the litter to less than 25% and limit the litter exposure to air. The last problem could be solved by covering the stack by plastic or polythene sheet (Rankins *et al*., 1993; Wang *et al*., 1996).

2.4.4.2. Methods of deep stacking litter

Methods of stacking litter are stated by Northern Carolina Cooperative Extension services on a publication prepared by Thomas A. Carter and Matt Poore (1995). Procedures for storing litter are important because storage techniques often are the difference between a low and a high quality feed ingredient:

1- Permanent structure with roof

The ideal storage facility for stockpiling litter is a structure with a permanent roof. Protecting the material from rain maintains its quality by eliminating excess moisture and also by easily handled when it is kept out of the weather, in structures with ceiling heights of 12 feet or greater. Side walls protect against blowing rain and make it easier for loading, unloading and compact materials. For stockpiling, stack litter 6-8 feet high at the peak of the stack and pack with a heavy-wheeled vehicle as the material is layered. Avoiding stacking any thing 4-5 feet high where the material is in contact with wood and that can minimize risk of spontaneous combustion; generally it is better to use concrete block walls.

2- Covered temporary stockpile

Litter can be stacked in a temporary windrow or bunker arrangement with reasonable success. The advantage of covered temporary stockpile over permanent structure is the low investment cost of the former to the latter. Construct the windrow by dumping litter in a narrow pile (6-8 feet depth). It is desirable to compact the litter to save space and ensure a good heat. Driving over the narrow pile of litter with heavy vehicle does compaction. When the windrow is constructed, apply heavy sheet of plastic carefully and anchor the edge to prevent wind damage. Then back filling the soil over the sheet. An impermeable base such as clay is preferred to prevent nutrient infiltration. The site of stock piling should be a high well-drained location. The site should have a grass buffer around the storage area and be located at least 100 feet from any perennial waterway or drinking water source. Bunker designed for storing silage on livestock farms can also be used to stockpile the litter.

2.5. Safety of feeding poultry litter

2.5.1. Drugs and residues:

2.5.1.1. Antibiotic and medicinal drugs

Medicinal drug residues were present in broiler litter in variable amounts if the drugs had been included in the broiler diet (Webb and Fontenot, 1975). However, residues of the three drugs that where in litter; namely chlortetracycline, nicarbazin and amprolium; did not accumulate in animal tissues of finishing beef cattle after a 5 day withdrawal. In a number of states of USA a withdrawal period of at least 15 days is required before beef cattle may be slaughtered if poultry litter from birds that have been treated with drugs, was included in a feedlot ration. Cardiopathy was observed in cattle fed litter from broiler fed the coccidiostat, maduramycin (Shloberg *et al*. 1992). In South Africa Fourie *et al*. (1991) reported deaths among cattle due to the feeding of litter containing maduramycin. However, residues of other coccidiostat used in the poultry industry did not cause a problem in ruminants consuming the manure (Van Ryssen, 1991).

2.5.1.2. Copper toxicity

Copper toxicity has been a problem widely reported when broiler litter is fed to sheep (Fontenot and Webb, 1975). Copper sulphate was once used in poultry industry as a mold inhibitor, which resulted in high levels of cupper in broiler litter. Suttle *et al*. (1978) reported elevated copper levels in liver of lambs fed dried battery or broiler waste, but no signs of toxicity were observed. To solve the problem we can change from using copper sulphate as a mold inhibitor to use propionic acid, which add to the nutritive value of broiler litter and so high levels of Cu should not be a problem from such a litter. In another hand, copper accumulation in the liver of ewes fed poultry litter was decreased by about 50% from feeding 25ppm molybdenum and 5 g sulphate per kilogram of diet (Olson *et al*., 1984). The problem should not be as severe as in cattle since they are not sensitive to high dietary Cu. 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. The same conclusion was drawn by Webb *et al*., (1980) feeding beef male diets containing high levels of broiler litter. Very limited number of cases of copper toxicity in cattle fed poultry litter was reported by veterinarians (Pugh *et al*., 1994). Banton *et al*. (1987) also reported copper toxicity in a herd of dairy cows fed broiler litter containing 620-ppm copper and in steer fed litter contains 685 to 920 ppm copper.

2.5.1.3. Calcium

Hypocalcemia in beef cows has been reported on farms when broiler litter was fed (Ruffin *et al*., 1994). Other workers (Pugh *et al*., 1994) reported decreased blood serum calcium in beef cows fed high levels of broiler litter. Pregnant beef cows were fed 8 kg of a mixture of 80% broiler litter and 20% corn plus small amount of long hay (Wright, 1996), a sharp drop in serum calcium occurred, but there were no physical signs of milk fever.

2.5.1.4. Hormones

Infertility and abortion in cows are sometimes suspected to be due to the consumption of poultry litter obtained from poultry having hormonal treatment. Fortunately estrogenic drugs are no longer approved to be used as a hormonal treatment of hens in USA or elsewhere in the world (Fontenot and Jurubescu, 1980).

2.5.1.5. Pesticides

Insecticides are sometimes included in poultry diets to combat insects in manure. Pesticides used directly on manure to control flies, would be a problem. However, Fontenot and Webb (1975) reported that no evidence of pesticide accumulation in wastes or in animal tissues from animal fed wastes. In conclusion manure intended as an animal feed should preferably be processed before flies become a problem.

2.5.2. Pathogenic organism and parasites

2.5.2.1. Pathogenic bacteria

Non-processed or unsterilized poultry wastes are potential sources of pathogenic microorganisms. However, in a report by Martin and McCann (1996) analyzing 86 unprocessed samples from farms in Georgia (USA) for the presence of pathogenic organism. No salmonella or E. coli was isolated from any of the 86 samples. Deep stacking has been shown to destroy coli forms (Hovatter *et al.*, 1979 and Chaudhry *et al.*, 1996). Heat processing also destroys potential pathogens (Fontenot and Webb, 1975). In addition to that proper ensiling of animal wastes appears to be effective in destroying pathogens (Chaudhry *et al.*, 1996; McCaskey and Anthony, 1979). It seems that a pH of 4 to 4.5 and a temperature over 25^{o}C are important for destruction of salmonella. However, due to high ammonia and minerals of poultry waste it is rather difficult to reach a pH below 5 without adding other materials like whole plant corn forage. In spite of that, ensiling of broiler litter with added water has been shown to destroy colifroms even if the pH did not go below 5.4 (Caswell *et al.*, 1978). The potential risks of clostridia in ensiled waste containing diets was suggested by alleged botulism outbreak in cattle fed poultry wastes in Israel (Egyed *et al.*, 1978) and in Northern Ireland (McLoughlin *et al.*, 1988). For all the cases stated above, decomposed poultry carcasses were observed in litter. Then for that reason those scientists emphasized the importance of removal of poultry carcasses from litter before it is fed to animals. Other workers (Hogg *et al.*, 1990;) reported that botulism was diagnosed in cattle grazing on pasture that had been fertilized with poultry litter. They suggested that the source of the toxins was ingestion of poultry carcasses containing botulism.

2.5.2.2. Fungi toxins

Mycotoxins posed no problem in poultry litter than in common feedstuffs (Lovett, 1972). However, mycotoxins produced by Aspergillus species are the most likely to be a problem, particularly if damp litter is used.

2.6. Voluntary feed intake in ruminants:

In the investigation of voluntary feed intake in ruminants, it is instructive to consider the anatomy of domestic ruminants in relation to the anatomy of all ruminants.

2.6.1. Digestive tract of ruminants:

There are approximately 180 species of ruminants existing in the world today. The digestive tract of ruminants is well known to contain multiple stomachs and the term rumination is used in modern English to indicate the process of chewing the cud as well as to mediate or turn something over in the mind. Ruminants are highly specialized to process specific diets (Hofmann, 1988, 1998). The ruminant digestive tract is fit to a particular ecological niche and as reported by (Hofmann, 1988) ruminants range in specialization from concentrate selectors through intermediate feeders to species adapted to grazing Fig (2). Ruminants that are concentrate selectors have relatively large parotid glands and small rumens with high rate of passage, lower distal fermentation chambers and large spiral colons in comparison to grazing ruminants. However, grazing ruminants have proportionally smaller parotid glands that produce salivary buffers for their relatively large rumens with lower rate of passage (Hofmann, 1998). Overall, grazing ruminants are specialized for efficient foregut fermentation with a lower rate of passage. Cattle (*Bos taurus* and *Bos indicus*) and sheep (*Ovis aries*) have anatomical characteristics that identify them as grazing ruminants while goats (*Capra hircus hircus*) have anatomical characteristics that identify them as intermediate between concentrate and grazing ruminants.

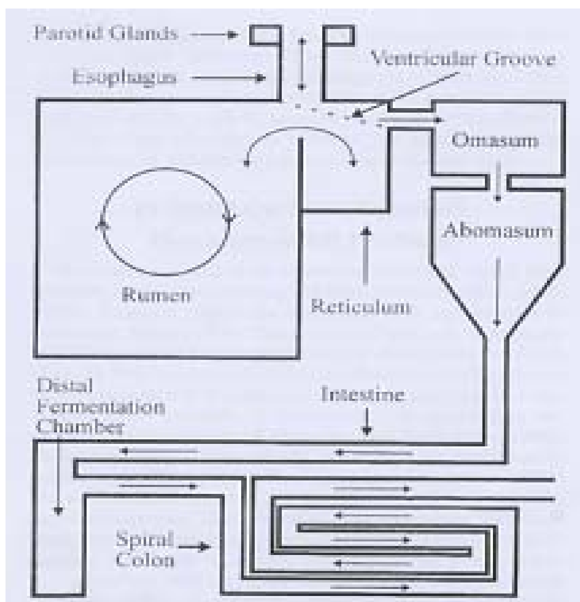

Figure 2 a diagrammatic representation of the key aspects of the ruminant digestive system. The relative size of the parotid glands, distal fermentation chamber, and spiral colon are varied to fit a ruminant to a particular ecological niche (Fisher, 2002).

2.6.2. Factors regulating feed intake in ruminants:

2.6.2.1. Feedback mechanisms

2.6.2.1.1. Distension or fill feedback

Distension or fill is intuitive feedback it is not without controversy (Allen, 1996; Forbes, 1995, 1996). Tension receptors are present in ruminant animals. Coming to same conclusion, Fisher and Baumont (1994) reported that distension alone did not explain the observed variation in intake rate during a meal. Therefore distension should not be considered separately from other possible feedbacks when predicting the impact on feed intake.

2.6.2.1.2. Chemostatic or metabolic feedback

If the rumen has a reserve capacity on some feeds of moderate to high nutritive value then some other factor or factors related to the metabolism of feed must be limiting intake. These regulatory factors are known as chemostatic or metabolic feedbacks (Illius and Jessop, 1996). The ruminant has a demand for energy, protein, and fat. The metabolic control of fat is referred to as a lipostatic feedback. Recent works by Ceddia *et al*. (2001) discuss the control of the lipostatic set point. The demand for feed in a healthy animal is related to the animal's ability to metabolize feed and that varies widely with animal class and condition (Illius and Jessop, 1996). Dietary imbalances can increase feed intake in an attempt to compensate for a deficient nutrient while disposing of surplus nutrients. If dietary imbalance is large then feed intake may be reduced ((Illius and Jessop, 1996; Fisher, 1996). When energy is limited, then voluntary dry matter intake of highly digestible (high energy) diets may decrease dramatically because of metabolic limitation to processing energy (Fisher, 2002). Constraints to intake are serious when protein is limiting but when diets are very high in protein, then protein may simply be metabolized for energy.

2.6.2.2. Oxygen efficiency theory

It has been proposed that intake is simply regulated to maximize the efficiency of oxygen consumption (Ketelaars and Tolkamp, 1996). As stated by Jones (1998) intake is closely linked to metabolism, and metabolism is linked to oxygen consumption. Rumen fill is viewed as a consequence of animal feeding behavior rather than having a regulatory effect on intake. This argument is based mainly on aging theory and the demonstrated relationship of oxidative damage to aging. In mammals, it is relatively simple to extend lifespan with a moderately restricted caloric intake (Rogina *et al*., 2000). Given *ad libtum* access to feed, animals overeat and shorten their lifespan (Fisher, 2002). The rigors of reproductive behavior and avoiding predation in wild ruminants and (for recent history) the impact of the abattoir on domestic ruminants place a premium on rapid growth and early sexual maturity rather than longevity.

2.6.3. Factors influencing food intake in ruminants:

Factors influencing food intake in cattle were fully reviewed by Bines (1976). Bines (1976) states that voluntary intake of food in cattle may be influenced by characteristic of animal, its food or the environment. These may affect frequency of feeding, the length of each meal, and the rate of eating during a meal or any combination of these.

2.6.3.1. Animal factors

As the animal grow, the abdominal volume increase. This increase in abdominal volume effects intake by providing the space into which the rumen can expand during eating. Increase in intake of a given diet, during the growth of an animal is not linear however, but varies in proportion to the metabolic weight of the animal. The same is true for Mohammed (2004) finishing bulls to different target slaughter weights varying from 200 kg to

350 kg. He noticed that the daily dry matter intake (kg/animal/day) significantly increased ($P<0.001$) as the slaughtered animal weight increased. However, in the same study the daily dry matter intake proportion of slaughter weight or metabolic body weight ($W^{0.75}$) declined ($p<0.001$) as the body weight increased suggesting higher feed conversion efficiency of heavier bulls than the other ones. Growing animals given a good quality ration *ad libitum* after a period of restriction will gain weight faster than similar animals, which have not been so restricted (Wilson and Osbourn, 1960). In a recent study by Fadol, (2005) feeding two groups of Western Baggara bulls on molasses based diet. One group fed *ad libtum* and the other one fed 50% of the *ad libtum* intake for a period of time. Although there was no significant difference between the two groups in total gain or average daily gain but the daily feed intake was higher in the *ad libtum* fed group ($p<0.001$) suggesting better feed utilization of the restricted group.

The data collected by NRC (1996) indicated that intake/unit of metabolic body weight begins to decline at about 350 kg average-frame-size steer equivalent weight. These data indicate that the degree of fatness and/or a reduction in demand for growth influence voluntary intake. Increased body fat likely reduces appetite as a result for competition for abdominal space (Bines, 1976). Also this may be considered in term of energy balance, the thin animal having a requirement for nutrients for fat synthesis, which is reduced or absent from the fat cow (Bines, 1971).

Sex hormone could affect feed intake differently. It was stated earlier that males are capable of a greater rate of growth than females and this reflected in a greater intake of food (Bines, 1976). Parallel to these results Rahama (1996) in a recent study revealed that bull calves showed significantly higher dry matter intake than heifer calves.

Two opposing effects influence feed intake during pregnancy. The increased demand for nutrients for development of the foetus tends to cause intake to rise. Towards the end of pregnancy however, as the foetus increases rapidly in size, the effective volume of the abdominal cavity for expansion of the rumen during feeding is reduced and this will depress intake relative to demand particularly if the concentration of the ration is low (Bines, 1976).

As long as gene variance is concerned, increased genetic potential for growth likely stimulates intake as a result of a greater demand for production (NRC, 1996).

Age of the animal will affect the appetite and thus voluntary intake. Such a factor is likely to result from condition of teeth, strength of jaw musculature and other factors that are likely to act on break down of fibrous constituents of foods. This may properly be of practical significance where roughages form a major part of the ration (Bines, 1976).

It is common sense that disease will negatively affect the voluntary feed intake by the animal.

2.6.3.2. Food factors

Mc Donald et al. (1984) found that ruminants would adjust voluntary feed intake in relation to physiological demand for energy if gut fill or rumen load does not limit the consumption. On the other hand protein deficiency has been clearly shown to reduce food intake and this can be corrected by addition of protein or urea (Bines, 1976). However, excessive level of urea (more than 45% of ingested nitrogen) may cause a depression in intake again (Bines, 1976). Reduced intake due to protein deficiency may be due to a reduction in microbial cellulolysis in the rumen or a reduced ability of the animal to handle the end products of digestion. Many workers (Ferrel *et al*., 1978; Swingle et al., 1979; Merchen *et al*., 1987 and Ahmed, 2005) reported that cattle fed low energy diet consumed more feed probably to compensate for low dietary energy value. Similarly Ahmed (2003) studied the effect of high and low energy level (9 and 12 MJ/kg DM) and high and low protein levels (10% and 12%) respectively on performance of Western Baggara bulls. He reported that bulls fed on low energy diet consume more ($P<0.05$) than those fed on high-energy diet but the protein content of diets did not ($P<0.05$) affect the total dry matter intake of bulls. However, Mohamed (1999) finishing Baggara bulls on different dietary energy levels (11.5, 10.5, 9.5 and 8.5 MJ/kg DM) found that the daily feed intake as kg or as a proportion of body weight or metabolic body weight was not affected by different dietary energy levels except when dietary energy level was 8.5 MJ/kg DM where there was a significant drop ($p<0.05$) in feed intake. Coming to same conclusion Church (1979a) demonstrated the effect of different dietary energy values (2.0 to 3.5 DE Kcal/g) on sheep daily dry matter intake (g/body $wt^{0.75}$). The dry matter intake increased as DE of rations increased to 2.47 Kcal/g (equivalent to 8.67 MJ/kg DM) and then declined.

2.6.3.3. Environmental factors

Environmental factors influence feed intake of ruminants differently. These factors are temperature, humidity, solar radiation and wind velocity. The most important factor is temperature. High ambient temperature depresses the feed intake of domestic livestock, but in case of cattle the feed intake of Bos taurus was depressed at lower ambient temperature than that of Bos indicus breeds. Furthermore food consumption and rumination practically ceases in Bos taurus cattle as ambient temperature rises above

40oC (Payne, 1970). In a recent study Rahama (2005) conducted a feedlot performance trial of Western Baggara bulls during winter and summer times. She found that at winter time bulls consume more food (11.24 to 11.30 kg/day) than that at summer time (8.80 to 8.91 kg/day).

2.7. Animal growth

Judge *et al*. (1989) define growth as a normal process of increase in size and weight produced by accretion of tissues similar in constitution to those of original tissues or organs; while development is the gradual expansion in size to acquire completely individual characteristics. However the relationship between increases in live weights of animals fed generously throughout life and age or time is not linear. And when plotted together they produce a very characteristic growth curve. This curve often termed a sigmoid growth curve that starts from time of conception until the animal reaches maturity (Lawrence and Fowler, 1997).

Animals in the wild or even under domestication experience periods of alternating food abundance and poverty. In such cases a smooth progression a long the sigmoid-shaped growth curve, predetermined for the individual by its genetic template, is disrupted. When this occurs and growth fall below genetic potential, growth rate accelerates and exceeds those achieved by comparable animals fed well and continuously (Lawrence and Fowler, 1997). This phenomenon is known as compensatory growth. This apparent tendency of animals to regain the position lost on their growth curve by exhibiting enhanced growth rates is both biologically and economically important. Biologically the thanks are due to the nature that has endowed animals with such an apparent ability to contend with fluctuations in food supply by storing growth potential. Economically this phenomenon allows owners of herbivorous animals; in particular; to plan feeding schedules so that maximum use of herbage grazed *in situ* can be realized while economizing on supplementary feeding during periods when natural food supplies are in deficit.

2.7.1. Growth rate

Growth rate or rate of gain is usually calculated as change in weight during specific time interval. Breeders often select for animals having higher growth rates especially for those intended to be used for meat production, being economical and compatible with carcass merits.

2.7.1.1. Factors affecting growth rate:

The growth rate is affected by many factors namely initial live weight, dry matter intake, plane of nutrition, breed, sex, age, growth promoter and environmental factors.

The plane of nutrition and the dietary energy level are among the most important factors that were affecting the growth rate in beef cattle. Rankins (1995) studied the effect of feeding broiler litter to weanling steers and heifers on growth rate. The litter was mixed with equal quantities of cereal grain (e. g corn, sorghum grain) or other energy source to result in a diet that contains approximately 11.5 MJ/kg of diet. The animals gained 0.8-1.2 kg/day. However, lower growth rates (0.3-0.59 kg/day) were reported by Nouel and Combellas (1999) growing cattle on diets containing a mixture of 79 % poultry litter, 1% common salt and 20% of citrus pulp or maize meal with 0.05% of a commercial flavouring or without it. Similar results were obtained by Hadjipanayiotou *et al*. (1993) in Syria feeding maize-poultry litter silage and control diet to female and male Shami calves. The recorded daily gain although it was lower compared to other studies, it is still higher in silage-fed groups (316 and 890 g/day) than those fed the control diet (278 and 698 g/day respectively. In another study by Meyreles and preston (1980) feeding low and high level (1.5 or 3.0 kg/day) poultry litter as a supplement to a basal diet of molasses and whole cotton seed. Their results revealed that steers receiving lower level of supplemental poultry litter perform better in term of live weight gain than that receiving high level (461 against 286 g/day) respectively. Growth rate of Western Baggara bulls was studied extensively by many workers using nonconventional feeds like Eltahir (1994) 1.13 kg/day, Mansour (2004) 0.8-1.3 kg/day and Rahama (2005) 1.09-1.27 kg/day. El Khidir *et al*. (1988) fed two groups of Kenana bulls on ration composed of agricultural by-products. They obtained an average live weight gain of 0.93 and 1.11 kg/day for the two groups kept on traditional and unconventional concentrate diets respectively. Another very important factor that could influence live weight gain is the dietary energy. Mohamed (1999) studied the performance of Western Baggara bulls on feedlot using different dietary energy levels. He found that average live weight gain for bulls fed 11.5, 10.5, 9.5 and 8.5 MJ/kg dietary energy were 1.07, 1.01, 1.05 and 0.49 kg/day respectively. Ahmed (2003) observed the same trend as bulls fed high energy levels gained better than those fed low energy diet (1000-801 g/day and 726-681 g/day respectively). In the same study protein also influence a non-significant increase in live weight gain. Similar results were obtained by Ahmed (2005). He conducted a feedlot performance trial of Baggara heifers fed different dietary energy levels (11.5, 10.5 and 9.5 MJ/kg DM) and animals gained 0.73, 0.67 and 0.58 kg/day respectively. Mostly ruminant animals fed on isonitrogenous and iso caloric diets would perform similarly in term of live weight gain except for some minor differences (Turke, 2002 and Salim, 2003). The above statement is true if any of protein or energy contents of feed is not limiting.

2.8. Feed conversion ratio

Feed conversion ratio is defined as feed consumed per unit of weight gain and it is negatively related to the live weight gain. In other words it is the quantity of feed required to produce one unit gain of live animals. The reciprocal of feed conversion ratio is termed feed efficiency (Preston and Willis, 1974). Feed conversion ratio is affected by many factors like breed , sex and plane of nutrition. Eltahir (1994) reported that the feed conversion ratio was superior in 50% Friesian bulls compared to Western Baggara bulls (5.55 versus 6.49) fed on molasses based diets. Reyneke (1976) finished bulls, steers and heifers in a comparative study. He found that bulls had lower feed conversion ratio than steers and heifers. Levy et al. (1968) observed that feed conversion ratio declined with the increase in live weight and duration of fattening. However, Mansour (2004) observed that there was an increase in feed conversion ratio as the animal live weight increased. That may be illustrated by the fact that the last scientist conducted a comparative study of young bulls against mature ones. Normally high plane of nutrition induces better feed utilization and so lower feed conversion ratio. Ahmed (2005) studied the effect of different dietary energy levels (11.5, 10.5 and 9.5 MJ/kg DM) on feed conversion ratio. He found that as the dietary energy level increase, there was a decline in feed conversion ratio. The same result was reported by Ahmed (2003) using high and low dietary energy level. In the same study the protein contents of the tested diets (low and high) influence the same effect. However diets containing high level of poultry litter could be considered low energy diet and thus implies an increased feed conversion ratio (Mahmoud, 2004). Mapoon *et al.* (1979) reported a feed conversion ratio of 12.7 for bulls raised on a complete diet of molasses, poultry litter, bagasse and protein supplement (35%, 37%, 20% and 8% respectively) in a 185-day trial. Similar results were obtained by Meyreles and Preston (1980) feeding steers a basic diet of molasses supplemented by two levels of poultry litter (1.5 or 3.0 kg/day). They reported a feed conversion ratio of 23.0 and 17.9 respectively.

2.9. Growth of carcass

Depending on the slaughter weight without considering body composition as the only parameter to evaluate the growth and so economic return of such animal is not valuable no more (Berg and Walter, 1983). Carcass is that portion of animal remaining after the removal of head, feet, tail and internal organs except the kidneys and the surrounding fat (Yeates, 1965). During postnatal growth animal bone grew at a low rate, muscle intermediate and fat grew at a high rate (Tulloh and Romberg, 1963). Such a growth of animal tissues should be towards consumer preferences. Carcass composition is affected by plane of nutrition, breed type, sex, slaughter weight and growth promoters. Many researchers studied the effect of dietary energy concentration on changes on carcass traits (Ahmed, 2005; Ahmed, 2003; Wooten *et al.*, 1979). They concluded that higher dietary energy would influence fat proportion while decreasing total muscle and bone proportion. However, Mohamed (1999) found that Western Baggara bulls offered high-energy diet had higher muscle, fat and low bone proportion. Different breeds exhibit different body composition. Eltahir (1994) finished 15 Western Baggara bulls and 15 crossbred bulls (50% Friesian x Local Sudan Zebu) on molasses based concentrate diet (11 MJ/kg DM ME). He reported that crossbred bulls were leaner than local ones (68.38 versus 64.57 respectively). However, in the same study the opposite was true for fat

(10.72% versus 14.06%) and bone proportion also showed the same trend (20.92 versus 21.36). Wooten *et al.* (1979) studied the effect of slaughter weight on carcass composition of culled range cows intensively fed high-energy diet. They obtained an average muscle content of 61.8%, 65.5% and 68.12 and fat as 18.71%, 19.44% and 19.6% and bone as 16.71%, 15.15% and 14.49% for the group slaughtered at 476.8 kg, 508.2 kg and 530 kg respectively.

2.9.1. Muscle to bone ratio

Plane of nutrition affects muscle to bone ratio differently. Jones (1985) reported that steers fed on grain based diet (high energy) produced carcasses with 3.34 muscle to bone ratio, which was higher than 3.18 for that fed forage based diet (low energy). The same conclusion was drawn by Mohamed (1999) finishing Baggara bulls on different dietary energy levels (11.5, 10.5, 9.5 and 8.5 MJ/kg DM respectively and found that muscle to bone ratio is highly influenced by dietary energy (2.7, 2.38, 2.37 and 1.6) respectively. However, Ahmed (2003) and Ahmed (2005) reported that different dietary energy levels had no influence on muscle to bone ratio of meat of Baggara cattle. Eltahir (1994) reported that local breed (Western Baggara bulls) was not different from 50% Friesian bulls in term of Muscle to bone ratio (3.03 versus 3.28 respectively). Similarly Guma (1996) carried out a comparative study of beef production potential between Kenana and Baggara bulls of Sudan intensively fed on sorghum-based diet. He found that no significant difference in muscle to bone ratio (4.0 and 4.4) respectively between the two breeds. Many workers reported that slaughter weight influenced muscle to bone ratio positively (Mohammed, 2004 and Wooten *et al*., 1979).

2.9.2. Carcass measurements

As stated by Epley *et al*., (1971) carcass measurements include carcass weight, weight of kidney fat, area of longissimus dorsi muscle (rib eye area), back fat thickness and linear measurements like carcass length and depth.

2.9.2.1. Longissimus dorsi muscle area

Longissimus dorsi muscle area has been considered as a method of evaluating the meatiness of beef carcasses. Mohamed (1999) found that longissimus dorsi muscle area was significantly ($p<0.05$) greater in Baggara bulls finished on high and medium energy diets (11.5, 10.5 and 9.5 MJ/kg DM) than that fed on low dietary energy level (8.5 MJ/kg DM). Similarly Ahmed (2003) concluded that bulls fed on high dietary energy level had higher (42.1-42.2 cm^2) longissimus dorsi muscle area than that fed on lower dietary energy level (38.0-38.3 cm^2). However, Wooten *et al*., (1979) and Ahmed (2005) studied the effect of energy concentration on changes in carcass traits of cattle. They found that longissimus dorsi muscle area was not affected by the dietary energy levels. The same result was reported by Eltahir (1994) comparing the local breed (Western Baggara bulls) with 50% Friesian (55.17 versus 56.33 cm^2) respectively. Mansour (2004) fattened young and mature Western Baggara bulls on molasses based diet. He found that the rib eye muscle area was significantly higher for mature bulls than that of young bulls (10.0 and 8.7 $inch^2$) respectively. Similarly Wooten *et al*., (1979) obtained an average longissimus dorsi muscle area of 56.2, 56.6 and 62.2 cm^2 with culled range cows intensively fed on high energy diet and slaughtered at 476.8, 508.2 and 530 kg respectively.

2.9.2.2. Back fat thickness

Back fat thickness measured over the longissimus dorsi muscle has been shown to be positively and highly correlated to total fat percentage and indirectly of carcass muscle (Brungrdt and Bray, 1963). Wooten et al., (1979) and Ahmed (2003) studied the effect of energy concentration on changes in carcass traits of cattle. They concluded that back fat thickness was significantly affected by the dietary energy level. However, Ahmed (2005) found that dietary energy level did not influence the back fat thickness. Mansour (2004) reported that no difference in back fat thickness between young and mature fattened Western Baggara bulls (2.0 and 2.3 mm respectively). Wooten *et al*., (1979) obtained an average back fat thickness of 0.45, 0.93 and 1.35 cm with culled range cow intensively fed on high-energy diet and slaughtered at 476.8, 505.2 and 530 kg respectively. They concluded that back fat thickness was significantly affected by the slaughter weight.

2.9.2.3. Linear carcass measurements

Many workers (Yeates, 1952; Berg and Butterfield, 1976) reported that carcass length, depth and width measurement had been advocated as useful predicators of carcass composition.

2.9.2.4. Wholesale cuts

Beef cattle industry depends mainly on economical production of beef from cattle that yielded higher percentage of highly acceptable retail cuts with a minimum of fat trim. Kock *et al*. (1981) reported that wholesale cuts differ in economic value because of differences in desirability of lean in each cut and differences in composition.

2.10. Meat quality attribute

Meat quality attribute is a combination of physical structure and chemical characteristic of meat, which resulted in maximum desirability from the standpoint of appearance and acceptability (Pearson, 1960).

2.10.1. Colour

Lawrie (1991) indicated that the colour of meat is due to muscle myoglobin content and its chemical state as well as its haemoglobin content. As the myoglobin content increase the meat becomes red and darker. Preston and Willis (1974) claimed that meat colour is markedly affected by stress, age, sex, breed and plane of nutrition. Crouse *et al*. (1984) found that heifers finished on forages had darker lean than those finished on concentrates. In a comparative study done by Guma (1996) between Baggara and Kenana bulls finished on sorghum based diet. The study revealed that former reported higher degree of lightness and yellowness and lower degree of redness than the later. Such results suggest that Baggara bulls produce better quality meat in term of colour. Dietary energy level influence meat colour differently. Ahmed (2005) fed Western Baggara bulls different dietary energy levels (11.5, 10.5 and 9.5 MJ/kg DM). His results indicated that dietary energy level had no effect on meat colour. However, Mohamed (1999) in his comparative study of meat quality attributes of Baggara bulls finished on different dietary energy levels reported that the group in low energy diet (8.5 MJ/kg DM) had significantly (P,0.05) lower lightness (L) and higher yellowness (b) values than those given the higher (11.5, 10.5 and 9.5 MJ/kg DM) dietary energy level.

2.10.2. Water holding capacity

Water holding capacity was defined by Hamm (1960) as the ability of meat to retain its own or added water during the application of some external force. Ahmed (2003) studied the effect of two energy levels (low and high) and two protein levels (low and high) on water holding capacity of meat of Sudan Baggara bulls and reported that water holding capacity was affected neither by energy level nor by protein level. However, Mohamed (1999) for the same breed reported that the water holding capacity was significantly inferior in bulls fed 8.5 MJ/kg DM than those fed 11.5, 10.5 and 9.5 MJ/kg DM dietary energy level. Similarly Ahmed (2005) finishing Western Baggara bulls on different dietary energy levels (11.5, 10.5 and 9.5 MJ/kg DM) found that water holding capacity was the lowest in bulls having 9.5 MJ/kg DM dietary energy level than the others.

2.10.3. Cooking loss

Ahmed (2005) observed that no significant difference in cooking loss between bulls having different dietary energy level. While Mohamed (1999) reported that cooking loss was significantly ($P<0.05$) greater in meat from bulls fed 8.5 MJ/kg than that from those fed 11.5, 10.5 and 9.5 MJ/kg DM dietary energy levels.

2.10.4. Flavour

It is a complex sensation that involves odor, taste, texture, temperature and pH (Ahmed, 2003). Flavour was found to be affected by age (Mansour, 2004); breed (Eltahir, 1994 and Guma, 1996) and sex.

2.10.5. Juiceness

According to Weir (1960) juiciness is defined as the initial impression of wetness due to rapid release of meat fluids and larger lasting effect brought about by the stimulating action of fats on salivary glands. Many workers (Mohamed, 1999; Ahmed, 2003 and Ahmed, 2005) reported that dietary energy level had no influence on juiciness of meat from Western Baggara bulls.

2.10.6. Tenderness

Tenderness is the predominant quality determinant and probably the most important organoleptic meat characteristics (Lawrie, 1991). Mohamed (1999) reported that meat from Baggara bulls fed high-energy diet (11.5, 10.5 and 9.5 MJ/kg DM) was tenderer than that from bulls fed low energy diet (8.5 MJ/kg DM). While Ahmed (2005) found that different dietary energy levels (11.5, 10.5 and 9.5 MJ/kg DM) had no effect on meat tenderness of bulls fed those diets.

2.10.7. Chemical composition

The chemical composition of carcass does not usually have a direct bearing effect of their commercial value, but the chemical composition is important in relation to eating ability of the meat, the processing characteristic, the tendency of loosing weight, the keeping quality and the nutritive value of the meat (Ahmed, 2005). Lawrie (1991) reported that the proximate chemical composition of meat was 75% moisture, 19% protein, 2.5% lipid and 3.5 soluble not protein substances. Plane of nutrition could affect the chemical composition of meat (Mohamed, 1999; Ahmed, 2003 and Ahmed, 2005).

2.11. Measurement of digestibility

Nutritive value of feed for specific animal is generally measured by its digestibility and intake by such an animal. Digestibility is simply a measure of the availability of food nutrients. When digestibility is combined with intake data, one can make a rather accurate prediction of overall nutritive value and, hence, the potential production a given feed can support. Intake is relatively more important than digestibility in determining overall nutritive value because highly digestible feeds are of little value unless consumed by animal in question. However, digestibility usually provides a fairly reliable index of nutritive value because more digestible feeds are normally consumed to a greater extent than less digestible feeds. In addition, measures of digestibility are somewhat easier to obtain than measures of intake, and, thus, considerable efforts have been made by animal nutritionists to develop effective means of determining digestibility. The most important, reliable and accurate mean of measuring digestibility of specific feed by a certain animal is the conventional digestion trial.

2.11.1. Conventional digestion trial

Conventional digestion trial is the most reliable method of measuring a feed' digestibility. Unfortunately it is somewhat time consuming, tedious and costly. Basically, the feed in question is fed in known quantities to the animal that already restrained in an individual cage so that a quantitative collection of feces can be made. Accurate records of feed intake, refusals and fecal outputs are kept and sub samples of each (usually 10% of daily output in case of feces) is retained for analysis. When estimates of nitrogen balance are desired, urine output also is measured. Even though conventional digestion trial are the standard with which all other measures of digestibility are compared, the values obtained still vary ±1 to 3% as a result of animal-to-animal variation, sampling and analytical errors (Galyean, 1997).

2.11.2. Prediction of digestibility from chemical composition

Many methods were developed to predict digestibility of the feed in question as an alternative to the conventional digestion trial because of the reasons reported earlier. One of them is the prediction of digestibility from chemical composition of the feed in question (Johnson and Dehority 1968). Generally digestibility estimates obtained from prediction equation are not as precise as one might desire ± 3 to 4% of the values obtained from conventional trials

(Galyean, 1997) and nowadays *in vitro* digestibility measurements are most commonly used to estimates digestibility than prediction equation based on chemical composition. More recently Kamalak *et al*. (2005) developed a prediction equation of dry matter intake and dry matter digestibility of some forages using gas production technique in sheep. They concluded that the in vitro production technique has good potentiality to predict dry matter digestibility and dry matter intake.

2.11.3. In vitro fermentation methods

In vitro digestibility techniques provide a quick, inexpensive and precise prediction of conventionally determined digestibility in ruminants. The most reliable and commonly used in vitro technique is that of Tilley and Terry (1963). Estimates of digestibility by the Tilley and Terry procedure are within 1 to 3% of the conventionally determined values (Galyean, 1997).

2.11.4. Nylon bag digestibility techniques

Another method of estimating digestibility of feeds is the nylon bag technique. A full review of the procedure and factors affecting the results are represented by Huntington and Givens (1995). One disadvantage of nylon bag technique is that fewer samples can be run at one time than with the Tilley and Terry method, and a donor animal with a large rumen cannula is desirable. Nylon bag (in situ) technique, however, quite useful for evaluating kinetic aspects of digestion in ruminants through the use of multiple incubation times and computer models proposed by Ørskov and McDonald (1979).

2.11.5. Indigestible marker method

Digestibility could also be estimated by the use of indigestible markers (internal and external). These methods have special application to conditions where conventional methods are difficult to apply or when representative samples for in vitro methods are difficult to obtain (i. e., grazing animals).

2.11.6. Digestibility of poultry litter

In South Africa two scientists (Mavimbela and Van Ryssen, 2001) study the effect of dietary molasses level on digestion of nutrients in sheep fed dried broiler litter. Sheep were fed broiler litter alone (100% litter treatment), broiler litter plus 7.5% sugar cane molasses (92.5% litter treatment) and 15% sugar cane molasses (85% litter treatment). They reported that different molasses-litter mixtures had no effect on total tract apparent digestibility of N (0.73) and OM (0.65-0.73). Similar results were obtained by Gaber *et al.* (1993) feeding sheep with average body weight 23.9 kg on three isonitrogenous diets of control at the rate of 0.5 kg concentrate diet/head/day to cover 58-65% of protein requirement for growth of sheep (NRC, 1985). For the second and third group 50% and 75% of concentrate nitrogen was replaced by dried poultry litter respectively. Their results reflected that inclusion of dried poultry litter did not decrease DM, OM, EE and NFE digestibility by sheep. However, the same study revealed that there was a significant increase in crude protein and crude fiber digestibility over the control diet. Lower values of DM (36.6%) and OM (39.5%) digestibility were reported by Ndlovu and Hove (1995) feeding goats on a basal diet consisted of mature veld hay and dried poultry manure mixed in proportion of 75:25 (W/W) and milled together such that they were inseparable. That lower digestibility of the basal diet may be attributed to low quality diet (CP 6.4% and CF 61.0%). In another study of Wang and Goetsch (1998) investigating the effect of consuming diets based on litter harvested after different numbers of broiler growing periods or with molasses addition before deep stacking on intake and digestibility by Holestein steers. Their results revealed that digestible organic matter intake by growing steers was less for litter harvested after one broiler growing period than after three or six when fed with 0.5% body weight of corn, although the effect of the number of periods was negligible with corn given at 1.5% body weight. Molasses addition before deep stacking or at meals did not enhance feeding value of litter harvested after six broiler growing periods. The same effect of molasses addition to poultry litter in digestion of feeds was reported by Mavimbela and Van Ryssen (2001) earlier in this chapter. The use of poultry litter as a protein supplement for soybean meal for beef cattle fed fibrous diets was studied by Hozler and Levy (1976). They concluded that using poultry litter as a protein supplement did not exert a deteriorus effect on apparent digestibility of dry matter, organic matter, crude fiber, ether extract and nitrogen free extract (50.0, 56.2; 54.6, 58.0; 54.8, 53.3; 43.7, 52.7; 48.4, 49.7 poultry litter supplement versus soybean oil meal supplement). However, crude protein digestibility (%) and nitrogen retention (g/kg $W^{0.75}$) were inferior for diets containing poultry litter (47.4, 79.9; 0.294, 1.187 of poultry litter supplement versus soybean oil meal supplement. Since the total amount of nitrogen supplied for both supplemental groups was equal, and the digestibility of crude protein of soybean meal ration was significantly higher than that of poultry litter ration, a considerable advantage in the quantity of digestible protein from soybean meal over that from poultry litter is indicated. As stated earlier processing litter is a must to eliminate pathogenic organisms. Another common method of processing litter is through silage making. Many scientists (Harmon *et al*., 1975; Rankins, 1995; Al-Rokayan *et al*., 1998; Chaudhury *et al*., 1996 and Mthiyane *et al*., 2001) carried out experiments ensiling different concentration of poultry litter with forages. They concluded that the inferiority of forage ensiled with poultry litter with respect to protein and mineral contents had demonstrated the role the two feed ingredients can play in improving the silage nutritional composition, fermentation characteristics and destruction of pathogenic organisms. However inclusion of excessively high amounts of poultry litter could cause deleterious effects on the quality of the resultant silage product. So that they recommend a 30-45% inclusion rate is the most appropriate level of incorporation of poultry litter in silage. The superiority of ensiling over deep stacking of poultry litter in influencing the nutritive value to sheep was demonstrated by Chaudhury *et al*. (1996). They found that apparent digestibility of organic matter and crude protein were lower ($P<0.05$) for diets containing deep-stacked litter (559.1, 608.7 g/kg Dm) than for the other waste-containing silage diets (578.7-594.1, 675.8-709.0 respectively).

2.12. Degradability of poultry litter

As mentioned earlier by Bhattacharya and Fontenot (1966) that poultry litter is generally high in protein (25%) of which approximately 45% is true protein and 55% is non-protein nitrogen. Such composition of poultry litter implies high degradation values of dry matter and crude protein (N x 6.25) in the rumen of a fistulated bull. However, Mthiyane *et al*. (2001) reported lower dry matter values at zero incubation time (267-378 g/kg) of sugar cane tops ensiled with different concentration of broiler litter (0% to 60%). The same study revealed that addition of broiler litter increased the degradation of the tested silages especially at 48-hour incubation time ($P<0.05$). Those lower degradation values may be attributed to higher fiber contents (NDF 594.0-973.9 g/kg DM) of the resultant silages. Similarly Mahmoud (2004) studied the effect of different dietary poultry litter inclusion rates on degradation characteristics by ruminants. She reported lower values of a (from fitted models of Ørskov and McDonald, 1979) as 24.06, 22.80, 26.25 and 19.20 for diets containing 0, 10, 20 and 30% poultry litter. Her results could be explained by the higher inclusion rate of sorghum grains in the tested diets (35-45%).

CHAPTER THREE
MATERIALS AND METHODS

3.1. Poultry farms survey:

Premium poultry farms survey was done in the period from January to February 2003 in Khartoum State to gather information about poultry counts and management practices including poultry litter production and uses. The survey conducted in this study followed another survey done by Ministry of Agriculture, Animal Wealth and Natural Resources-Khartoum State, General Administration of Animal Resources in October 2001 and reported in March 2002. That survey reported about 306 poultry farm. 21 farms belonged to Gezira state but were included in Khartoum State survey as their products were marketed in Khartoum State. Three large poultry farms and six smallholder farms were included in this study. A questionnaire (Appendix 1) was delivered to those farms by hand and after that the received data was collected and analyzed.

3.2. Experimental

A series of experiments were conducted to elucidate the feeding value and carcass characteristics of deep stacked broiler litter as a ruminant feed. All experiments were done in Animal Production Research center, Khartoum North, Hillat kuku in the period from January to December 2005.

3.2.1. Feeds and feeding

3.2.1.1. Deep stacked broiler litter:

Broiler litter collected from a commercial broiler house, bedded with wood shavings was used. The broiler litter is a mixture of bird excreta, wasted feed, bedding and feather. Deep stacking was prepared in an under ground silo pit (2*2.5*1.5 cm). The collected litter was spread on a plastic sheet and sprayed with water to bring its moisture contents to about 30% (Dry matter [DM] % = 70 %) using locally made garden watering can. The amount of water added was calculated according to the formula:

$$\text{Kg of water} = \frac{\text{DM \% of feed} - 70}{70} * \text{kg feed}$$

Then, the sprayed litter was filled in plastic sacks and put in the underground pit and pressed manually. The pressed material was covered using plastic sheet. A thin layer of soil (3 to 5 cm) was placed over the plastic sheet. 3 pits were prepared. Actually preparation of one silo pit was made in two days and the pit was opened after a period of at least one month. Representative samples of broiler litter were taken after deep stacking and proximate analysis was made on dried (65^{o} C) ground samples as outlined by AOAC (1975).

3.2.1.2. Experimental feeds

Four concentrate mixtures were used comprising deep stacked broiler litter at a rate of 0%, 20%, 40%, and 60% of concentrate in addition to other feed ingredients of molasses, urea, groundnut cake, wheat bran and salt (Table 1). All concentrate mixtures where prepared to be isonitrogenous (230 protein g/kg) and isoenergetic (10 ME MJ/kg DM). Sorghum stover (chopped) was used as a source of fiber. Complete diets were also preformed containing 0%, 12%, 24% and 36% deep-stacked broiler litter. Ground sorghum stover constitutes 40% of all the complete diet. All ingredients were mixed manually to make homogenous isonitrogenous and isenergetic diets (Table 2).

Table (1): Ingredients and chemical composition of the diets fed to cattle in feedlot performance trial.

Parameters	**Broiler litter (%) in concentrate diet**				**Deep stacked broiler litter**	**Sorghum straw**
	0	20	40	60		
Diet composition (%)						
Molasses	45	43	39	36	-	-
Groundnut cake	8.5	8	4	1	-	-
Wheat bran	42	26	15	2	-	-
Urea	3.5	2	1	0	-	-
Processed broiler litter	0	20	40	60	-	-
Salt	1	1	1	1	-	-
Total	100	100	100	100	-	-
Chemical composition (g/kg DM)						
Dry matter	689.5	712.7	691.4	654.2	677.6	957.7
Crude protein	229.2	212.5	216.7	220.8	265.0	35.2
Ash	97.7	113.0	147.0	144.0	145.6	72.7
Crude fiber	72.0	60.0	96.0	118.0	236.6	380.0
Ether extract	18.0	14.0	10.0	18.0	34.4	12.6
Calculated ME[1] (MJ/kg DM)	11.01	10.78	9.97	9.95	9.12	6.69

Proximate analysis was performed according to AOAC (1975) methods.
[1]ME of concentrate diet was calculated according to the equation
ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.014 NFE + 0.005 CF (MAFF *et al*., 1975).

The ME for sorghum straw was 6.69 MJ/kg DM as reported by Sulieman and Mabruk, (1999).
The ME for deep stacked broiler litter was calculated according to the equation TDN%= 75- Ash% (Jacob *et al*., 1997) and then ME (MJ/kg DM) = TDN kg* 4.4 *4.18* 0.82 (NRC, 1996)

Table (2): Ingredients and chemical composition of the diets fed to sheep and goats in feed intake trial.

	Dietary broiler litter			
Parameters	**0 %**	**12 %**	**24 %**	**36 %**
<u>Diet composition (%)</u>				
Molasses	18.7	25.8	23.4	21.6
Groundnut cake	6	4	2.4	0.6
Wheat bran	33.4	16.4	9	1.2
Urea	1.3	1.2	0.6	0
Deep stacked broiler litter	0.0	12	24	36
Salt	0.6	0.6	0.6	0.6
Sorghum Stover	40.0	40.0	40.0	40.0
Total	100	100	100	100
<u>Chemical composition (g/kg DM)</u>				
Dry matter	775.0	759.0	746.0	702.0
Crude protein	161.6	152.0	159.8	142.8
Ash	103.3	128.6	139.9	138.6
Crude fiber	172.0	166.0	188.0	160.0
Ether extract	22.0	22.0	18.0	20.0
Calculated ME[1] MJ/kg D.M	9.3	9.1	8.9	8.7

Proximate analysis was performed according to AOAC (1975) methods.
[1]ME of the complete diet was calculated according to the equation
ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE (MAFF *et al*., 1975).

Experiment 1

3.2.2. Cattle feedlot performance and carcass characteristic trial

Thirty six bulls with an average initial body weight 166.7±9.71 kg were used in this study. Those animals were obtained from Animal Production Research Center (Hillat Kuku) Khartoum North. Animals were vaccinated against Rinderpest, Anthrax, Black quarter and Hemorrhagic septicemia. All animals were also injected intramuscularly with Ivomec as a protection against internal and external parasites. After that animals were assigned to randomly four groups according to the percentage of deep stacked broiler litter in concentrate diet into 0%, 20%, 40% and 60% as nine animals for each group. Each group was further subdivided into three subgroup of three animals each. The sub group was housed separately in a pen measuring (5.0 X 3.4 m^2) with free access to water, feeders and mineral blocks. The feeding trial lasted for 14 weeks. The first two weeks were considered as an adaptation period.

After that all animals were slaughtered and slaughter data was recorded.

3.2.2.1. Feed intake and live weight growth

Concentrate mixtures were offered at early morning (8 a.m) for all groups. While sorghum was provided at 2 p.m in the afternoon at the same feeders. The difference between weights of the quantity offered and refusal on the next morning resembles the daily feed intake. All animals were weighed early morning at weekly intervals using a weigh bridge of 1500 kg maximum capacity load with 5 kg division.

3.2.2.2. Slaughter data:

All animals were slaughter serially after an overnight fasting period. Animals were slaughtered according to Muslim procedure (Halal) were animals were bled by cutting across the carotid arteries and jugular veins on sides as well as esophagus and trachea, using sharp knife. When complete bleeding was effected, the head was removed at the atlanto-occipital joint. All slaughter procedure and carcass data adopted in this study followed Meat and Livestock Commission M.L.C (1974)

a. Non carcass components

External offal parts such as the hide, four feet and tail were removed and weighed. The internal organs of the thoracic and abdominal cavity were removed and weighed separately. The kidneys and surrounding fat were left attached to the carcass.

b. Carcass components

The hot carcass was weighed and delivered into a chilling room for 24 hours at approximately 4^{o} C. The chilled carcass weight was recoded. After that, the carcass was cut longitudinally into two halves by sewing along the vertebral column. The left side of the carcass was used to collect data on carcass composition.

c. Linear carcass measurements:

Linear carcass measurements were done using a measuring tape graduated in centimeters including carcass length, leg length, leg circumference, abdominal depth, chest depth, fat thickness and longissimous dorsi muscle area (cm^2).

d. Carcass partitioning:

Meat and Livestock Commission M.L.C (1974) method for cutting beef Carcass was cut into different cuts. The cuts were shin, clod, neck, brisket, thick ribs, extended thin ribs, chuck, extended roasted ribs, hid quarter flank, rump, sirloin, thick flank, tope and silver side and lastly leg.

e. Sirloin dissection:

Sirloin dissection was performed by placing it on a dissecting bench and tissues were separated using scalpels and forceps. The subcutaneous layer of the fat was removed. Muscles were then separated from the bones, intermuscular fat and trimmings. The different tissues were (muscles, bones, fat and connective tissues) immediately placed on trays and weighed to the nearest gram using an OHAU's balance.

3.2.2.3. Samples for meat quality and chemical analysis

Samples were taken from logissimus dorsi muscle after 24 hours postmortem. Each muscle sample was divided equally into 2 halves. One half was used for chemical analysis and the other half was used to determine meat quality attribute. Samples destined for quality attributes were allowed to oxygenate for two hours at 4^{o} C before color determination. Hunter color component l (lightness), a (redness) and b (yellowness) were recorded using Hunter lab. Tristimulus Colorimeter Model D25 M-2. Subsequently those samples were stored for chemical analysis, cooking loss and water holding capacity determination.

a. Chemical composition of muscle samples

All chemical analysis of muscle samples (total moisture, ash, total protein and fat) were performed according to the procedure described by AOAC (1975).

b. pH determination:

For pH determination, a sample of 1g (minced meat) was homogenized in 20ml distilled water for one minute. Then the pH was read on laboratory pH meter (adjusted with buffer pH 7.0 and pH 4.0) at room temperature.

c. Water holding capacity

One gram sample from the minced muscle was used and placed in a humidified filter paper (Whatman No. 1) kept in a dessicator over saturated KCL solution and pressed between two plexiglass plates for 3 minutes at 25 kg load. The meat film area was traced with a ball pen and the filter paper was allowed to dry. The meat and moist moisture areas were measured with a compensating planimeter. The resulting area covered by meat was divided into the moisture area to give a ratio expressed as water-holding capacity (WHC) of meat. A larger ratio indicates an increase in the watery condition of the meat or a decrease in WHC (Babikir and Lawrie, 1983).

d. Cooking loss determination

Thawed samples (at 5^{o} C for 24 hours) of longissimus dorsi muscle were weighed. They were cooked in plastic bags placed in a water bath at 80^{o} C for 90 minutes. Then they were cooled in running tap water for 20 minutes, dried from fluid and reweighed. The loss of weight during cooking was expressed as a percent of pre-cooked weight.

$$\text{Cooking loss (\%)} = \frac{\text{Wt. before cooking-Wt. after cooking}}{\text{Wt. before cooking}} * 100$$

e. Sensory evaluation

For sensory evaluation longissimus dorsi muscle samples were allowed to thaw overnight at 4^{o} C. They were then wrapped in aluminum foil and roasted in an electric oven at 175-180 ^{o} C for one hour (Griffin *et al*., 1985). Semi trained panelists (N=7) evaluate each sample for color using scale of 4 points (1=Extremely dark to 4=dark brown); Tenderness (1=Tough to 4=Tender); Odor (1=Extremely intense to 4=Bland); Juiciness (1=Dry to 4=Very juice) and for overall acceptability scale of 5 points was used (1=Unacceptable to 5=Extremely acceptable). See appendix 2.

Experiment 2

3.2.3. Digestibility trial

Four non castrated male sheep (38.4 ± 3.90 kg body weight) were arranged into 4 X 4 Latin square design. Sheep were kept in metabolism cages to enable accurate determination of feed intake and allow easy collection of feces and urine. They were given free access to fresh water and mineral salt licks. The diets consist of concentrate mixture (0, 20, 40 and 60% broiler litter) from table (1) plus ground sorghum stover at the rate of 2:1 on fresh basis to give complete diets of Control (Cont.), low level deep stacked broiler litter (LBL), medium level deep stacked broiler litter (MBL) and high level deep stacked broiler litter (HBL) respectively. The animals were adapted to each diet for two weeks at the rate of approximately 2% of body weight followed by balance trial of ten days. The first three days were to adapt to harnesses and bags and in the followed seven days measurement of daily food intake and fecal excretion were made. The feces were collected in canvass bag secured by means of harnesses over body of sheep. Sub samples of feeds and feces (10%) were taken daily and kept in refrigerator waiting for analysis. The digestibility was calculated as follows:

$$\text{Digestibility \%} = \frac{\text{Conc. of ingredient in feed} - \text{Conc. of ingredient in feces}}{\text{Conc. of ingredient in feed}} \times 100$$

Experiment 3

3.2.4. Degradability study

Samples from digestibility study (Cont, LBL, MBL and HBL) after drying and grinding, were weighed (2 grams) into nylon bags tied and incubated into two fistulated bulls (250 to 300 kg body weight) for a series of time. Namely 3, 6, 9, 12, 24, 36, and 48 hours. The dry matter loss was recorded for each sample for each time. The residue in the bag was subjected to analysis of nitrogen (Kjeldahl method) to calculate the nitrogen loss of the tested diets at different incubation times. DM and CP losses on degradability study were fitted to the model of Ørskov and McDonald (1979) as shown below.

$$p = a + b\ (1- \exp^{-ct}) \qquad \text{(i)}$$

Where: p = degradation at time t

t = incubation time

e = the basis of the natural logarithm

a = Y axis intercept at time 0. Represent soluble and completely degradable substrate that is rapidly washed out of the bag.

b = the difference between the intercept (a) and the asymptote. Represents the insoluble but potentially degradable substrate which is degraded by the micro-organisms according to first-order kinetics.

c = rate constant of b function

1- (a + b) = the undegradable portion of a sample.

a, b and c are constants fitted by an iterative least squares procedure.

$$\text{Effective degradability (P)} = a + b\ (c/(c + k) \qquad \text{(ii)}$$

Where: a, b and c as defined for equation (i).

k = rumen small particle outflow rate

Experiment 4

3.2.5. Feed intake trial of sheep and goats

A trial was conducted to determine palatability and acceptability of the diets containing different levels of broiler litter to sheep and goats through measurement of daily dry matter intake. Twelve male sheep (25.08 ± 1.644) and twelve female goats with no significant milk production were arranged into complete randomized design in a two simultaneous experiments to measure the feed intake. Each experiment lasted for twenty one days of which two weeks adaptation period followed by one week for data collection on intake. The animals were housed individually with free access to water and mineral blocks. Diets were prepared as shown in table (2) and offered daily at 8 a.m. The refusals were collected the second day and the dry matter intake was calculated as the difference between the offered and the refused quantity on dry matter basis.

3.3. Chemical analysis

Samples of diets from feedlot performance trial, digestibility trial and palatability and acceptability trial were analyzed for their proximate components (Dry matter, crude protein, ether extract and crude fiber) by AOAC methods (1975). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined according to Van Soest (1982).

3.4. Statistical analysis

1. Statistical analysis was done using computer program SAS (1990) as follows:

A. analysis of variance was conducted to examine the effect of different experimental diets on feedlot performance parameters such as daily feed intake, average daily weight gain and feed conversion ratio.
B. Slaughter data, carcass data and meat quality attributes were also subjected to one way analysis of variance were the experimental diets considered as the treatment effect and slaughter weight was considered as a covariate.
C. For digestibility experiment analysis of variance was also conducted considering the effect of period and animal beside the main effect of the experimental diets.
D. Data on feed intake of sheep and goats was analyzed using one-way analysis of variance (Steel and Torrie, 1960).

3.8. Economic appraisal

An economic appraisal study was conducted to estimate return and profit margin for 36 Western Baggara bulls in feedlot trial lasted for 14 weeks and based on molasses and or processed broiler litter as a feed ingredient.

CHAPTER FOUR
RESULTS

4.1. Poultry farms survey:

The survey revealed that all the selected poultry farms in Khartoum State practiced the same management practices in term of:

1. Detergents, cleaners and pesticides were usually applied to poultry houses before administering new batches.
2. Litter type was wood shavings and application rate was not precisely calculated.
3. Poultry litter commonly collected after each production period in plastic sacks and solely sold as a fertilizer.
4. No medicinal or metabolic additives were used except for coccidiostat.

The three selected large poultry farms were Sudanese Kuwait Company, Arab Poultry Company and Arab Company for Livestock Development. In addition to previously mentioned criteria those companies used close system for housing birds provided indeed by modern feeders and drinkers saving feed and water losses. Feed processing units were also available with professionals carry on the job. In contrast smallholder farms used open system for housing birds provided with modern and or traditional feeders and drinkers. Further more feeds were purchased ready from other factories. The following table (table 3) summarized the information about stock numbers and estimated annual output of poultry litter on fresh basis.

4.2. General appearance of the deep-stacked broiler litter:

Product of deep stacking broiler litter showed a dark color without any odd smell. The mold growth seldomly found on the outer layer, which caused a slight loss of the product because the portion covered with mold, was discarded. Also some areas in the product showed black color and sticky indicative of overheating and so discarded also.

4.3. Feedlot performance trial:

Table (4) showed the effect of replacing 0, 20, 40 and 60% of molasses based concentrate diet by deep-stacked broiler litter on performance of Western Baggara bulls. The results indicate that feeding - broiler litter did not suppress the total gain or the average daily gain except for higher inclusion rate (60%). At that higher inclusion rate, both total gain and average daily live weight gain significantly decreased ($P<0.05$). The daily dry matter intake of concentrate or sorghum stover or total intake were not affected by inclusion the deep stacked broiler litter in the tested diets but the total dry matter intake tended to be higher in diets containing higher inclusion rates. However, dry matter intakes as a percentage of live weight and as g/kg metabolic body weight were not found to be different from each other except for higher inclusion rate ($P<0.01$). Also feed conversion ratio was not affected by inclusion of deep stacked broiler litter in a basal molasses diet except for the higher inclusion rate ($P<0.01$) where there was a significant increase in the quantity of kg of feed needed to be converted to one kg live weight gain than the other feeds.

4.4. Slaughter data:

4.4.1. Non carcass components

Table (5) showed the data related to non-carcass component of bulls fed different dietary broiler litter levels. There was an inverse relationship between empty body weight of bulls fed the tested diets and dietary inclusion rate of broiler litter ($P<0.001$). The lowest empty body weight was recorded for the bulls fed the highest inclusion rate of broiler litter (60%). Some non-carcass components were found to be significantly heavier in bulls fed waste containing diets for example head, four feet, liver, kidney and kidney fat. However, other non carcass components like hide, heart, gut fill, omental fat and pelvic fat appeared to be not affected by replacement of molasses based diet by different levels of broiler litter.

4.4.2. Carcass components

The effect of different dietary deep-stacked broiler litter fed to Western Baggara bulls on their carcass yield were shown in table (6). It is clear that slaughter weight, empty body weight, hot carcass weight and cold carcass weight (kg) were significantly ($P<0.001$) low for carcasses of bulls fed highest inclusion rate of broiler litter. However, both the hot carcass and cold carcass proportion of live weight or empty body weight were not different between different treatments. Chiller shrinkage (%) was highly influenced by different dietary levels of broiler litter. The highest value was obtained by the highest inclusion rate (60 %).

4.4.3. Linear carcass measurements

Table (7) shows the effect of different dietary deep-stacked broiler litter fed to Western Baggara bulls on their carcass measurements. Shin length, carcass length, leg circumference and subcutaneous fat thickness

were shown to be influenced by inclusion rate of broiler litter. The lowest values were given by carcasses of bulls fed on highest inclusion rate. However other carcass measurements like neck length, shoulder length, chest circumference, abdominal depth, waist and rib eye muscle area were found not to be affected by different dietary broiler litter levels.

4.4.4. Carcass partitioning

The carcass left side cold weight and the yield of whole sale cuts as a percentage of left side cold weight from bulls fed different levels of deep stacked broiler litter are given in table (8). As dietary inclusion rate of poultry litter decreased the left cold side weight (kg) increased (P<0.001). However, replacing molasses based diet with different levels of deep stacked broiler litter influenced no effect (P>0.05) on the whole sale cuts of bull carcasses fed those diets.

4.4.5. Sirloin dissection

Composition of high priced whole sale cut sirloin as percent of the cut weight were presented in table (9) It was clear from the table that different dietary levels of deep-stacked broiler litter had no effect (P>0.05) on composition of sirloin in term of muscle%, bone%, fat%, muscle bone ratio, muscle fat ratio and bone fat ratio.

4.4.6. Meat quality attributes

Table (10) presents the effect of different dietary deep stacked broiler litter on meat quality of Western Sudan Baggara bulls. Lightness subjective scores (L) decreased (P<0.001) and redness subjective scores (a) increased as the inclusion rate of poultry litter increased in concentrate diets. Yellowness scores (b) similarly was affected (P<0.05) by different dietary broiler litter levels with the lowest value was obtained by the highest inclusion rate. Water holding capacity was found to be superior (P<0.05) in meat of bulls fed waste containing diets than the molasses based one. From the same table it is clear that cooking loss (%) of meat

was not influenced by different dietary poultry litter levels. Still there was a trend for increasing the cooking loss % as the broiler litter inclusion rate increased.

4.4.7. Chemical composition and pH value of longissimus dorsi muscle

The chemical composition and pH value of longissimus dorsi muscle was presented in table (11). It is clear from the table that different dietary levels of broiler litter had no effect ($P>0.05$) on chemical composition (moisture%, protein% and fat %) or pH of longissimus dorsi muscle except for ash%.

4.4.8. Sensory evaluation

The results of panel test of cooked meat samples from bulls different broiler diets were presented in table (12). It is clear that broiler litter inclusion rate did not influence the sensory scores of cooked logissimus dorsi muscle in Western Baggara bulls.

4.5. Digestibility (%), total digestible nutrients (TDN) percentage and metabolizable energy (MJ/kg DM) of sheep fed different levels of broiler litter:

The chemical composition of diets used in digestibility trial is shown in table (13). The results of digestibility trial and energy contents of the experimental diets are presented in table (14). The apparent digestibility values of dry matter, organic matter and crude fiber percentages were higher, though not significantly different, for molasses based diet than for waste containing diets. Similar trend was observed for total digestible nutrients (TDN) percentage and metabolizable energy (MJ/kg DM) contents of the tested diets. Crude protein digestibility was inferior ($P<0.01$) in the diet containing the highest inclusion rate of broiler litter. However, ether extract appeared to be more ($P<0.001$) digestible in litter containing diets.

Table (13): Chemical composition of diets containing different levels of broiler litter fed to sheep in digestibility trial.

Parameters	Experimental diets			
	Control[1]	**LDBL[2]**	**MDBL[3]**	**HDBL[4]**
Chemical composition (g/kg DM)				
Dry matter	606.2	606.6	617.5	568.6
Crude protein	143.8	168.8	159.4	150.0
Ash	102.5	121.4	136.8	139.4
Crude fiber	202	214	220	240
Ether extract	24	16	18	12

[1] The diet without broiler litter.
[2] Low level of deep stacked broiler litter.
[3] Medium level of deep stacked broiler litter.
[4] High level of deep stacked broiler litter.

4.6. **Degradability study:**

The dry matter and crude protein degradability characteristics of different test diets in experiment 3 are shown in table (15). Soluble dry matter (a) was almost the same in different diets and accounts for 50% of the dry matter contents of these diets (ranging from 50% to 55.1%). However, the degraded part (b) and potentially degraded part (a+b) tended to be higher in waste containing diets and increased with increasing broiler litter level. The opposite is true for the rate of degradation of b (c) and the undegraded dry matter part (1-[a+b]). Concerning crude protein degradability that presented in table (14), the soluble part (a) was higher in waste containing diets (ranging from 64.3% to 70.4%) than control diet (48.8%) while the degraded protein (b) and its rate of degradation followed the opposite trend. All the tested diets showed a high potential degradation (a+b) that was more than 85%. The undegraded part of crude protein (1-[a+b]) followed the same trend as the dry matter.

4.7. Feed intake trial of sheep and goats:

The chemical composition of diets used in feed intake trial of sheep and goats is shown in table (2). Dry matter intake of sheep and goats offered diets containing variable levels of poultry litter are shown in table (16). In sheep trial the dry matter intake as kg/day was high in the diet containing no broiler litter but it began to drop as the diet inclusion rate of broiler litter increased. Also the dry matter intake as a percentage of live weight and as $g/kg^{0.75}$ followed the same course as the previous parameter. However, in goat trial the dry matter intake as kg/day or as a percentage of live weight and as $g/kg^{0.75}$ increased with the increase in inclusion rate of dietary broiler litter up 24% inclusion rate and then dropped. In other words there appear to be a positive relationship between dry matter intake and dietary inclusion rate of broiler litter up to 24% inclusion rate and then dropped.

Table (15): Dry matter and crude protein degradation characteristics (g/kg) of diets containing different levels of broiler litter fed to sheep in digestibility trials.

	Experimental diets			
Parameters	**Control[1]**	**LDBL[2]**	**MDBL[3]**	**HDBL[4]**
Dry matter				
A	51.6	50.0	53.9	55.5
B	38.0	38.4	44.5	48.3
a+b	89.6	88.4	94.4	100.0
1- (a+b)	10.4	11.6	5.6	0
C	0.019	0.021	0.014	0.010
ed (k = 0.02)	72.0	71.6	73.1	71.9
ed (k = 0.05)	65.8	65.6	66.0	65.4
ed (k = 0.08)	64.0	63.8	64.1	63.7
Crude protein				
A	66.7	67.4	64.3	70.4
B	20.6	22.7	24.8	25.1
a+b	87.4	90.2	89.1	95.5
1- (a+b)	12.6	9.8	10.9	4.5
C	0.066	0.047	0.065	0.018
ed (k = 0.02)	82.6	83.4	83.2	82.5
ed (k = 0.05)	78.5	78.5	78.2	77.2
ed (k = 0.08)	76.1	75.9	75.3	75.1

[1] The diet without broiler litter.
[2] Low level of deep stacked broiler litter.
[3] Medium level of deep stacked broiler litter.
[4] High level of deep stacked broiler litter.

Table (16): Dry matter intake of sheep and goats offered diets containing variable levels of poultry litter.

Parameters	Dietary broiler litter 0 %	12 %	24 %	36 %	Standard error	Level of significance
Sheep						
No. of animals	3	3	3	3	-	-
Period (days)	21	21	21	21	-	-
Mean live weight (kg)	29.25	27.25	26.75	27.25	1.490	NS
Metabolic body weight ($W^{0.75}$)	12.57	11.92	11.76	11.92	0.487	NS
Dry matter intake (kg/day)	1.58	1.30	1.23	1.09	0.184	NS
Dry matter intake (% of live weight)	5.39	4.75	4.58	3.99	0.537	NS
Dry matter intake (g/ kg $W^{0.75}$ per day)	125.43	108.61	104.10	91.32	12.846	NS
Goat						
Number of animals	3	3	3	3	-	-
Period (days)	21	21	21	21	-	-
Mean live weight (kg)	27.50	27.92	28.33	29.42	1.791	NS
Metabolic body weight ($Wt^{0.75}$) kg	12.57	11.92	11.76	11.92	0.487	NS
Dry matter intake (kg/day)	1.20 [b]	1.26 [ab]	1.57 [a]	1.07 [b]	0.147	*
Dry matter intake (% of live weight)	4.34 [ab]	4.53 [ab]	5.59 [a]	3.62 [b]	0.481	*
Dry matter intake (g/ kg $Wt^{0.75}$ per day)	99.46 [ab]	103.95 [ab]	128.42 [a]	84.35 [b]	12.18	*

4.8. Economic appraisal:

The economic appraisal trial results in Sudanese Dinnars are represented in table (17). The animal purchases are almost the same for all treatment groups. Also animal sales followed the same course except for those animals fed on the diet containing the highest inclusion rate of broiler litter. The last results were reflected also in margin profit and profitability percentage. Feed costs in Sudanese Dinnars and as a percentage of the total inputs were lower in waste containing diets than in control diet. The cost of one kg body weight gain was lowering as the poultry waste inclusion rate increased up to 40% and then increased at 60% inclusion rate.

Table (17). Cost study of cattle in feedlot performance trial (all costs in Sudanese Dinnars).

Item	Broiler litter (%) in concentrate diet			
	0	**20**	**40**	**60**
1-Income				
Animal sales	81,000.0	79,833.0	79,500.0	72,501.0
2-Inputs				
Animal purchase	27,312.2	27,043.9	26,883.2	25,795.6
Feeds	32,043.1	28,729.5	27,280.3	25,101.0
Management and labor	2,000.0	2,000.0	2,000.0	2,000.0
Total	61,355.3	57,773.4	56,163.5	54,896.6
3-Margin	19,644.7	22,659.6	23,336.5	17,604.4
4-Profitability (%)	32.02	38.18	41.55	32.07
5-Animal purchase (% of total inputs)	44.51	46.81	47.87	46.99
6-Feed purchase (% of total inputs)	52.23	49.73	48.57	45.72
7-Cost of 1 kg body weight gain	613.55	599.74	571.17	676.82

CHAPTER FIVE

DISCUSSION

The poultry farm survey done in this study (Table 3) although it was simple and took just a sample of poultry farms, it can tell us that large companies are interested in raising broilers rather than other production type, perhaps because of their small live span and quick return. Whereas smallholder farms were more interested in raising layer than broilers. Another important outcome was that large companies and smallholder poultry farms produced annually an average of 8,820 and 291 tons of poultry litter respectively. Those huge amounts of poultry litter should better be used for raising ruminants, and at the end ruminant'feces could be used as a fertilizer and so get two benefits instead of one. In another hand using poultry litter as a fertilizer is hazardous causing environmental pollution and could be a readily source of diseases. Those results because of small number of farm samples and might not represent the real situation but highlighting some issues to be furtherly studied in future to come.

Ingredients and chemical composition of the diets fed to cattle in feedlot performance trial are showed in Table (1). The crude protein content of the deep-stacked broiler litter reported in this study was a bit higher while ash contents and crude fiber contents were lower than values (254, 268 and 244 g/kg DM respectively) reported by Wang and Goetsh (1998). This was most likely due to the higher ratio of bedding to wasted feed, excreta and feathers. The prepared experimental rations blended well deep-stacked broiler litter with other feed ingredients perhaps because of molasses (more than 35% of molasses in concentrate rations). In line with previous studies

(Fontenot, 1981; Hadjipanayiotou *et al.*, 1993 and Hadjipanayiotou, 1994) no disease problems were encountered in this study from including processed broiler litter in rations of cattle or small ruminants. In addition, there were no indications of harmful effects on humans consuming meat from animal fed deep-stacked broiler litter.

From Table (4), it was clear that total gain of Western Baggara bulls was not affected by replacing the concentrate diet by processed poultry litter except for highest inclusion rate. Although the experimental rations were prepared to be isonitrogenous and isocaloric (Table 1), the digestibility trial (Table 14) revealed that organic matter digestibility was not affected by dietary inclusion of poultry litter. So that lowered body performance might be attributed to lower CP digestibility values (Table 14) for diets containing the highest inclusion rate of poultry litter. The same conclusion was drawn by Holzer and Levy (1976) raising cattle on low and high broiler litter levels. The reason for lower CP digestibility for HLBL diet might be due to extensive CP loss in the rumen in a form of ammonia (more than 70% of CP) and that decreased the bypass protein (table 15), might have imposed negative impact on liver for removing that excess ammonia. There was also evidence that processed broiler litter is very soluble where proportion (a) constituted more than 30% for DM and more than 75% for CP (Hadjipanayiotou, 1994). Generally the daily live weight gain in kg and feed conversion ratio of Western Baggara bulls (table 4) was comparable with other studies (0.85-1.01, 9.4-11.2; 1.09-1.27, 7.7-8.96 and 1.13, 6.49)using molasses based diets (Mohammed, 2004, ; Rahama, 2005 and Eltahir, 1994 respectively) or using conventional diets (Mohamed, 1999 for 0.49-1.07, 9.09-10.97). Sometimes the daily gain reported in this study was higher than that reported by other studies (Ahmed, 2005 for 0.58-0.73 kg/day) raising the same breed on conventional diets.

The inclusion of poultry litter in ruminant's diet in this study caused a non significant decrease in growth rate. Nevertheless that decrease became only significant ($P < 0.01$) and most prominent for bulls fed on the highest inclusion rate of poultry litter. In line with these results Meyreles and Preston (1980) reported lower growth rate (286 g/day) for steers fed 3 kg poultry litter supplement compared with 461 g/day growth rate for those fed 1.5 kg/day poultry litter. Furthermore Mahmoud (2004) recorded a non significant decrease in growth rate of sheep fed increasing level of poultry litter. Generally the growth rate reported in this study (0.97-1.15 kg/day) is very high compared with other authors (0.378-0.780; 0.772; 0.51-0.59 kg/day) using poultry litter as a cattle feed ingredient (Meyreles and Preston, 1980; Hadjipanayiotou *et al.*, 1993 and Nouel and Combellas, 1999 respectively). Those results might be attributed to the low energy density and protein quality of other ingredients included with poultry litter.

Feed conversion ratio is the quantity of feed required to produce one unit gain of live animal. The lower the feed conversion ratio, the most efficient feed value. Feed conversion ratio reported in this study (table 4) ranged between 6.97 and 8.87 kg DM feed/kg live weight gain which deteriorated gradually as the poultry litter inclusion rate increased. That deterioration could be due to low energy density of poultry litter compared with other ration ingredients. In accord Mahmoud (2004) reported higher feed conversion ratio (10.33) for sheep fed high level of poultry litter (30 %) compared with others fed no (0 %)or low levels (10 % and 20 %)of poultry litter (7.36, 9.21 and 9.42 respectively). In contrast Meyreles and Preston (1980) reported an elevated feed conversion ratio (23.0 and 17.9) for bulls fed low level poultry litter compared to others fed high level poultry litter (1.5 kg and 3 kg poultry litter/animal/day respectively). The latter result was explained by the fact that animals on low level poultry litter consumed more feed (32.6 % more feed intake), hence the nutritive value increased by duplicating the daily amount of poultry litter supplement. However, the feed conversion ratio reported in this study was in accord (Eltahir, 1994; 6.49) or lower (9.09-10.97 and 9.4-11.82) than that reported by others (Salim, 2003 and Mohammed 2004 respectively) raising the same breed to the same target weight. Other researchers recorded a high feed conversion ratio (12.7) for rations containing poultry litter (Mapoon *et al*., 1979). Their results might be attributed to lower energy value of poultry litter. Moreover poultry litter was used as an emergency feed for stockers and so high growth rate was not the prime goal.

It was clear also that inclusion of deep-stacked broiler litter imposed no negative effect ($P>0.05$) on feed intake of the tested diets or affecting palatability (feed intake as % body weight range 3.8-4.2 in Table 4). Further more; there was a trend of increased feed intake (kg/day) as the inclusion rate of processed poultry litter in concentrate diets increased. That increase was often, accompanied by the decrease in energy value of the tested rations (Table 14). In other words animal compensated for lower energy concentration in diet by increasing feed intake (Ahmed, 2003 and Ahmed, 2005). That was true to some extent, but at severe shortage of energy the animal could not compensate and there was a drop in feed intake (Mohamed, 1999). The same was true for intake as percentage of live weight or as g/kg metabolic body weight. Generally the data on dry matter intake reported in this study is higher than that proposed by NRC (1996) for cattle of the same body weights, and this could be due to higher energy density of rations adopted by NRC (1996) and more likely, efficient breeds used for setting up these data.

Commonly carcass quality is evaluated on a specific intended market, for the carcass and its products. The most important and most common carcass traits are quality grade (meat quality attributes) and yield grade (carcass weight, fat thickness, percentage kidney, pelvic and heart fat and ribeye area). All data on non carcass components of bulls reported in this study (Table 5) were within the normal range reported by other workers finishing Baggara cattle on conventional diets (Ahmed, 2003 and Mohamed, 1999) or molasses based diet (Mohammed, 2004; Turke, 2002; Rahama, 2005 and Eltahir, 1994). From Table (5) it was clear that non carcass components as a percentage of empty body weight tended to be heavier in litter containing diets. The empty body weights were higher in bulls fed control diet than bulls fed litter containing diets especially at higher inclusion rate (60 %) of poultry litter ($p < 0.001$). That result was not unexpected since bulls fed control diet had already heavier slaughter weights than others. The body fat stored in slaughtered bulls as a percent of empty body weight reported in this study (Table 5) was not influenced by experimental rations. But still there was a trend of decreasing fat percent in poultry litter containing rations. However, other non-carcass components responded differently to inclusion of broiler litter in concentrate diets. The present results given in Table (6) indicated that inclusion of different levels of poultry litter in concentrate ration impose no negative action on the percent of hot or cold carcass weight related to slaughter or empty body weight of bulls. Dressing percentage on hot basis or cold basis was not significantly different ($p > 0.05$) between bulls fed different experimental diets. The yield of the wholesale cuts from bulls raised in this study was not influenced by diet except the left side cold weight (table 8). All data on carcass composition are in consistence with data reported by other workers (Ahmed, 2003; Mohamed, 1999; Mohammed, 2004; Turke, 2002; Rahama, 2005 and Eltahir, 1994). Minor differences may occur due to different slaughter weights. Except for ash content, meat from bulls fed litter containing diets was the same qualitywise as meat from bulls fed control diet. That was reflected in a non-significant difference in subjective evaluation of the meat from different animals fed control or litter containing diets.

Crude protein contents of diets used in digestibility study (Table 13) were within the normal range of sheep feeds in such weight and condition (NRC, 1985) for normal growth and production. Apparent digestibility values for DM and OM tended to be lower for diets containing the highest inclusion rate of broiler litter (HLBL). The difference was especially large ($P < 0.01$) for CP digestibility. Also lower CP digestibility values for diets containing processed poultry litter were reported by Holzer and Levy (1976). The reason for lower CP digestibility for HLBL diet might be due to the Maillard type reactions which involves the irreversible binding of certain aminoacid residues in proteins with sugars at the high temperature ($60^{O}C$) during deep stacking (Chaudhry *et al*. 1996). Generally the apparent digestibility values for DM and OM reported in this study agrees with the findings of many researchers (Bhattacharya and Fontenot, 1966; Harmon *et al*., 1975; Casewell *et al*., 1978; Chaudhry *et al*., 1996 and Al-Rokayan *et al*., 1998) who used processed broiler litter by deep stacking or ensiling with green forages to form complete diets for ruminants. The energy values (TDN% and Metabolizable energy as MJ/kg DM) calculated from *in vivo* digestibility showed a decreasing trend by increasing the inclusion rate of processed broiler litter suggesting that the energetic value of processed litter was lower than that of other feed ingredients included in the tested diets. Generally the energy values of the tested diets reported in this study classified them as medium to high quality hay.

Both DM and CP degradation characteristics of diets containing different levels of processed broiler litter were very high (Table 15) and agree with other results reported by Turke (2002) and Salim (2003) using molasses based diets (molasses consistituted more than 40% or 50% of ration respectively). There was also evidence that processed broiler litter is very soluble where proportion (a) was more than 30% for DM and more than 75% for CP as stated by Hadjipanayiotou (1994). However, Mahmoud (2004) reported lower values of the soluble portion of CP (a) (less than 23%) for diets containing up to 30% sun-dried poultry manure. The last result maybe due to higher inclusion rate of sorghum grain (more than 35%) in the tested diets and sorghum as a cereal is known to have a low degradable protein fraction (Huntington, 1997).

Dry matter intake of sheep in this study as kg per day or as a proportion of body weight (Table 16) are consistent with many studies using poultry litter as feed ingredient (Gaber *et al*. 1991; Mahmoud, 2004 and Hadjipanayiotou *et al*., 1993) or using other feeds (Elmahi *et al*., 2005). However, the dry matter intake of sheep reported in this study was a bit higher than that stated by NRC, 1985 (1-1.3 kg/day/animal) having the same average live weight. That was expected since the energy density of feed in NRC 1985 was higher (ME=2.8-2.7 Mcal/kg DM =11.7-11.3 MJ/kg DM) than feeds used in this study. The same was true for goats as the values for dry matter intake as kg per day or as a proportion of body weight recorded in this study (Table 16) lies between the normal limits reported by other workers feeding molasses based diets (Gubartalla, 1998) or sorghum based diets (Ibrahim, 1996) to Nubian goats. Again, the dry matter intake of goats reported in this study was higher than that reported by NRC, 1981 (445-715 g/day/animal) having the same average live weight. That was expected since the energy density of feed in NRC 1981 was higher (ME=2.73-2.22 Mcal/kg DM = 11.4-9.3 MJ/kg DM) than feeds used in this study. Generally goats appeared to be more adapted to increasing level of dietary deep-stacked broiler litter.

CHAPTER FIVE
CONCLUSION

From the results of this study it could be concluded that feeding deep-stacked broiler litter up to 60% concentrate inclusion rate to cattle impose no harmful effect on their health or causing a severe reduction in their body performance or meat quality. Even more, it was a cheap feed and produced a reasonable growth rate (0.97-1.15 Kg/day).

Small ruminants were also found to be well adapted to inclusion of deep-stacked broiler litter in complete diets up to 36% without causing any health problems or remarkable decrease in daily feed intake. Further studies may be needed to elucidate the effect of long term feeding of small ruminants on poultry litter.

Extension work should be done to elucidate the benefits of using poultry litter as ruminant feed rather than a fertilizer and so that possible contamination of underground water is minimized. Farmers should also be encouraged to explore deep stacked broiler litter as a feasible method of waste management and develop their own complementary system of animal production i.e. recycling processed litter as ruminant feed.

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APPENDIX

بسم ا الرحمن الرحيم

استبيان حول مصادر و استخدامات فرشة الدواجن في ولاية الخرطوم

بواسطة د. نهاء حامد طالب

مركز بحوث الإنتاج الحيواني- كوكو-

التاريخ : / / م

1. اسم المزرعة أو المشروع ....
2. الموقع ....
3. المساحة الكلية للمزرعة .... فدان .... متر مربع
4. المساحة المستغلة من المزرعة ....
5. المساحة الكلية للحظائر ....
6. المساحة المستغلة من الحظائر ....
7. ملكية المزرعة
   - أ. قطاع خاص .... ☐
   - ب. قطاع عام .... ☐
   - ت. أخرى أذكر ....
8. نوع الطيور المنتجة و عددها
   - أ. بياض ☐ العدد ☐
   - ب. لاحم ☐ العدد ☐
   - ت. أمهات ☐ العدد ☐
   - ث. فراريج لاحم ☐ بياض ☐
   - ج. كتاكيت لاحم ☐ بياض ☐
9. نوع العلاف المستخدم
   - أ. مصنع داخل المزرعة .... ☐
   - ب. مشترى جاهز .... ☐
   - ت. أخرى أذكرها ....

10. اذا كان العلف مصنع داخل المزرعة فهو يتكون من :

المكونات	النسبة المئوية
أ. ذرة رفيعة	☐
ب. ذرة شامي	☐
ت. ردة قمح	☐
ث. أمباز فول	☐
ج. أمباز سمسم..	☐
ح. مركزات	☐
خ. مولاس	☐
د. حجر جيري	☐
ذ. صدف	☐
ر. ملح طعام	☐
ز. اضافات	☐
س. أخرى أذكرها	

11. هل تستعمل مواد التطهير في المزرعة

أ. نعم .... ☐

ب. لا .... ☐

12. نوع المبيدات و المطهرات المستعملة لتعقيم الحظائر

أ. ميلاثيون .... ☐

ب. د.د.ت .... ☐

ت. أخرى مثل ....

13. زمن استعمال هذه المبيدات

أ. قبل ملء الحظيرة بالدواجن .... ☐

ب. بعد ملء الحظيرة بالدواجن .... ☐

ت. أخرى أذكر ....

14. نوع التربية و الحظائر المستعملة

نوع الحظائر	عدد الحظائر	المساحة للحظيرة/متر^2
أ. مغلقة	☐	☐ ..
ب. مفتوحة	☐	☐ ...
ت. شبه مفتوحة	☐	☐ ...
ث. أخرى مثل		

15. نوع الشرابات المستعملة
أ. نظام البطاريات .... ☐
ب. شرابات بلدية .... ☐
ت. شرابات حديثة .... ☐
16. كيفية تجميع الفرشة
أ. بواسطة شوالات بلاستيكية .... ☐
ب. بواسطة شوالات خيش .... ☐
ت. مباشرة من الحظائر .... ☐
17. كيفية التخلص من الفرشة
أ. البيع للاستعمال كسماد .... ☐
ب. الحرق .... ☐
ت. أخرى أذكرها ....
18. زمن التخلص من الفرشة
أ. سنويا .... ☐
ب. شهريا .... ☐
ت. أخري أذكرها ....
19. نوع الفرشة المستعملة
أ. نشارة خشب .... خشنة... ☐ ناعمة... ☐
ب. تبن قمح أو فول .... ☐
ت. أخرى أذكرها ....
20. كمية الفرشة المستعملة
أ. شوال/حظيرة........... ☐
ب. كجم/متر^2 .... ☐
ت. أخرى مثل ....
21. الفرشة المنتجة سنويا و متوسط سعرها
الكمية بالوحدة متوسط سعرها
أ. بالجوال .... ☐
ب. بالطن .... ☐
ت. باللوري .... ☐
ث. أخرى أذكرها ....

22. نوع المضادات الحيوية المستعملة

أ. اوكسيتتراسايكلين .... ☐

ب. ارثرومايسين .... ☐

ت. أخري مثل ....

23. هل تستعمل مضادات الكوكسيديا

أ. نعم .... ☐ ..

ب. لا .... ☐ .

24. نوع التحصينات و المصال المستعملة

أ. قمبورو .... ☐

ب. نيوكاسل .... ☐

ت. جدري الطيور .... ☐

ث. أخرى مثل ....

25. ما هى مشاكل المزرعة

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26. ملاحظات أخرى

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الاسم :

الوظيفة :

التاريخ :