بسم الله الرحمن الرحيم

Effect of Sorghum straw and concentrates on Performance and Carcass characteristics of Sudan Baggara Bulls

By

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DEDICATION

To the soul of my dear father, to my dear mother.

To my brothers and sisters.

To my small family.

With love and respect.

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LIST OF CONTENTS

LIST OF TABLES

ABSTRACT

The research work (from July to October 2006) study was conducted to study the effect of different levels of Sorghum straw (10% for group A, 20% for group B , 30% for group C and 40% for group D) in rations on feeding performance and carcass characteristics of Sudan Baggara bulls.

Thirty six Sudan Baggara bulls were used .They were of an average initial weight of 202 Kg. Animals were randomly divided into four treatment groups of nine animals each. Each group was further subdivided into three subgroups of three animals .The four groups were employed in a feeding trail for an average of 63 days .

Following an adaptation period of three weeks, each group was fed one of the four experimental diets during which feedlot performance was monitored.

The data of feed intake were collected daily and that of live weight was done at weekly interval.

The bulls were fattened to a target slaughter weight (260 Kg) where thirty six bulls were slaughtered (9 bulls from each group).Carcass data were collected and meat chemical analysis was carried out.

The total dry matter intake was not significantly (P>0.05) different between the four treatment groups (Sorghum straw + molasses concentrated diet). Also the average dry matter intake was not significantly (P>0.05) different between the four treatment groups.

The result obtained showed no significant (P>0.05) differences in the average daily gain (0.96 for group A , 1.02 for group B , 0.84 for group C and 0.91 for group D) among the treatment groups.

Feed conversion ratio (FCR) was not significantly different between the four treatment groups (10.40 for group A, 9.63 for group B , 11.69 for group C and 10.84 for group D)

A degradability trial of the diets was carried out using two fistulae bulls. Followed by a digestibility study which was conducted to evaluated the diets using three rams , each ram was placed in a metabolic unit for 17 days , the first three days of the treatment period was change over period .Sorghum straw showed the mean (48.23 %) of degradable dry matter and initial washing loss (at zero time) .

Digestibility of (D.M) and (CP) of Sorghum straw were 62.065 and 91.980 respectively .Molasses concentrated diet potential degradability of (D.M) and (CP) were 89.60 and 87.30 respectively. Digestibility of (D.M) and (CP) of molasses concentrated diet were 76.19 and 92.84 respectively.

The result indicated that non-carcass component showed no significant (P>0.05) differences between the four treatment groups.

Statistical analysis of the carcass yield and characteristic indicated no significant (P>0.05) differences among the treatment groups. Also dressing percentage and chiller shrinkage were not significantly (P>0.05) different between the four treatment groups.

Meat quality attributes showed no significant effect for water holding capacity (W.H.C) and cooking loss.

Meat chemical composition in this study showed no significant differences between the four groups.

The panelist score for the colour, flavour, juiciness, tenderness and over all acceptability were not significantly (P>0.05) differences among the four treatment groups of bulls.

ملخص الدراسة

أجريت هذه الدراسة في الفترة مابين يوليو واكتوبر من العام 2006 وذلك لتقييم اداء ابقار البقارة عند تغذيتها على علاف خشن من حطب الذرة الرفيعة (Sorghum straw) 10% للمجموعة الاولى ، 20% للمجوعة الثانية ، 30% للمجموعة الثالثة و 40% للمجموعة الرابعة. مع عليقة علاف المولاس المركز تحتوي على 52% مولاس ، 39% ردة قمح ، 5% كسب فول ، 3% يوريا و1% ملح طعام.

تم استخدام 36 ثور من ابقار البقارة وزعت عشوائيا على اربعة مجموعات كل مجموعة 9 ثيران بمتوسط وزن حي بلغ 201.53 كجم (± 6.85) وعمر عامين ونصف.

خلال فترة الدراسة كان يقدم العلاف الخشن من حطب الذرة الرفيعة الى الاربعة مجموعات اولا ثم تقدم عليقة علاف المولاس المركز بعد ذلك (يوميا).

جمعت البيانات عن معدل استهلاك الغذاء بطريقة يومية ولاوزان الحيوانات بطريقة اسبوعية. أستمرت التجربة حتى وصول الثيران لمتوسط وزن نهائي 260 كجم وتم ذبح العجول جميعا (9 عجول لكل مجموعة) وجمعت بياناتها عند الذبيحة كما تم التحليل الكيميائي للحم.

أظهرت النتائج عدم وجود فروقات معنوية في متوسط المادة الجافة اليومية المستهلكة من العلاف الخشن والمركز وايضا عدم وجود فروقات معنوية في المادة الكلية المستهلكة من العلاف الخشن والمركز كما أظهرت النتائج عدم وجود فروقات معنوية ($P>0.05$) في معدل الزيادة اليومية في الوزن الحي نتيجة للمعاملات الغذائية الاربعة المختلفة.

أشارت النتائج الى عدم وجود فروقات معنوية ($P>0.05$) في كفاءة تحويل الغذاء للمعاملات الغذائية الاربعة المختلفة.

أستمرت التجارب الغذائية لمدة 63 يوما واجريت ايضا تجربة لدراسة معدل تكسر البروتين في الكرش بأستخدام ثورين من نفس النوع ثم أعقبتها تجربة أخرى لدراسة معامل الهضم الظاهري بأستخدام 3 حملان وأستمرت لمدة 17 يوم.

ابانت الدراسة ان متوسط تكسر حطب الذرة الرفيعة للمادة الجافة هو 48.23 % ومعامل الهضم الظاهرى لحطب الذرة الرفيعة للمادة الجافة والبروتين هو 62.065 و 91.980 على التوالى ، كما اظهرت الدراسة ان معدل تكسر عليقة علف المولاس المركز للمادة الجافة والبروتين هو 89.60 و 87.30 على التوالى ومعامل الهضم الظاهرى للمادة الجافة والبروتين لعليقة علاف المولاس المركز هو 76.19 و92.84 على التوالى.

أظهرت النتائج عدم وجود فروقات معنوية (P>0.05) في الوزن عند الذبيح ووزن الجسم الفارغ وكذلك وزن الذبيحة الحار والبارد ونسبة التصافي ومحتويات الامعاء وبعض السقط للمعاملات الغذائية الاربعة المختلفة.

لم تسجل الدراسة اثارا معنوية لمعامل الهضم الظاهري للمادة الجافة ، المستخلص الدهني ، الالياف الخام والمستخلص الخالي من النايتروجين.

المعاملات الغذائية الاربعة لم تؤثر على اي من خواص الذبيحة اثرا معنويا. ابانت الدراسة عدم تأثر قدرة اللحم على حبس الماء بداخله معنويا بين المجموعات الغذائية الاربعة وكذلك الفقد في الوزن اثناء الطبخ.

أيضا أظهرت الدراسة عدم وجود اي فروقات معنوية على التحليل الكيميائي للحم في المجموعات الاربعة.

عند تقييم جودة اللحوم عن طريق التذوق اتضح أنه ليس هنالك فرقا معنويا من حيث اللون والنكهة والرائحة والعصيرية والطراوه والقبول العام في المجموعات الغذائية الأربعة.

خلاصة ذلك فإن حطب الذرة الرفيعة عند إضافته بمعدلات تصل إلى 40% مع عليقة علاف المولاس المركز يعطي نتائج مرضية في اكتساب الوزن الحي وكفاءة تحويل الغذاء كما بينت الدراسة جودة اللحم ومكوناته.

Chapter One

Introduction

Sudan is the largest African country with an area of about 2.5 million square kilometers. The country has the highest population of animals among the African and Arab countries. Recently Ministry of Animal Resources and Fisheries (MOARF, 2006), estimated animals population of different species at 138.2 millions of which the total cattle population is estimated at 40.9 millions. The export of live animals from different species in 2006 was estimated at 1,640,771 heads and that of red meat at 4565.1 tons (M.O.A.R.F. 2006).

The consumer preference to beef commodity is not only attributed to its high nutritive value but also to its particular enjoyable taste. Red meat is a rich source of high quality protein, iron, B vitamin and vitamin A (e.g. liver). Animal protein is of a high biological value containing essential amino acids that are necessary for physical well-being and proper mental and intellectua1 human development. Adequate and balanced dietary protein is essential for young individuals in particular and the whole nation in general. Sufficient supply of meat and other high quality protein for people in the developing countries will trigger a rapid social, political and intellectual development. Raising of per capita meat consumption to the recognized world standards is influenced by possession of a sizeable national livestock herd and/or availability of financial resources to cover purchase of meat.

Sudan Western Baggara cattle are the major beef animals in the country that provide the bulk of meat consumed in Northern Sudan and contribute considerably to the export of beef cattle. The livestock sector in the Sudan plays a major role in the livelihood of the people e.g. a source of income, a mean of transport, a prestige in the social life, a base for a wider sector of food and leather industry, etc… The greatest parts of the animal wealth of the country is raised mainly under open range conditions and owned by nomads and transhumant. The former have regular movements with their cattle in search of water and pasture.

In Sudanese livestock markets there are no measurements for fixing animal prices and this process is a subject of bargaining between the seller and purchaser. In this context to regulate and improve the traditional methods of livestock marketing through introduction of weighing machines. Unfortunately, trading channels of beef cattle are presently insufficient for ensuring reasonable quality grades and establishing differential prices. Further, the production systems are traditional and lack the proper technical and scientific methodologies that could be sued to improve the overall efficiency of beef production in the country.

Traditionally the retail butchers obtains meat animal from producers or whole-sellers who are price setters of the beef animals. In addition market suffers meat shortages especially during the summer period. Therefore, effort, to proved information on how local resources are utilized for more efficient beef production are expected to contribute to the future development of the beef industry in the country.

Beef is produced by the growth of body tissues of cattle. An understanding of growth and development of cattle may lead to development of methods for the manipulation of the growth in order to improve efficiency and produce more desirable meat products.

Feeds for beef animals constitutes between 70-80% of the daily cost. Reduction the cost of feed ingredients to beef, reduces cost of production, and hence increases margin of profit.

Carcass grading systems are used to describe the value of beef carcass in terms of lean meat yield and quality grades that are useful to the meat industry. Yield grading is an estimation of the boneless closely trimmed retail product that will be produced from the carcass. Carcasses are normally broken down into wholesale cuts.

The objectives of this study are to determine the effect of using pelleted roughage (Sorghum straw 5.81% C.P 39.04% C.F and 6.69% MJ/kg) at different levels (10% for group A, 20% for group B, 30% for group C and 40% for group D). With a concentrate diet made of 52% molasses, 39% wheat bran, 5% groundnut cake, 3% urea and 1% common salt (19.6% C.P., 4.26% C.F and 11.09% MJ/Kg.) on:

1- The study deals with the feedlot performance of Baggara bulls on growth and fatting rations.

2- The study of quantitative and qualitative characters of carcasses produced from animal kept under feedlot system.

3- In vitro and invivo studies on feeds fed to animal to assess degradability and digestibility values of ingredients fed.

Chapter Two

Literature Review

2.1 Cattle types in the Sudan

Cattle of the Sudan are classified into three groups viz; Northern or Arab, Southern or Nilotic and Nuba Mountains cattle (Bennett. et at 1954).

2.1.1. Northern or Arab type of cattle

The cattle of Northern Sudan were divided by Payne (1970) into Baggara (Western), Kenana, Butana, White Nile and Northern Province.

Baggara (Western) type are found in the Savannah regions between White Nile and western frontier of the Sudan (Khalil, 1961). Their northern limit is about 12½°N and their southern limit is about l0°N. The most usual coat colour is white or red; however, cattle of variable colours are seen. They possess a small hump and the dewlap is large and prominent (Wilson and Clarke, 1975). In Darfour Beni-Helba and Falata tribes show preference for white colour (Nyalwai type). While in Kordofan dark and red colour are preferred by Messiriya and Hawazma tribes. The dark red and black coloured cattle of Messiriya and Hawazma tribes are smaller in size than the whitish Nyalawai type (El-khalifa *et al.,* 1985).

Kenana type: found east of the Blue Nile in the acacia shrubs area that have 336-457mm annual rainfall. This area lies between 10° to 14° latitude north. The coat colour is whitish grey. The horns seldom exceed 31-35 cm. The hump is cervicothoracic in position and slopes from front to rear.

Butana type: found in a semi-arid area in compassed by the River Nile, Blue Nile and Atbara River. In the north, the Atbara River is making its northern boarder while the Blue Nile is making its southern boundary and the River Nile is making the western boundary. The coat colour of Butana cattle is usually red although mixed coloured animals are found.

White Nile type: found in the acacia shrubs area, in the White Nile Valley in Kosti District, where the Kenana are mixed with the Baggara and are termed "White Nile" (Mason and Maule, 1960). In this type, there are many coat colours, red, fawn, white, black and admixture of these colours.

2.1.2. Southern or Nilotic type of cattle

These are groups of Sanga raised by Nilotic tribes in the Sudan (Payne, 1970). Mason and Maule (1960) identified five related types, which included; Aliab Dinka, Neur, Awail Dinka, Eastern Neur and Anuak. The climatic environment of the habitat varies from humid to semi-arid but is always tropical. They are characterized by white and cream coat colours; the horns are crescent or lyre-shaped and often very large. The hump is cervicothoracic (Payne, 1970).

2.1.3 Nuba Mountain type of cattle

Mason and Maule (1960) classified this breed as Zebu. Mills (1953) stated that although cattle of this breed possess a hump and a well-developed dewlap, the head shape is typical of *Bos brachyceros* cattle. These cattle are found in Southern Kordofan. Different coat colours are found. They have a short broad head and their horns are short but very variable in form, lateral, straight or lyre-shaped. The hump is also very variable in size and they possess a very well developed dewlap (Mason and Maule, 1960).

2.2 Cattle growth and beef production:

There are several major production trends operating at the present time which should result in increased production and improvement in economic efficiency with which beef is produced. There are significant efforts to use cattle, which gain more rapidly, and to use cattle of larger mature size. These efforts are paralleled by the trends towards less fat. Large size and late fattening make possible the slaughter of animals at heavier weight without excess fat. Slaughter weight, sex, shape, nutrition and breed can all affect carcass composition and are the major factors in the hand of the producer of beef in his attempt to alter carcass composition (Berg and Buterfield, 1976).

2.3 Classification of animal feeds

Feedstuffs can be grouped into different classes on the basis of bulkiness (bulk density) and chemical composition. Feedstuffs are classified into roughages and concentrates based on the crude fiber (CF) content, which is primarily responsible for the bulk density of the feed.

2.3.1 Roughages

Roughages as described by Kellems and Church (1998) are plant materials primarily provide a dietary carbohydrates source for herbivores animals and are commonly referred to as forages or roughages. Forage is defined according to the same authors as the total plant material available to be consumed by an animal. Roughage is a term most often used by animal feeders and nutritionists to describe those dietary components that are characterized by being high in fiber (cellulose). Cheeke (2005) described roughages as bulky feeds, high in fiber and low in energy. The nutrients in roughages are made available primarily by microbial digestion either in the rumen or in the hindgut of non-ruminants. Kellemes and Church (1998) stated that, the terms forages and roughages are often used interchangeably to describe plant materials that are relatively high in structural carbohydrates, which contain high amounts of cellulose and hemicelluloses. Ribeiro and Moreira (2000) reported that, roughages are poor in digestive nutrients such as nitrogen and non-structural carbohydrates, which are present at low concentration.

Table (1): The Production of Agricultural By-products in Sudan (2003/2004):

Type of by-product	MT	%
Sorghum straw	11677836	62.4
Millet straw	2055000	11.0
Groundnut hay	2041980	10.9
Wheat straw	1469600	7.9
Sesame straw	984000	5.3
Cotton stalks	47280	2.5
Sun flower stalks	800	0 0.0
Total production	18710696	100.0

Source management of pasture and forages in Sudan, (2005).

They are poorly digestible due to presence of lignin and polyphenols. Feedstuffs are classified as roughages have a high crude fiber (CF) content, and the digestibility of protein and energy, is generally lower. The National Research Council (NRC 1989) uses the following criteria to classify a feedstuff as roughage: When it contains greater than 18%, crude fiber (CF) and less than 70% total digestible nutrients (TDN). Later, Reddy (2004) reported that, roughages are classified into succulent roughages (those which contain more than 80% moisture) and non-succulent; leguminous and non-leguminous; green and dry. Roughages can also be grouped based on their nutritive value into maintenance type, productive type and non-maintenance type.

1. Maintenance type of roughage have about 3-5% digestible crude protein (DCP) e.g. (cereal fodder, grasses and hay).
2. Productive type have more than 5% DCP e.g. legume fodder and their hay.
3. Non-maintenance type of roughages have below 3% DCP e.g. straws, Stover and sugarcane baggase.

2.3.2 Concentrate

Concentrate are feeds that are high in nitrogen free extract (NFE) and total digestible nutrients (TDN) and low in crude fiber (less than 18%). These feeds can be either high or low in protein content, e.g. cereal grains, oil meals and by-products of milling industry (Ensminger *et al.,* 1990). Concentrates, according to Reddy (2004); Cheeke (2005; and Kellemes and Church (1998) are further classified into 3 groups based on energy and digestible crude protein (DCP): carbonaceous-rich in energy and low in DCP (cereal grains), portentous-very rich in DCP (oilseed meals and cakes, animal protein supplement) and products with energy and protein in intermediary position (bran, husks). Broadly feeds and fodders can be classified into roughages, concentrates and feed additives (nutritive and non-nutritive).

2.4 Animal feed resources

The main animal feed resources are:

- Natural grasslands (permanent pastures).
- Planted established pasture (forage crops, either rain fed or irrigated).
- Crop residues.
- Agro-industrial by-products (sugarcane industry by-products, oil cakes, milling by-products).
- Slaughter and other by-products.
- Manufactured animal feed (animal feed industry).

2.4.1 Animal feed resources in Sudan

In Sudan livestock obtain feed from:

1. Grazing and browsing on natural pastures.
2. Crop residues and agro-industrial by-products.
3. Cultivated pastures and forage crops.

2.4.1.1 Natural rangelands

The availability and quality of native rangelands available to livestock vary with altitude, rainfall, soil type and cropping intensity. Total range area in Sudan is 279 million feddan. The productivity of this area is estimated as 78 million tons of dry matter (DM) and constitutes about 87% of the animal feed resources (AOAD, 2001). This feed resources is not enough to supply nutrients required by 65 million livestock units (LU), (l LU is equivalent to a250 kg animal), available in the country. This shortage is due to deterioration of grasslands particularly in the semi-desert and low rainfall savannah regions, expansion of agricultural mechanized schemes and destruction of pastoral resources through fire and overgrazing (Abu Swar and Darag, 2002).

2.4.1.2 Irrigated fodder

The area cultivated by irrigated fodder constitutes about 5% of the feed resources. This area yields about 4 million tons of dry matter (DM) that represent 4.36% of the total dry matter produced in Sudan (Abu Swar and Darag, 2002). The irrigated fodders in Sudan are alfalfa (94%), Abu 70 (5%), phelebsera, doliches lablab and clitoria, all together represent 1% (National Comprehensive Strategy, 1992).

2.4.1.3 Crop residues

Crop residues are produced in abundance. They include cereal straw (Sorghum, wheat and millet straws), sugarcane by-products (sugarcane tops) groundnut and cotton by-products. Crop residues according to Abu Swar and Darag (2002) yield about 22 million tons of dry matter. In spite of the availability of these by-products in Sudan, they are not fully utilized. Crop residues and agricultural by-products could be used as an alternative animal feed. However the energy content of these by-products is poorly utilized by rumen microbes due to the presence of the lingo cellulosic components which are either indigestible lignin or acting as a barrier between the potentially digestible fraction (cellulose and hemicelluloses) and the digestible enzyme (McDonald *et al.,* 2002). Recently, the enzyme lignose is produced from fungi and yeasts in abundance, this provide the evidence tor the feasibility of developing a composite microbial system with high capability of developing a composite microbial system with high capability of degrading straw lignocelluloses in order to make reasonable use of straw resources as reported by Zhang *et al.,* (2004). Van Soest (1964, 1966 and 1967) as a pretext for developing a new method for forage analysis and evaluation of nutritive value of feeds. In this method, which, vas named after the inventor, the forage dry matter is fractionated into cell walls (CW) and cellular content (CC). In other words, the scheme grouped the nutrients of feedstuffs on the basis of characteristics affecting their digestion (Figure1), i.e. easily soluble and digestible cellular content capable of being digested by enzymes secreted in the digestive tract of the animal, and the structural carbohydrates (cell wall constituents) that can only be digested by micro-organisms. The latter group may not be completely available due to lignifications.

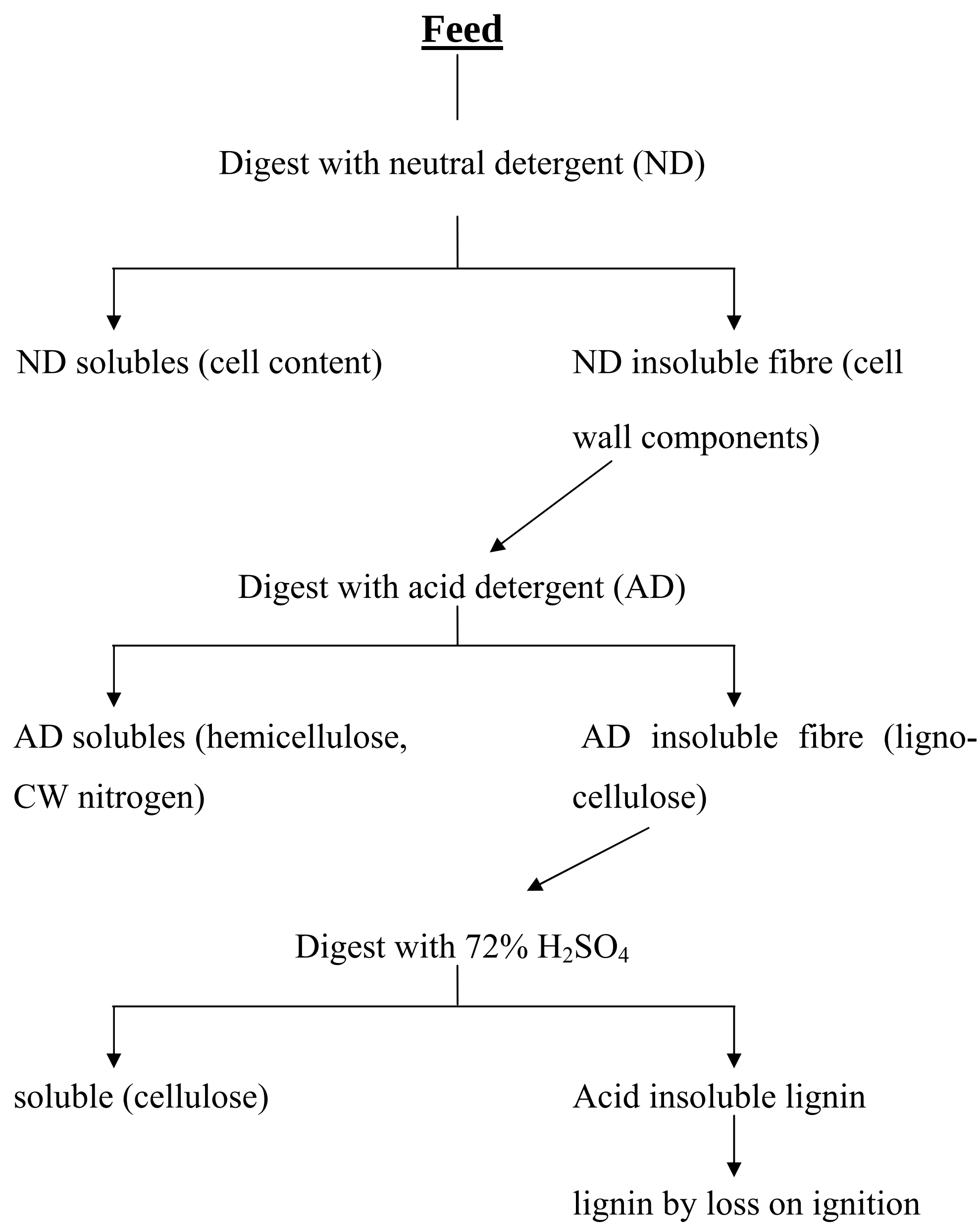

Figure 1. Partition of Forage Feeds. (From: Crampton & Harris, 1969).

Cell walls of forages can be prepared as neutral detergent fibre (NDF) by boiling for one hour with a 3% solution of sodium lauryl sulphate buffered at pH 7.0 (Van Soest & Wine, 1967), whereas lignocelluloses (lignin + cellulose) is prepared by the acid-detergent fibre (ADF) procedure, which is also a preparatory step for lignin determination by 72% su1phuric acid (Van Soest, 1963).

Animals fed on Sorghum straw alone result in negative nitrogen balance (Tagel-Din *et al.,* 1989). These negative aspects of cereal straws are believed to result from high neutral detergent fiber (NDF) content (resulting in high cell wall rigidity), and poor nitrogen content. Several treatments have been applied to try to increase intake and digestibility of cereal straws, perhaps the most widely used treatments are chopping the straw, addition of ammonia or urea N (Jackson, 1979, Dolberg *et al.,* 1981, Ibrahim *et al.,* 1987, Adu *et al.,* 1990) anaerobic in-silo fermentation, treatment with ammonium hydroxide (Solaiman *et al.,* 1979, Diarra, 1983) and supplementation with concentrates (Huston *et al.,* 1988), or with good quality hay (Adu *et al.,* 1990).

Results of cereal straw treatment with urea N appear to vary greatly. Urea supplementation usually results in higher dry matter intake and digestibility (Ibrahim *et al.,* 1987), however some authors (Ibrahim *et al.,* 1987) have found no effect of urea treatment on animal performance. Supplementation with concentrates (Huston *et al.,* 1988, Tagel-Din *et al.,* 1989) or with legume hay usually improves straw utilization (Adu *et al.*, 1990), although results may vary depending on the level of supplementation.

High levels of supplementation with concentrate have caused intake of the straw to decrease (Adu *et al.,* 1990). Question appears to remain un-answered on the effect of straw treatment on digestion and utilization at high levels of concentrate.

2.4.2 Molasses

Molasses is a product of the sugar-refining industry. The principal types are cane and beet molasses refined from sugarcane and sugar beets, respectively. They are similar in composition and feeding value.

McDonalds *et al.,* (2002) reported that sugarcane (*Saccarum officinarum)* is produced in tropical and subtropical regions. Sugar-cane is a perennial grass, with thick-sugar rich stems and abundant leaves. The cane is\ harvested when sugar content is at a maximum and transported to the Refining plant. The stems are pressed to squeeze out the juice, containing the sugar. The fibrous residue of the stalk is called (baggase) which is burned or used as low quality roughage for animal feed. The juice is concentrated by boiling, and then sugar crystallizes out of the concentrated juice and is collected as raw sugar. The juice residue is the molasses. From each ton of sugarcane approximately 100 kg of refined sugar and 25 -50 kg of molasses are produced (McDonald *et al.,* 2002). Liquid molasses contains 15 -25% water. It is black, syrupy sweet solution containing at least 46% sugars. It can be dried to produce dried molasses, but the added cost usually does not warrant drying. It is very low in protein content. Molasses functions primarily as an energy source and can be fed at levels up to 30 percent of the diet. EI Khidir *et al.,* (1995) had reached up to 52% of the diet successfully in feeding Sudan Baggara bulls. At higher levels, it has a laxative properties because of its high mineral content (particularly potassium). Bayley *et al.,* (1983) fed cane molasses at 68.5 percent of the diet of pigs, as the sole source of dietary carbohydrates, the faeces were black and liquid, but there were no more other adverse effect.

Molasses is often included in manufactured feeds at levels of 2-5 percent to increase palatability. McDonald et al. (2002) described the advantages of this as reducing the dustiness and "fines" and acts as pellet binder to improve pellet quality. At level above 5 to 10 percent it may cause milling problems because of stickiness and may form large clumps in the mixture or stick to the equipment in the feed mill.

There is much interest in the tropics in developing beef production systems based on molasses feeding. In sugar producing countries like Sudan, there are large quantities of molasses available. The high energy feed is not utilized directly by animals in large amounts. In Cuba for instance, intensive beef production has been developed on a molasses-urea based diets. Molasses provides the major source of fermentable carbohydrates and urea provides fermentable nitrogen, a roughage source such as sugarcane tops (SCT) or sugarcane baggase (SCB) is used to provide sufficient fiber to maintain normal rumen function. Protein-rich legume forage such as leucaena, may be used of both roughage and bypass protein (Gheeke, 2005). Five sugar factories were found in Sudan. They produced about 1.160,000 tons of molasses during 2002-2003.

Ninety six percent of this amount is exported and only 4% is available for the country consumption (Abuswar and Darag, 2002).On the other hand, Darag *et al.,* (1995) reported that, the amount of molasses produced in Sudan could maintain 1.1 million Animal Unit (AU) for three months during critical periods.

2.4.2.1 Molasses toxicity

In molasses-based feeding systems, a problem referred' to "molasses toxicity" may develop, characterized by neurological defects such as incordination and blindness (McDonald *et al.,* 2002). Molasses toxicity has a complicated etiology and involves an inadequate supply of glucose to the brain inducing thiamine deficiency and rumen stasis.

Inadequate glucose status occurs because molasses fermentation produces a high rate of butyrate to propionate as end products. Butyrate is ketogenic and propionate is glucogenic. An excess of butyrate relative to propionate results in inadequate glucose synthesis and shortage of glucose for brain metabolism. Molasses toxicity occurs when the roughage component of the diet is insufficient. Low fiber intake results in rumen stasis and proliferation of slow-growing microbes. Provision of adequate roughage is effective preventing molasses toxicity.

2.5 Concentrates (energy sources)

2.5.1 Sorghum grains

Sorghum and millets are the major food grains in the semiarid tropics, an ecological zone encircling the globe and including China, India, most of Africa, Australia, Argentina and parts of Southern United States. In the developed countries approximately 96% of the total Sorghum and millet grown is used for animal feed, where in the developing countries, only 8% of these crops is used for livestock (Cheeke, 2005), with the rest 92% used directly as human food. In the Sahelian zone of Africa, approximately 90% of the rural population depends on these crops as their major source of food. Sorghum is hardy, drought resistant crop adapted to environmental conditions too harsh to production of other cereals. It requires less water, can survive dry conditions and then resume growth when moisture becomes available. Sorghum grains act as an energy source. For ruminants, it requires more vigorous processing, such as steam flaking; to achieve optimum digestibility (Reinhardt *et al.,* 1997), However there is a considerable variability in feeding values among Sorghum cultivars and types, mainly because of variation in tannin content and seed coat color-brown-high tannin, bird resistant Sorghum give poorer animal performance and lower digestibility than low tannin type. Sorghum is a fairly poor protein source (7-10%) according to Cheeke (2005) with low availability of amino acids. Sorghum protein digestibility is fairly affected by tannin (Streeter *et al.,* 1993) Sorghum like other grains has very low calcium, high phosphorus phytate and no vitamin B_{12}.

2.5.2 Cereal milling by-products

2.5.2.1 Wheat bran

In wheat milling, the endosperm is separated from other fractions of the seed. The endosperm consists mainly of starch and gluten. The outer most layer of the seed is highest in fiber and when removed constitutes most of the bran fraction (Cheeke, 2005). Wheat bran consists of the outer most layers of the seed along with some flour. It is a flaky, reddish brown material. Wheat bran is quite palatable and is well known for its ability to prevent constipation because of its swelling and water holding capacity. Ellis (1981) reported that, the wheat bran of 93.5% DM contain a metabolizable energy (ME) of 10.10 MJ/kg DM and 16.83% crude protein (CP), on the other hand Cheeke (2005), reported 13.5 -15% CP for the wheat bran. In Sudan, Darag *et al.,* (1995) estimated the annual production of wheat bran as 285.420 ton/year, 7 out of 16 flour mills is working and all were located in Khartoum State (Abu Swar and Darag, 2002).

2.5.3 Concentrates (protein sources)

2.5.3.1 Groundnut cakes

Oilseed cakes and meals are by-products of vegetable oil production for edible and industrial purposes. In some countries groundnut is called peanuts *(Arachis hypogoae),* it is grown for human consumption and oil extraction. Principal producers are India, China, Nigeria, the United States and Brazil (Cheeke, 2005). Groundnuts are annual legumes, produced mainly in tropical and semi-tropical environment. In Sudan it is also produced as nuts and oil for human consumption or groundnut cakes as an animal feed, it is produced in underground pods. Groundnut meal contains approximately 45 to 50% crude protein (CP), and is quite deficient in lysine (Cheeke, 2005) and suboptimal amounts of cystine and methionine (McDonalds *et al.,* 2002). The latter authors also reported that groundnut meal is now usually made from the pods used as a feed source, when an un-decorticated meal is produced. Ellis (1981) estimated 43% (CP), 12.68% (CF) and 11.57% MJ/kg (ME) for the mechanically extracted decorticated groundnut cake. Orskov and Macleod (1982) reported higher degradability values for groundnut cakes compared to linseed meal and fish meal. Similar results were obtained by Stanton (1999) who signed that groundnut meal has a low bypass protein. Groundnut cake contains Low amounts of crude fiber (CF) which make it unsuitable alone for feeding ruminants (Abu Swar and Darag, 2002).

2.6 Animal feed industry

According to the FAO (2004) there are three definitions for animal feed industry, one of them is "commercial operations producing feed for sale", the second one is "integrated operations where large producers in particularly produce their own feedstuff" and the third definition for animal feed industry is "the cooperative operations where farmers jointly own the feed mill or production plant that produce the feed they use". On the other hand Cheeke (2005) uses the term animal feed manufacturing rather than animal feed industry and defined it as the process of converting ingredients raw materials "feedstuffs" into balanced diets that are then sold to producers of livestock and other animals. In many countries the term "feed compounding" and "compound feeds" are used.

Manufactured feeds are produced in feed mill that have equipments to process feedstuff "e.g. grinding and extruding" for mixing in the desired proportions and for mixing the ingredients to produce the finished product (Cheeke, 2005), often the mixed feed is pelleted, or it may be marketed as a meal type "mash feed".

Beef cattle and sheep are primarily grazing animals and generally receive little if any manufactured feed. Feedlot cattle are usually fed diets mixed at the feedlot and so are not major consumers of manufactured feed (Cheeke, 2005). The same author reported that, modern feed mills are largely computer controlled. The process begins with company nutritionist who computer formulate diets, using NRC (National Research Council) or other recognized requirement figures, tables of feed composition and current prices of ingredients. Many diets are least cost formulas, in which the ingredients are selected to meet the prescribed nutrients requirements figures at the lowest cost. There may be factors, such as palatability and physical texture that reduce animal performance. According to the FAO (2004), ten countries produce more than 60% of the world's, total industrial feed. Manufactured feeds for poultry are the greatest proportion of tonnage, next is swine followed by cattle feeds which are mainly concentrates for dairy cows.

Ensminger *et al.,* (1990) defined animal feed industry as the operations necessary to achieve the maximum potential nutritional value of feedstuffs, i.e. changing ingredients in such a manner as to maximize their natural value and the net returns from their use. The latter author also' tend to use the term "feed processing" as a synonomus to feed industry which may be physical and/or chemical.

Similarly, Church *et al.,* (1998) described animal feed industry as methods which might involve mechanical, chemical and/or thermal methods or combination of all of these methods to alter the physician form or particle size, to prevent spoilage, to isolate specific parts of the seed or plant, to improve palatability, or to inactivate toxins or anti-nutritional factors of one type or another.

2.6.1 Animal feed industry in Sudan

Animal feed industry in Sudan is basically located in the capital town Khartoum, with some factories in Gezira, Kassala and Gedarif States. Twenty seven animal feed factories and mixers were found in Khartoum State, only 19 out of them are working now (MAAI, 2001). The total production of the manufactured feed is 176.665 tons which are estimated of 60% of the designed capacity of these factories. Recently Kenana Sugar Company established a modem animal feed factory in 2004 at Kenana in the White Nile State, the capacity of this factory is (75.000 tons) and the actual production is 10.5 tons/hour. Kenana animal feed factory is designed to make use of the sugarcane industry by-products (mainly molasses and baggase).

2.7 Techniques used in improving ruminants feeds

2.7.1 Pelleting

Ensminger *et al.,* (2004) and Cheeke (2005) defined the pelleted feeds as agglomerated feeds formed by extruding individual ingredients or mixtures by compacting and forcing through die (chamber with holes) openings by any mechanical process as the extruded material leave the die, it is cut of by knives to pellets. The purpose of pelleting is to change dusty and unpalatable feed material into more palatable easy to handle larger particles by application of optimum amounts of heat, moisture and pressure. The normal size of pellets is 1.9mm to 3.9mm, though the maximum used pellets diameter is 6.25 to 9.4mm. The shape is mostly cylindrical, if smaller pellets are required, it is economical to produce 3.9 mm pellets and reduce it to the desired particle size by crumbling process. Kellemes and Church (1998) signed that a soft pellet breaks up when handled mechanically and variable particle size make it difficult if not possible to adjust feeder properly to prevent feed wastage. They concluded that the pellet should be hard and not crumbly.

2.7.2.1 Pellet quality

If the pellets crumble readily or contain a lot of dust (fines), customers will complain, pellet quality can be maintained by the use of pellet binders and by the selection of ingredient that will form good pellet (Cheeke, 2005). The characteristics of ingredients that control how it will react in pelleting are called its functional properties. The functional properties of starches and proteins are of major importance in determining the pelleting quality of feed ingredients (Wood, 1987). Pelleting improves animal utilization of wheat by-products (wheat bran) (Skoch *et al.,* 1983a, b). The endosperm of barley a1so react with water to increase viscosity, but those of corn, Sorghum and millets do not (Thomas *et al.,* 1998).

2.7.2.2 Pelleting of roughages

Ensminger *et al.,* (1990) and Reddy (2004) reported that roughages are usually ground before they are pelleted, sizes of the pellets range between 12/64 to 48/64 inches. Pelleted roughages weigh about 40 pound/cft as compared to 5-6 pounds/cft for long hay. Pelleting poor quality roughage will markedly increase the consumption of roughage. The same author signed that, in pelletizing complete feeds, incorporation optimizing the feed intake; otherwise, the feed intake is decreased. Feeding pellets particularly with higher concentrate content to ruminants may causes parakeratosis (degeneration of rumen papillae). Pelleting of diets low in forage has an adverse effect on rations containing a low level of crude fiber (CF) there is no advantage in pelleting feed for beef cattle and swine (Ensminger *et al.,* 1990). Oltjen *et al.,* (1971) fed a pelleted all forage based diet to steers which subsequently graded low choice and had approximately have the amount of back fat as cattle finished on all-concentrate diet. Pelleting and the associated reduction in particle size of the forage is important. Beardsley (1964) reviewed the research with pelleting and concluded that feed intake, daily gain and feed efficiency of cattle and sheep generally were increased when forage was pelleted, even though digestibility was depressed. Dinius *et al.,* (1975) found no differences in average daily gain of steers fed pelleted Alfa alfa hay blended with up to 67% Timothy hay. Beardsley (1964) has indicated that animal response was grater from pelleting a poor quality forage than from pelleting a high quality forage.

2.7.2.3 Advantages of pelleting

Many researchers (Ensminger *et al.,* 1990; Kellemes and Church, 1998; Reddy, 2004) have concluded similar advantages of pelleting in the following summary:

1. Increase the palatability of feed and thereby feed intake.
2. Improves the feeding value of different feeds, especially with roughages as compared to concentrates.
3. Increase the density of feed and thereby reduce the storage space required.
4. No segregation and selective feeding.
5. Reduces the wastage of feed by ruminants.
6. Pelleted feeds can be handled mechanically thereby saving labor and transportation cost.
7. Heat labile inhibitors are destroyed; gelatinization of starch occurs.
8. Feeding pelleted feeds enhances the growth rate and milk production and reduces cost of the end products (meat or milk).
9. Balanced feed.

The biggest deterrent to increased pelleting at the present time is difficulty of processing as the only disadvantage.

2.8 Feedlot performance

Feedlot performance as a fattening process is expressed in terms of dry matter intake (DMI) per day, body weight gain per day and the feed conversion ratio.

2.8.1 Voluntary feed intake

Feeding is a complex activity, which includes such action as the search for food, recognition of food and movement towards it, sensory appraisal of food, and the initiation of eating and ingesting (McDonald *et al.,* 2002). Voluntary feed intake is the main factor, which determines animal productivity; and this intake will be a reflection of the chemical composition, physical characteristics, digestion and the rate of passage of the diet through the digestive system (Welch, 1982).

2.8.1.1 Control of voluntary feed intake

Forbes (1996) concluded that, the control of voluntary feed intake by ruminants has been studied by many research groups over the past 40 years, using a wide variety of techniques. Over this period several theories have been proposed, each based on a particular factor. For example observation that forage intake is often positively related to the rate or extent of digestion in the rumen led to the physical theory which has been supported both by the discovery of receptors in the rumen wall sensitive to stretch and touch and by the fact that intake is depressed when the capacity of the rumen is reduced (Allen, 1996). Another theory is that Concentration and flow of nutrients and energy, including volatile fatty acids (VF A) produced by fermentation in the rumen, are involved in controlling intake (Illius and Jessop 1996); another theory is that ruminants eat the amount of feed that give the optimum yield of net energy (NE) per unit of oxygen consumed (Ketelaars and Tolkamp, 1996). Most authors have accepted that the factor they studied was just one of many possible and interacting factors and this means that the effects of these signals are additive (Forbes,1996, 1980b).

2.8.1.2 Factors affecting feed intake

Cheeke (2005) had summarized these factors affecting feed intake as palatability and feed preference, secondary compounds, dietary energy level, protein and amino acids concentration, forage composition, environmental temperature, pregnancy and lactation in females, metabolic body size, and learning and conditioning, as the major factors, other factors like smell of the diet, fatigue and rumination time are also considered as reported by Preston and Leng (1987); Mcleod and Smith (1989); Van Soest (1994). Palatability is a determinant of feed intake. Palatability is the summation of the taste, olfactory and textural characteristics of the feedstuff that determines its degree of acceptance. McDonald *et al.,* (2002) had reported that mechanical grinding of roughages and pelleting partially destroys the structural organization of the cell wall, thereby accelerating their breakdown in the rumen and increasing feed intake. They studied the relationship between the digestibility of feed and their intake and found a positive relationship between them. Similar results were obtained by Lippke (1986) that cattle select a diet that maximize digestible organic matter intake and he concluded that, forage intake in cattle is regulated by the indigestible NDF. General conclusions from studies of chewing time in cattle included a positive relationship between time spent chewing and increased particle size in the diet and increase dietary concentration of NDF (Sudweeks *et al.,* 1975, 1981; Woodford and Murphy, 1988). Chewing time/kg of DMI decrease as DMI increase (Sudweeks *et al.,* 1980; Beauchemin and Buchanan-Smith, 1996; Loginbuhl *et al.,* 2000). Animals often exhibit a reluctance to accept a new feed (Cheeke, 2005). Similar conclusion was achieved by Chapple *et al.,* (1987) who found that it took sheep several weeks to overcome fear of the feed trough and supplementary wheat, and then a period was needed to learn to eat, chew and swallow wheat. The learning process was accelerated if there were some experienced animals in the flock. Huntington and Bums (2007) had studied voluntary feed intake of gamma grass and switch grass balege by seers, they had concluded that reduced DMI was attributed in part, to the 'steers' behavior, this might give the individuality of animals behavior some importance in affecting voluntary feed intake.

2.8.2 Feed intake in beef cattle

NRC (1996) suggested maximum dry matter intake for finishing beef cattle ranged from 2.2% for live weight calves to 2.96% for cattle weighing 450 kg. For yearling steers, values given range from 3.2% to 3.6 of body weight for animals weighing 135 kg. Of course, the caloric and bulk densities will have a marked effect on maximum consumption.

Feedlots at times have problems with cattle which either consumes too little or too much feed. Cattle subjected to cold stresses in winter often have greatly reduced feed intake and fail to gain at expected rates (Gill *et al.,* 1987). Owen and Geay (1992) concluded that environmental factors such as high or low temperatures, wind and humidity alter feed intake. Exposure to high environmental temperature causes a reduction in feed intake, the ruminants being sensitive because of the heat produced by fermentation within the rumen (Forbes, 1980b). Guma (1996) concluded that Sudan Baggara cattle showed increase in feed intake up to 56 days of feeding and then feed intake decreased. The initial increase in feed intake could possibly be due to compensatory growth effects as these animals were coming directly from natural ranges, while the decreased intake could be related in part to the increased deposition of fat within the abdominal cavity, which reduces the effective volume of the cavity into which the rumen can expand during eating.

Beef cattle are well adapted to the utilization of forages. In the developed countries there has been a trend in recent year to feed diets high in grain because of the wide spread belief that the eating quality of the beef is superior with grain fed animals (Cheeke, 2005). The nutrient requirements of beef cattle (NRC, 1984) reviewed the daily consumption of 273 kg live body weight growing beef cattle as 7.1 kg as fed, putting gain of 1 kg/day. Bulls weigh 182 kg required 5.5 kg of feed as fed. Voluntary feed intake is an important factor determining total energy consumption and hence animal performance. Owen and Geay (1992) concluded that high feed intake is obtained through ad libitum feeding or by enhancing nutrients concentration by feeding a high proportions of concentrates. Dry matter intake of a given animal varies with the composition of the diets, bulk density can limit feed and energy intake (Mertens, 1985). Owen and Geay (1992) also reported that feed intake declines as energy concentration increased. Ledger *et al.* (1970) postulated that at similar live weights and on similar diets temperate cattle usually have a higher feed intake than zebu cattle. The average daily dry matter intake (DMI) ranged from 7.0 to 7.6 kg for Arussi breed and from 9.0 to 10.1 kg for Boran Breed during a fattening period ranging from 73 to 157 days, Jepsen and Creek (1976). Preston (1987) concluded that cattle with heavier starting weight achieve higher intakes in the feedlots. Similar findings, were reported by Gaili and Osman (1979) on Sudan Baggara bulls kept on feedlot at different initial weights 155, 179,205 and 221 kg, the dry matter intakes recorded were 9.9, 10.2, 11.6 and 13.3 kg/head/day, respectively. They concluded that, the overall mean for daily feed intake per head increased with the increase in the initial feedlot weight. Meissner *et al.,* (1982) investigated the performance of beef bulls at four live weights (100, 200, and 300) when fed two diets all-concentrate and all-roughage. They reported the following DM intakes kg/day on all-concentrate diet Africander 4.6, 5.2 4.3, Hereford, 5.2, 6.7 6.9, Simmental, 4.8, 6.6 7.5. On all-roughage diet the values were, 4.9, 6.7 and 7.5 for Africander, 4.7, 6.5 and 7.1 for Hereford and 4.3, 6.3 and 7.6 for Simmental.

Hankey and Kay (1988) reported that overall daily dry matter intake (DMI) differed significantly ($P< 0.01$) between breeds, Charolais crosses being higher (5.25 kg) than Aberdeen, Angus crosses (3.65). Thiessen *et al.,* (1984) reported overall means of 25 breeds from 12 to 72 weeks of age. The daily feed intake (kg/day) ranged from 3.6 to 9.0 kg. Butterworth *et al.* (.1984) found significant ($P<0.05$) differences in. dry matter intake (DMI) among diets containing different agricultural byproducts. The dry matter intake (DMI) averages were 4.5 and 4.8 kg/day/animal. Levy *et al.,* (1980) reported daily average dry matter intake (DMI) of 7.5 kg/day on a concentrate with 11.1 MJ/kg DM metabolizable energy and 6.5 kg/day for bulls kept on a second diet with 10.5 MJ/kg DM metabolizable energy. The metabolizable energy requirements per unit live weight gain (MJ/kg) were 68.5 and 82.1 for the bulls on the two diets, respectively. On the other hand, Merchen *et al.,* (1987) found that cattle fed low energy diets in the growing period consumed more ($P<0.05$) feed (10.2 vs 9.2 kg DM/day in one experiment, 9.2 vs 7.3 kg DM/day in the second experiment. Elshafie and Mcleroy (1964) studied the feedlot performance of Sudan Baggara bulls ranging in age from yearling to three years. They recorded average dry matter intakes as 6.5, 7.9 and 9.2 for the three groups, respectively. El Hag and George (1981) reported an average dry matter intake of 7.5 kg/day of bulls from the same breed fed different rations based on agricultural byproducts. Eltayeb *et al.,* (1990) reported that average dry matter intake ranged from 9.5 to 10.5 kg/day for Sudan Baggara bulls fattened on different levels of concentrate diets. Mustafa *et al.,* (1990) found that daily feed intake ranged from 10.4 to 11.6 kg for Sudan Baggara bulls kept on milled Sorghum Stover. Eltahir (1994) reported an average daily dry matter intake of 7.3 kg/head/day for Sudan Baggara bulls fed on molasses based fattening ration. Guma (1996) reported an average dry matter intake of 5.9 kg/day of bulls of the same breed kept on a concentrate diets for 180 days. Other findings were reported by Abd Elgalil (1997) as 8.74 kg/head/day for Sudan Baggara bulls kept on diets of two different sources of protein. Mohamed (1999) reported dry matter intake (DMI) of 7.17, 7.17, 7.35 and 5.67 kg/head/day for bulls of the same breed fed diets of different energy levels (11,5, 10.5, 9.5 and 8.5 MJ/kg DM metabolizable energy, respectively. Intesar (2002) reported a dry matter intake (DMI) of 7.53, 6.92, 8.45, 7,61, 7.87 and 8.23 kg/head/day for Sudan Baggara bulls fed on diets of different protein sources. Suliman (2004) conducted an experiment using non-conventional source of protein (karkade seeds) in Sudan Baggara bulls diets, he reported 5.48, 4.74,4.88,4.95 and 4.89 kg/head/day as daily dry matter intake (DMI).

Itidal (2004) studied the utilization of sugarcane baggase for fattening sixty Sudan Baggara bulls, the diets used contained 0, 10, 20 and 30 percent of the sugarcane baggase, she reported average daily dry matter intake (DMI) as 4.82, 5.31, 6.09 and 6.1 kg/head/day, respectively.

2.9 Feed conversion ratio (FCR)

Feed conversion ratio is also known as efficiency of feed utilization, it is defined as the amount of feed required to produce one unit of live weight gain. Since feed affects total profits of beef cattle production as its' the major item of expense in finishing cattle. Ensminger (1999) reported that feed accounts for 70-80% of the cost of feedlot finishing exclusive of the purchase price of the animals. This explains the importance of FCR as an important ratio to assess. Levy *et al.* (1968) and Thiessen *et al.* (1984) observed that feed efficiency declines with the increase in live weight and duration of fattening. Reyneke (1976) in a comparative study on beef production from bulls, steers and heifers, concluded that bulls required 5.14 kg/DM/Kilogram live mass gain. Under feedlot conditions, Charolais and Hereford bulls kept on high molasses level required 5.6 and 6.4 kg dry matter per unit weight gain, respectively (Veitia *et al.,* 1919). Cobic *et al.,* (1980) reported that, the feed conversion was most efficient in animals fed the highest crude protein level (14.3 -16.6%) in dry matter of the ration. Gaskin *et al.,* (1982) studied the feed requirements for maintenance and gain in crossbred bulls *of* Jersey X Angus on concentrate diets. They found that the respective feed conversion ratio values were 4.7 to 7.2 kg/dry matter/kg live weight. Theissen *et al.,* (1984) reported values ranging from 5.52 to 13.41 for Dexter and British Charolais breeds fed standard pelleted diets.

Elshafie and Mcleroy (1964) investigated the response *of* Sudan Baggara cattle to a fattening ration composed of agricultural byproducts. They found that the feed conversion ratios were 6.5, 7.9 and 9.2 kg

DM/unit live weight gain for age groups ranging from yearlings to three years old.

Ahmed *et al.,* (1977) found that the feed conversion efficiencies were 8.327 and 8.83 kg DM/kg live weight gain for two age group of thirty months old Sudan Baggara bulls, fed two different concentrate diets. Gaili and Osman (1979) found overall means of feed conversion ratio *of* 8.75, 8.82, 9.37 and 9.75 corresponding to initial feedlot live weight of 155,179,205 and 221 kg. EI Hag and George (1981) reported that the efficiency of feed conversion was significant ($P< 0.05$) between treatment groups of Sudan Baggara bulls finished on agricultural byproducts. Values ranged from 6.3 to 7.4 kg DM/unit live weight gain.

El Khider *et al.,* (1988) investigated the effects of a traditional and unconventional fattening diets on Kenana bulls calves. They found that the average feed conversion ratios were 5.0 and 4.9 kg DM, respectively. Mustafa *et al.* (1990) used mature Sudan Baggara bulls on feedlot diets of different levels of milled Sorghum Stover. They obtained feed conversion values that ranged from7.4 to 8.5 kg DM. Eltayeb *et al.,* (1990) studied the effect of feeding different levels of Sorghum on the feed conversion efficiency of Sudan Baggara bulls. They reported values ranging from 8.6 to 10.8 kg DM/kg live weight. Eltahir (1994) reported an average feed conversion ratio of 6.5 kg/DM/unit of live weight gain for the same breed. Guma (1996) studied beef production potentials of Sudan Baggara cattle, and reported FCR value of4.3, 5.1, 5.8, 6.4, 7.5 and 8.3 kg DM/unit values. Values for the same breed reported by EI Khidir *et al.,* (1995) was 6.54 kg DM/unit of live weight gain. Mohamed (1999) reported 6.73,7.11, 7.00 and 11.75 kg DM/unit of live weight gain for Sudan Baggara bulls kept in diets of different energy levels. lntesar

(2002) reported 8.06, 7.97, 7.89, 7.21 and 7.08 FCR for the same breed when fed on diets of different protein sources. ltidal (2004) reported FCR values of 5.15, 5.02, 6.09 and 7.35 kg DM/unit of live weight gain corresponding to zero percent, 10, 20 and 30% sugarcane baggase levels in Sudan Baggara bulls diets. Suliman (2004) studied the use of karkade seeds *(Hibiscus sabdariffa)* as a non- conventional protein source at 0, 25, 50, 75 and 100% levels, he reported FCR for Sudan Baggara bull of 6.85, 8.85, 9.7, 9.75 and 11.27, respectively.

2.10 Live weight gain

Average daily gain (ADG), is an important parameter in beef production as it is used to determine the rate of growth and development. Widdson (1980) defined growth phenomenon as an increase in body size. Live weight gain is affected by plane of nutrition, breed type, age, sex and growth promoters. A comparison of growth rates of bulls of different breeds showed that, at the same age, Charolais bulls have the highest, 1.3 kg/day followed by South Devon 1.08 kg/day, Hereford 1.03 kg/day, beef Short horn 0.97 kg/day, Angus 0.95 kg/day and Galloway 0.92 kg/day (Rabelinand Tulloh, 1992). Studies of the tropical African cattle showed that an average daily live weight of the young Nguni cattle is 1.096 kg/day when kept under feedlot condition for 140 days (Raude *et al.,* 1975).

Comparative studies of the potentials of local breeds in Sudan is lacking. However many researches were carried out on feedlot performance of the local breeds. Elshaife and Mcleroy (1964) studied the performance of' Sudan Baggara bulls on feedlot using agricultural byproducts. The age groups were 18, 24 and 30 months and the fattening period was 100 days. They obtained average daily weight gains of 1.0, 1.11 and 1.19 for the three age groups, respectively. The same author (1966) reported average daily gain of 0.84 kg/day in two groups of the same breed.

Mukhtar and E1 Triefe (1970) reported a value of 1.0 kg as average daily weight gain for Sudan Baggara bulls calves fed on Sorghum based ration. Mukhtar and Elshafie (1972) reported 1.1 kg/day as average daily gain for bulls. On the same breed Ahmed *et at.* (1977) obtained 1.25 kg average daily weight gain using a conventional concentrate ration added to low quality roughage during 90 days fattening period. Gaili and Osman (1977) fed Sudan Baggara bulls on two different fattening diets, they reported 1.31 and 1.23 kg/day, respectively. Gaili and Osman (1977) reported 1.13, 1.15, 1.24 and 1.36 kg/day as average daily weight gains for bulls at an average initial feedlot weights of 155, .179,205 and 310 kg, respectively.

EI Hag and George (1981) reported daily weight gain ranging from 1.0 to 1.2 kg for bulls fed on poor quality agro-industrial byproducts. Mustafa *et al.* (1990) found an average daily weight gain of 1.4 kg/day for the same breed when fed on a conventional concentrate diet. El Tayeb *et al.,* (1990) reported an average daily weight gain of 1.05 kg for Sudan Baggara bulls fed ad-libitum on Sorghum Stover plus concentrate mixtures. Eltahir (1994) studied the feedlot performance for the same breed, he reported 1.13 kg/day as average weight gains. EI Khider *et al.,* (1995) fed 2206 Baggara bulls in a large experimental feeding trial, the initial feedlot weight ranged from 150 -600 kg body weight divided into 10 groups based on body weight. They reported 0.958 and 1.044 kg/head/day as live weight gain for bulls of 300 kg live bodyweight. Abd Elgalil (1977) reported 1.10 kg/head/day for the same breed fed on 9.69 MJ/kg DM metabolizable energy. Mohamed (1999) reported 1.07, 1.01, 1.05 and 0.59 kg/day as an average weight gain, for Sudan Baggara bulls fed diets of different energy levels. On the same breed, lntesar (2002) reported 0.934, 0.870, 1.077, 1.056 and 1.113 kg/head/day as live weight gain using diets of different protein sources. ltidal. (2004) reported 0.97, 0.96, and 0.91 kg/head/day for Sudan Baggara bulls fed on diets of different levels of sugarcane baggase (SCB).

2.11 Livestock fattening

Tropical regions of the world including Sudan are probably the richest in potentials for animal production. Nevertheless, until recently, there has not been the development of intensive feedlot fattening that has taken place in the developed countries like the Untied States. FAO (2002) reported that livestock products accounts for about 19% of the value of food production and provide 34% of the protein and 16% of the energy consumed in human diets. FAO projections suggested that global meat production and consumption will rise from 233 million tones in the year (2000) to 300 million tones in the year (2020). Livestock fattening is entirely dependant upon growth and development which make the live weight changes (Hammond, 1932). The beef industry includes breeding, feeding and marketing cattle with the eventual processing and merchandising of retail products to consumers. The process involves many people and utilizes numerous biological and economic resources. In Sudan beef production depends mainly on the nomadic range system. Beef cattle have been the main concern of the country due to their contribution to the national economy. Sudan Baggara cattle are numerically the most important beef cattle in Sudan, raised by nomads in the Baggara belt that comprises southern Darfur, southern Kordofan and White Nile States (E1 Khalifa, 1985). They are characterized by a large hump, relatively short horns and variable colors (Bennet and Hawison, 1952; Wilson and Clarke, (1975). E1 Khalifa *et al.,* (1985) concluded that Sudan Baggara cattle are not a uniform type of cattle the name is given to those cattle which belong to a certain geographical area. Traditionally cattle destined for slaughter are directly drawn from pasture in very lean condition. Then they are subjected to short term feeding period to reach the market weight and to improve meat quality. Livestock fattening in Sudan is based on Sorghum grains and oilseed cakes at a ratio of 50% each (E1 Hag and Hamad, 1983; Eltayeb *et al.,* 1990); Mustafa *et al.,* 1990).

Other researchers (El Hag and George, 1981, E1 Khidir, 1984, 1995; Tibin and Ahmed, 1997a, 1997b) sighted the use of agricultural and agro-industrial byproducts in livestock fattening in Sudan.

2.12 Nutrients requirements for beef cattle

The National Research Council (NRC) nutrients requirements are the authoritative figures used in the United States and many parts of the world. They are intended to be true requirements and do not have a margin of safety. In Britain, the Agricultural Research Council (ARC) publishes recommendations of nutrients requirements for livestock, several other countries also have their own recommendation but the NRC and ARC are most widely used (Ensminger, 1990). In Sudan similar system is not yet established.

2.12.1 Energy requirements

Ruminants need energy for their life processes. As far as the diet is concerned it is best to consider the useful energy rather than the total or gross energy (GE) (Owen, 1979).

Expressing energy requirement and energy values of feedstuffs for ruminants is somewhat more complex because of rumen fermentation and the complexity of interaction between diet and fermentation and products. One example of this complexity is the effect of balance of absorbed VFA on metabolic efficiency if there is a surplus of acetate (C_2)

or a deficiency of propionate (C3), theC2 energy cannot be utilized in the citric acid cycle reactions of metabolism (Cheeke, 2005).

McDonalds *et at.,* (1987) reported that faster growing cattle have gains of higher energy concentration; for example 300-kg steers of a medium-sized breed growing at 1 kg/day retain 15.5 MJ/kg, whereas the same animals growing at only 0.5 kg/day retain only 14.3 MJ/kg. The influence of breed is a reflection of mature size, the sex of the breed is also considered having an effect on energy requirements e.g. the gains of heifers have a higher concentration of energy than those of steers, and the gains of steers have a higher concentration than those of bulls.

2.12.2 Protein requirements

The latest version of the Nutrient Requirements of Beef Cattle (NRC, 1996) uses metabolizable protein (MP) system to calculate protein requirements. Practical diets for growing and finishing cattle typically are formulated on the basis of percentage of CP, with little efforts to consider ruminal N transaction and/or the protein amino acid requirements of ruminants (Galyean, 1996). The minimum protein level giving maximum growth or nitrogen retention is taken as the estimate of the requirements (McDonald, 1987). Kay and Maedearmid (1973) found no significant differences (P>0.05) in live weight gain between bulls given diet containing 14.5 and 17% crude protein (CP). They concluded that where cereal diets were used to fatten bulls no improvement in weight gain was achieved by increasing CP content above 14.5% for bulls up to 250 kg (LWT) and subsequently above 12%. Similar findings were obtained by Cobic *et al.,* (1980) and Dicke (1996). They added that for bulls up to 250 kg of live weight gain for satisfactory live weight gain and feed efficiency, the ration should contain at least 14% CP in DM, while about 12% CP could be sufficient up to 350 kg, which would be lowered to 10% in the final period of fattening. Similarly Galyean (1996) reported that, dietary CP level in beef finishing diets is typically 12.5% or greater. Kousgaard (1980) reported better daily gains in animals kept on higher protein level.

2.12.3 Minerals requirements

Calcium and phosphorus are the minerals required in greatest quantity by beef cattle (Cheeke, 2005). McDonalds *et at.,* (1987) reported that, the net requirements of a mineral elements for maintenance plus growth is calculated as the sum of the endogenous losses and the quantity retained. They concluded that, dietary requirements decline less with ages because the availability of these elements is reduced as the animal matures. It should be noted that within small ranges in weight mineral requirements are considered to be proportional to live weight, not to metabolic weight.

2.12.4 Vitamins requirements

The B-complex vitamins and vitamin K are usually synthesized in adequate amounts in the rumen and vitamin D is obtained with exposure to sunlight. Therefore, vitamin A and E are the major vitamins of concern (Cheeke, 2005). Requirements are often determined from diets containing synthetic sources of vitamins (McDonald *et al.,* 1987).

2.13 Digestibility coefficient

Nutritional feed values are currently based on aggregate criteria such as fecal digestibility. Digestibility is the result of two competing processes: digestion and passage. In order to develop mechanistic model of digestion to be used for feed evaluation, both processes have to be quantified (Wilfart *et al.,* 2007). The digestibility of feed is most accurately defined as that proportion which is not excreted in the faeces and which, is therefore, assumed to be absorbed by the animal. It is commonly expressed in terms of dry matter and as a percentage or a coefficient (McDonald *et al.,* 2002). The same authors reported that, since the excretion in faeces of substances not arising directly from the feed, the values obtained in digestibility trials are therefore called apparent digestibility coefficients (ADC) to distinguish them from the coefficients to true digestibility coefficient (TDC) which are difficult to determine. Since the 1960s many pasture and range studies have coupled fecal output estimates with in vitro digestibility measurements to calculate intake (Cordova et al., 1978). However several researchers have reported that in vitro estimates are unreliable estimates of in vivo digestibility because of associative effects (Mehrez et al., 1983), level of intake effects (Van Soest, 1982), rate of passage differences (Ellis, 1978) and variation in botanical composition of the diet (Holechek *et al.,* 1986). Other less animal dependant techniques used to determine digestibility are, in vitro digestibility (Tilley and Terry, 1963), in situ degradability (0rskov and McDonald, 1979); and gas production (Theodoron *et al.,* 1994).

2.13.1 Factors affecting digestibility

McDonald *et al.,* (2002) reported many factors affecting the digestibility such as feed composition, ration composition, preparation of feed, enzyme supplementation of feed, animal factors and level of feeding. These factors either overestimating or underestimating the apparent digestibility coefficient values. In the *in vivo* methods, the initial trial condition generally have a low weight because of the final results are a combination of the adaptation period and the observation period. The other methods can be influenced to variable degrees by the initial conditions (Aerts *et al.,* 1977 and Judkins *et al.,* 1990). The digestibility trials are often conducted with mixed diets because of the impossibility of having maintenance level (Pigden *et al.,* 1980).

2.14 Degradability of crude protein (CP)

ARC (1980) defined the extent of ruminal protein degradation in terms of proportion of dietary nitrogen that does not reach the duodenum. The definition describes the manner in which the values were obtained, that is by direct measurement of total nitrogen (TN) or non ammonia nitrogen (NAN) flow minus the determined microbial nitrogen flow, such experiments give unique values applicable to the particular diet, animal and feeding regimen. Considerable variation in degradability of nominally similar feedstuffs were apparent in the published values. Additional information was available from studies using synthetic fiber bags suspended in the rumen. Such studies clearly showed differences between and within classes of feedstuffs in both, the rate and the ultimate extent of disappearance of N from the bags. Mehrez and Ørskov (1977) and Wilson and Strachan (1981) described the use of the synthetic fiber bag technique to determine degradability value for each type of feedstuffs contain a number of protein types, each of which may have a characteristic rates of degradation, a sufficiently close description of the rate of disappearance of N from synthetic bag can be achieved by assuming there to be only three components, the first is soluble components which is rapidly washed out of the bag, forming the proportion (a) in the equation given by 0rskov and McDonald (1979). Broderick *et al.,* (1988) reported that proteins with low degradation are especially valuable for ruminants with high protein requirements as dairy cows in early lactation and early weaned calves and lambs. Other ruminants that have been reported to respond to additional non-degradable protein are wool producing sheep fed at maintenance and growing cattle fed high NPN diet containing little preformed protein. New feeding systems place emphasis on quantifying rumina1 protein (ARC, 1984; NRC, 1985), therefore, it is necessary to access rapidly and accurately the degradation of feed proteins.

In the metabolizable protein systems, the dietary CP that animals consume is divided into two fractions: ruminal degradable CP (RDP) and ruminal undegradable CP (RUD). Microbial activity in the rumen depends on the availability of both RDA and ruminally fermentable OM. The degradability of CP and DM of feeds are therefore key variables for the metabolizable protein feeding systems (Yan and Agnew, 2004). A number of approaches are used for the determination of dietary CP and

DM degradability, with the widely adopted method being the Dacron bag technique as developed by 0rskov and McDonald (1979). This method requires ruminant animals be fitted with a ruminal Cannula, which may not be available under commercial farm conditions. However, there is in the literature some evidence of significant relationship between CP or DM degradability and nutrient concentration in forages. For example, Hoffman *et al.* (1993) reported a positive relationship of N or DM degradability with dietary CP concentration and a negative relationship with dietary fibrous fraction. Similarly, Von Keserlingk *et al.,* (1996) found that N degradability was negatively related to NDF concentration and positively to CP concentration in the diet.

2.15 Body components

2.15.1 Non carcass components

Non-carcass components include external offals (head, skin and the four feet) and the internal offals (heart, lung and trachea, liver, spleen, kidney, blood and gastro-intestinal tract (GIT). Body components were expressed as a fraction of final finishing weight and empty body weight (EBW) which was obtained by subtracting the digestive tract contents from the final weights as suggested by Fox *et al.* (1976). Guma (1996) reported heavier omental fat and gut fill and lighter hide, feet, heart, lungs and trachea for Kenana bulls. Mohamed (1999) found that the head and hide were significantly ($P< 0.05$) heavier in Sudan Baggara bulls -fed low energy diets, but the intestines, stomachs, liver, diaphragm and esophagus were heavier when Sudan Baggara bulls fed high energy diets.

2.15.2 Carcass weight and dressing percentage

Carcass weight is the simplest and most precise measurements of attributes of the beef carcass, many researchers (Epley *et al.,* 1971 and Yeasts, 1965) studied the relationship between the carcass weight and the carcass length and concluded a positive relationship between the two variables. Hall (1962) in his study of the dressing percentage (DP) of Sudanese cattle based on live weights, reported 36.3, 45.5 and 46.8 for bulls weight, 260, 275 and 280 kg live body weight, respectively.

2.15.3 Meat processing attributes

The properties of meat are controlled by several factors spanning from the conception of the animal to the consumption of the meat (Hoffiman.. 1994). These determine the quality of the meat as described by indices such as pH, color, tenderness, flavor, juiciness and nutritive value.

2.15.4 Water holding capacity (WHC) and cooking loss

WHC could be defined as the ability of meat to retain its own or added water during application of some external forces (Hamm, 1960). Water of meat is found in two forms, bound water (5% of total meat water) and free water. WHC of meat is affected by species *of* the animal, age and muscle type and function.

Studies by Gundriff *et al.,* (1971) and Koch *et al.* (1976) emphasized that large differences exist for most carcass traits according to slaughter end point. Meat obtained from well-finished animal has high water holding capacity and lower cooking losses. Mohamed (1999) found that well fattened bulls fed high energy diets revealed improved water holding capacity and reduced cooking losses. Ahmed (2003) found that bulls fed diets high in energy and protein showed improved water holding capacity and reduced cooking losses than those fed on diets with low energy and protein levels.

2.15.5 Meat chemical composition

Meat contains 75% water, 19% protein, 2.5% lipid and 2.5% soluble non-protein substances (Lawrie, 1998). The same author reported that meat chemical composition is influenced by different factors such as species, age, breed, sex, exercise and plane of nutrition.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Experimental animals

Thirty six entire Sudan Baggara bulls of 2.5 years old, with an average live body weight (LWT) 201.53$\pm$6.85 Kg were selected from a commercial herd purchased by the Animal Production Research Center (APRC) at Hillat Kuku from Elmoelih livestock market at Omdurman. The animals were trekked to the site in Hillat Kuku of a distance of about 30 kilometers. On arrival they rested for 1-2 day and then were dosed against internal and external parasites using anthelmentic. The animals were then identified by plastic ear tags and divided according to their live weight into four experimental groups of nine animals each. Each group of 9 animals was subdivided into three animals each. Each three animals were gives a 4x3m pen, giving reasonable space allowance. The pen's roof was made of bamboo held at 3.5 meters above the ground without any bedding materials. The pen's sides were made of two inches iron pipes. The pens were equipped with feeding trough attached to the outer side of the pen to facilitate easy handling of the diet. Water troughs were placed inside the pens, under the shade, protected from sun and dirt. Fresh clean water was available all over the day and night. The experiment was continue for 63 days during July-October 2006.

3.1.1 Adaptation period

An adaptation period of three weeks was allowed to the animals before the start of the experiment.

3.2 Experimental feeds

For the purpose of this study the experimental bulls were fattened from an initial live weight of 200 kg to a finishing slaughter weight of 260 kg. A diet composed of two fractions i.e. sorghum straw and a molasses concentrates was used. Table 3 shows the composition of the molasses concentrates. Ground cakes and urea were milled to facilitate their mixing with each other and with other ration ingredients. Molasses and urea were added to the ration after dissolving urea in water in order to reduce urea accumulation in the rumen, which could lead to urea toxicity. The Sorghum by-product is represented by Sorghum straw, which is the arial Part of Sorghum Plant that is remaining after removing the grain. It is either left in the field to be ploughed later in the soil or be grazed by animals. Also Sorghum straw were harvested about 2 weeks after grain harvest and chopped using a hand chopper, it is cut of by knives into small particles for the dietary treatments. Abd El Rahman *et al.,* (1981), reported that Sudan produces about 64 % of all the amount of Sorghum straw in the Arab world, but the high cost for transportation from collection areas increases its utilization cost as feed for animals. The chemical composition of Sorghum straw has been found to vary according to soil type and fertilization. The straw is primarily composed of three organic compounds cellulose, hemi cellulose and lignin. Furthermore straws contain protein, sugar, salts and ash, (mainly silica) (El Khidir *et al.,* 1984).

Assuming the daily dry matter intake of the bull is about 3% of its liveweight , the sorghum straw was offered to the animals in the morning meal at 7.00 a.m. in amounts of 10%,20%, 30% and 40% of the total intake of group A, B, C and D , respectively. After assurance that the desired levels of sorghum straw has been consumed the animals were then allowed access to the molasses concentrates and the consumption of this diet fraction is expected within the limits of daily feed intake i.e. 90%, 80%, 70% and 60% for the four groups, respectively.

It is noteworthy due the progressive changes in liveweights of the animals during the course of this experiment the intake of Sorghum straw was rechecked for each group at 200kg ,220kg and 240kg live weight to maintain the planned levels of feed intake.

Dried green alfalfa was given once a week at a rate of 2 kg/head to avoid vitamin A efficiency. All animals had free access to minerals blocks which were available throughout the experimental period as one block in each pen.

Table (3): Ingredients proportion of the molasses concentrates.

Ingredient	Percent
Molasses	52
Wheat bran	39
Groundnut cake	5
Urea	3
Common salt	1
Total	100

Table (4): Chemical composition of the experimental diet

Component	Molasses feed Concentrate (M.F) Mash	Sorghum straw Pellet
Moisture (%)	11.6	4.37
Ash (%)	6.2	7.88
Crude protein (%)	19.6	5.81
Crude fiber (%)	4.26	39.0
Ether extract (%)	2.12	2.15
Nitrogen free extract (%)	56.22	40.79
Calculated metabolizable energy (MJ/kg DM)*	11.09	6.69

** ME (MJ/kg DM) concentration was calculated according to MAFF (1975)*

Table (5): Molasses composition

Item	(%)
Water	17-25
Sucrose	30-40
Glucose	4-9
Fructose	5-12
Other reducing substances	1-5
Other carbohydrates	2-5

Source: Randalt. Hall (1999).

Table (6): Chemical composition of the mineral block.

Item (mineral)	(%)	g/kg^{-1}	$I.U./kg^{-1}$

Salt	90	-	-
Sodium	36	-	-
Calcium	1.3	-	-
Phosphorus	0.23	-	-
Magnesium	0.3	-	-
Manganese	-	200	-
Cobalt	-	124	-
Iodine	-	140	-
Zinc	-	120	-
Iron	-	1690	-
Copper	-	400	-
Vit. D_3	-	-	4000

Mineral block weighs 10 kg

Source: Saudi Company for Veterinary Products.

Table (4) shows the chemical composition of the experimental diets which was obtained by using the standard procedure of the official method for analysis of the association of official analytical chemist AOAC (2000). The Metabolizable energy (ME) content of the diet was calculated as described by Ministry of Agriculture and Fisheries and Food (MAFF, 1976):

$$ME\ (MJ/kg) = 0.0\ l2CP + 0.031\ EE + 0.005CF + 0.01NFE$$

Where crude protein (CP) and the other components of the equation were expressed as g/kg DM. Table (6) shows the chemical composition of the mineral block.

Throughout the experimental period, daily feed allowances were offered to each group ad-libitum (10% weight back) in one meal at 7:00 a.m.

The feeding period was extended for 63 days during which different measurements were conducted. These include; weighing of animals which was performed weekly. Daily feed intake, daily body weight gain and feed conversion ratio were recorded. Feed intake was determined dai1y as the differences between feed offered and refusals. Samples for dry matter (DM) determination were taken from feed refusal at weekly intervals. Live animal weights were recorded to the nearest 5kg prior to the morning feed using weighing bridge balance of 1500kg maximum capacity load and of 5kg division .Animals were night fasted and weight was taken in the morning before feeding.

3.4 Degradability trial

The degradability study of the experimental diets was carried out in two fistulated bulls, according to the Dacron nylon bag technique of Mehrez and Ørskov (1977).

The Cannula was fitted into the rumen of the bulls. The Cannula was made of plastic tube 12cm long and 4cm in diameter locally made from polythene with flange made in one end to prevent it from coming outside the rumen, the other end of Cannula was screwed to allow a cover to be fixed. The experimental bulls were kept separately in shaded pens. They were fed at maintenance level on a balanced roughage concentrate diet with free access to water and mineral blocks.

Approximately 2g of the sample material were weighed into labeled nylon bag measuring 7x12cm and with pore size 40µm, thus giving a sample weight to surface area ratio of 18 mg/cm^2 (Ørskov, 1982). These bags were then introduced into the rumen of a two fistulated bulls, thereby ensuring two replicates per sample. The test times were for 0, 6, 12, 24, 36, 48, 72 and 96 hrs. Bags corresponding to the longest incubating time were inserted first and followed by the other bags in sequentially decreasing time (Ørskov, 1982; Osuji *et al.,* 1993; Newman *et al.,* 2002). This was to ensure that all the bags were withdrawn at about the same time. On withdrawal of the bags from the rumen, they were washed under running tab water until the rinse water was clear and the bag-attached microbe contamination assumed to have been reduced to the nearest minimum. At the end of the rinse, the bags were then dried at 65°C for 48 hrs to a constant weight to determine rumen residue DM content. To determine the water loss at zero hour, that is, loss due to non-incubation for both the DM and CP components, samples of the test materials were soaked in warm water (approximately 37°C) for one hour followed by washing and drying as done with the residue from incubation. Dry matter DM and crude protein CP losses were computed as the difference in weight between the pre-incubated and post-incubation samples and expressed as percent. The weight data gathered were subsequently analyzed by NEWAY computer program tor estimating degradability constants, by fitting them into the non-linear equation $P = a + b\ (I - e^{ct})$ of McDonald (1981) where P is the potential degradation of the nutrients components under investigation after time "t", "a" the water soluable fraction "b" the insoluble but rumen degradable fraction, and "c" the rate of degradation of the rumen degradable fraction, "b". Effective degradability (ED) of the examined nutrients components were calculated using the outflow rates of 0.02, 0.05, and 0.08/hrs according to Ørskov *et al.,* (1980) mode1: ED = a + (bc/c+k) where ED is effective degradability and "a", "b" and "c" are the constant as described earlier in the non-linear equation above and "k" is the rumen fractional outflow rates.

3.5 Digestibility trial

Three rams were selected randomly, each ram was placed in a metabolic unit with free access to water and mineral blocks.

The experimental diets were fed in one meal at 07:00 a.m. each day. The dry matter intake (DMI) was adjusted as 1-1.5% of the animals live bodyweight.

The experimental period lasted for 17 days, the first 3 days were changeover period, followed by 7 days adaptation period, at the end of which faeces were collected daily for another 7 days. Faeces was collected in a zipped canvas bags attached to webbing hareness (McDonald *et al.,* 1987). The hareness was fitted to the sheep 3 days before the beginning of the collection of faeces.

Every morning throughout the collection period at about the feeding time, the canvas bags containing the faeces from the previous 24 hrs, was zipped open, the faeces of each sheep in the experiment was then collected into a plastic bucket and transferred quantitatively to a tarred polythene bags, and weighted to the nearest 50g, on a 10kg top loading balance. Faecal samples (10%) were taken and stored at-20°C until the end of the collection period.

3.5.1 Samples analysis

The frozen Faeces were thawed and then homogenized, and 10% weight sub samples was taken. One (1) gram of the fresh sample was weighed into a 800ml kjeldhal flask for nitrogen (N) determination .The rest of the sub-sampling was dried in a forced dry oven at 60°C for 48 hours, and then dry matter (DM) content was determined and then the sample was ground for analysis.

3.5.2 Calculation of digestibility

The dry matter digestibility (DMD) coefficient expressed as a percentage and calculated as follows:

$$\frac{\text{DM intake DMI - Faecal output DM}}{\text{DMI in grams}} \text{ X 100}$$

The organic matter digestibility (DOM) coefficient was also expressed as a percentage as follows:

$$\frac{\text{(DMI) -ash of the feed) - DM faecal output) – (ash content of faeces)}}{\text{Dry matter intake (DMI) - ash of the feed)}} \text{ X 100}$$

Crude protein digestibility (CPD) coefficient was expressed as percentage as follows:

$$\frac{\text{(DMI) X crude protein (CP) of the feed – faecal output DM X CP of faeces}}{\text{(DMI) X CP content of the feed}} \text{ X 100}$$

3.6 Slaughter and carcass characteristic

The bulls were slaughtered at 260kg target live weight. Animals destined for slaughter were offered water but not feed for 14 hours before slaughter. The bulls were weighed before slaughter which is adopted according to the Muslim practice i.e. severing the Jugular veins, carotid arteries, trachea and esophagus by a sharp knife without stunning. Blood was collected immediately at the time of slaughter using a plastic bucket placed under the neck.

The hide was weighed after dressing and then evisceration was performed. The alimentary tract was removed, weighed and then after clearing the contents weighed again to obtain the empty weight.

The internal offal's (heart, liver, spleen, lung and trachea, diaphragm, pancreas, genital organs, omental fat and mesenteric fat) were carefully removed and weighed. The tail was removed at its base and weighed. The kidneys and its fat were left intact in carcass.

3.6.1 Carcass data

The carcass was weighed hot and split along the vertebral column into the left and right sides. The left side was chilled for 24hrs at 7°C. The left side was weighed before and after chilling to calculate the degree of shrinkage. Dressing percentage was determined by dividing the hot carcass weight over slaughter weight (i.e. live body weight) multiplied by 100. The left side was prepared for dissection.

Carcass was then splitted into 14 Joints representing the wholesale cuts (shin, clod and neck, brisket, thick rib, extended thin rib, chuck and blade, extended roasted ribs, thin flank (Hindquarter), rump, sirloin, thick flank, topside and silver and leg) according to the method described by meat and livestock commission (MLC, 1974) for beef carcass.

3.6.2 Carcass cutting into whole sale cuts

Carcass was split into 14 joints (whole sale cuts) according to method 2 described by meat and livestock commission (M.L.C 1974) for beef carcass. The separation procedures of each joints was as follows:

Shin: was separated at the elbow joint, by following the contour of the shinbone passing through the joint and cutting across the muscle.

Clod and neck: the two cuts were separated by cutting along the posterior edge of the clod bone to the blade bone joint. This cut was extended in a straight line to the dorsal edge of the fore quarter. The separation of the clod is done by cutting to the point of the removal of the shin parallel to the edge of brisket. The 2 cuts were separated from each other by anatomy seaming.

Brisket: was separated by cutting along a straight line extended from a point on the 10^{th} rib, 3" from the join of the rib and cartilage to the anterior removal point, which was defined during the removal of the clod and neck.

Thick rib (4 bones) and extended thin rib (6 bones): the 2 cuts were separated by marking a point on the posterior edge of the 10^{th} rib at a distance measured from the ventral tip of the eye muscle and equal to the double length of the eye muscle, the 2 cuts were removed from the carcass by a straight cut from this point to a point on the first rib measured 2 inches from the vertebral edge of the ventral body. The thick rib was separated from the extended thin rib by a straight cut along the posterior edge of the 4^{th} rib.

Chuck and blade (4bones) and extended roasting rib (6bones): were separated from the carcass by cutting vertically along the posterior edge of the 4^{th} rib, while the separation interiorly was already achieved by removal of the neck and shin. The chuck and blade were separated by a straight cut that extended from the 10^{th} rib to the first rib (two inches from the ventral edge of the vertebral body).

Hind quarters flank: removed from the carcass by cutting along a straight line extended from a point on the 10^{th} rib located at a distance from the base of the eye muscle equal to the eye muscle length to the ventral tip of the rump muscle.

Rump: was removed by cutting along a straight line extending from a point just clear of the anterior edge of the hip bone and postriorly from a point 2 inches anterior to the itch bone.

Sirloin: was separated from the carcass by cutting along the posterior edge of the 10^{th} rib interiorly. Separation of the sirloin posteriorly and ventrally was already achieved by the removal of the rump of the hind quarter flank respectively.

Thick flank plus top side and silver side: were separated anterioly by an inscribed line 2 inches anterior to the itch bone, the thick flank was separated by cutting along the ventral edge of the itch bone, following the contour of this bone to the ventral edge of the round muscle.

Leg: was removed from the carcass by cutting along a line parallel to the anterior edge and passing through the stifle joint.

3.6.3 Tissue analysis

The carcass tissue analysis in this study was based on the analysis of the sirloin tissues to predict the analysis of the whole carcass. This method is used to reduce the cost and time used to dissect the whole carcass. The sirloin cut was placed on wet towels. Using scalpel or knife and forceps to remove the subcutaneous layer of fat, visible blood, lymph and nerve vessels were removed according to the procedure of Hanking and Howe (1946).

Subsequently the muscles were separated from the bone. Intramuscular fat and connective tissue (CT) were also dissected out of the muscles. Muscles, bone, fat and trimmings (composed of connective tissue CT), fascia, blood and lymph vessels) were each weighed.

3.7 Sample preparation for chemical analysis and quality parameters

Samples were taken from L. dorsi muscle, after 24 hours post-mortem. Each muscle sample was freed from external visible fat and C.T and sub-sampled for chemical analysis and quality parameter.

Samples for chemical analysis were immediately minced and stored at -10 C awaiting analysis. Sample destined for quality attributes were allowed to oxygenate for 2 hours at 4°C before colour determination. Hunter colour components L (lightness), a (redness) and b (yellowness) were recorded using Hunter lab tristimulus colorimeter model D25M-2.

Subsequently these samples were frozen stored for cooking loss and shear force determination.

3.8 Chemical composition

3.8.1 Proximate analysis

Determination of total moisture, ash, total protein and fat (ether extract) were performed according to AOAC (l975) methods.

3.8.2 PH determination

For pH determination, a sample (weighing approximately one gram) was homogenized in 20ml. distilled water for 1 minute, then the pH was read on a laboratory pH meter (adjusted with buffer, pH 7.0) at room temperature.

3.9 Quality attributes

3.9.1 Water holding capacity (W. H. C)

Samples (about 1 gram) from minced muscle were used. Each sample was placed on humidified filter paper (what man No. 1) kept in a desiccator over saturated kc1 solution) and pressed between 2 plexi-glass plates for 3 minutes at 25kg. Load. The meat film area was traced with a ball pen and the filter paper was allowed to dry. Meat and moisture area were measured with a compensating planimeter.

The resulting area covered by the meat was divided into the moisture area to give a ratio expressed as water-holding-capacity of meat. A larger ratio indicates an increase in WHC (Bahiker and Lawrie 1983).

$$\text{WHC} = \frac{\text{lose water area -meat film area}}{\text{Meat film area}}$$

3.9.2 Cooking loss determination

Muscle L. dorsi samples were thawed at 5 C for 24 hours and weighed. Samples were cooked in plastic bags in a water bath at 80C for 90 minutes, cooled in running tap water for 20 minutes, dried from fluids and reweighed. Cooking loss was determined as the loss in weight during cooking and expressed as a percent of pre-cooking weight (Babiker and Lawrie, 1993).

$$\%\ \text{cooking loss} = \frac{\text{wt. before cooking-wt. after coking x 100}}{\text{wt. before cooking}}$$

3.10 Objective measurement of tenderness

For share force and C.T strength determination, an Instron model 1000 fitted with a Warner-Bratzler shear device was used. Rectangular meat samples having across sectional area of $1cm^2$ were shorn across the muscles fibre to give shear force valves of the muscle fibres.

Cubical meat samples (1x1x1cm) were also cut from the cooked meat and were used to determine C.T strength by shearing along the muscle fibre. Shear force and C.T strength were taken as the means of several determination.

3.11 Sensory evaluation

For sensory evaluation, longissimus dorsi muscle samples were overnight thawed at 4°C and roasted, wrapped in aluminum foil, in an electric oven at 175-180°C for one hour (Griffm *et al.*, 1985). Semi-trained panelists (n = 10) evaluated coded meat samples in individual booths. Panelists evaluated each sample for colour (1 = extremely dark brown 5 = brown); juiciness (1 = dry, 4 = very juicy), flavor intensity (1=bland, 4 = extremely intense), tenderness (1 = tough, 4 = tender) and over all acceptability (1 = unacceptable 5 = acceptable).

3.12 Statistical analysis

Data were analyzed by Stat Soft, Inc. (1995). Statistica for windows (Computer program manual).

Chapter Four

RESULT

4.1 Feed lot performance

The analysis of the feedlot performance of Sudan Baggara bulls fed different levels of sorghum straw 10% for group A, 20% for group B, 30% for group C and 40% for group D with molasses concentrated diet.

The average initial live weight was almost the same showing no significant ($P>0.05$) differences among the four treatment groups (202Kg for group A, C, D and 198Kg for group B). The final live weight was almost the same showing no significant ($P>0.05$) differences among the four treatment groups. The average daily live weight gain presented in table (7) was not found affected by the dietary treatments, Although it was 1.02 Kg/day in group B and 0.84 Kg/day in group C. Again the total live weight gain was not influenced ($P>0.05$) by the dietary treatments. However the treatment group B showed the highest value (61Kg).

4.1.1 Feed in take

The feed intake data for the four treatment groups are presented in table (7). Means of the dry matter intake (DMI) among the treatment groups were not found to be significantly ($P>0.05$) in-flounced by dietary treatments although group C and D total dry matter intake were 707.10Kg and 703.34Kg respectively (higher) than group A and B total dry matter intake were 658.41Kg and 654.52Kg respectively (lower).

In this study bulls fed different levels of sorghum straw spent more time in group C and D than group A and B and this may attributed to chewing and secreted more saliva before swallowing, this may be related to the particle size of the pellet or to the increase neutral detergent fiber (NDF) of the diet which might lead to toughness of the pellet.

4.1.2 Feed conversion ratio (FCR)

The feed conversion ratio (FCR) among the treatment groups given in table (7) was not significantly (P> 0.05) different between the four groups. They were 10.40Kg for group A, 9.63Kg for group B, 11.69Kg for group C and 10.84Kgs for group D. Although there was a difference in the (FCR) between group B (9.63 Kg) and group C (11.69 Kg), but statistically there was no significance difference between them.

4.2 Degradability of sorghum straw

In situ technique degradability were carried out to assess the nutritive value and potential of crop residues (Sorghum straw) used as animal feed at different incubation period (table 8).

Generally the dry matter disappearance was observed increased with increasing rate up to 24hours and then increase at reducing rate up to 96 hours of incubation. Sorghum straw showed the mean (48.23%) of degradable dry matter and initial washing loss (at zero time).

Table (9) showed the calculated coefficients of degradability formula which illustrate (a,b and c), degradability parameter (initial washing loss and degradability of water insoluble) and effective degradability at different time of outflow. Sorghum straw had 0.039 fraction/ hour of the parameter (c). Sorghum straw had 45.59 value of degradability of water insoluble. It is was observed that the retention time of feed in rumen markedly influences the proportion of the dry matter (D.M) degradable by the rumenal flora (lag time of Sorghum straw 1.4 hours) in rumen.

Generally the effective degradability decrease with increasing time of outflow rate.

4.3 Digestibility coefficients of Sorghum straw

Table (10) presents the apparent digestibility coefficients of Sorghum straw. Apparent digestibility of dry matter (DM) 62.065, organic matter (OM) 62.913, crude protein (CP) 91.980, crude fiber (CF) 67.737, nitrogen free extract (NFE) 51.590, ether extract (EE) 65.620, neutral detergent fibre (NDF) 58.375 and acid detergent fibre (ADF) 58.680.

4.4 Dry matter and crude protein degradation characteristics of molasses concentrated diet

Degradability characteristics of dry matter (DM) and crude protein (CP) of the molasses concentrated diet were evaluated in this study using the nylon bag techniques and presented in table (11). The potential degradability (PD) of dry matter and crude protein were 89.60 and 87.30 respectively. Effective degradability (ED) of dry matter decreases with increased in outflow rates ranging from a low of 72% (K=0.02) to 64% (K=0.08), also ED of crude protein decrease from 82.60% (K=0.02) to 76.10% (K= 0.08).

The immediately soluble fraction (a) of dry matter and crude protein were 51.60 and 66.70 respectively which seemed to be more soluble and this is a reflection of the fact that the dry matter components were most readily soluble. The insoluble but degradable part (b) of the dry matter and crude protein were 38.00 and 20.60 respectively.

4.5 Digestibility and nutritive value of mollassess concentrated diet

4.5.1 Apparent digestibility

Table (12) summaries means of in-vivo apparent digestibility of the experimental diet (mollassess concentrated diet). Apparent digestibility coefficient of the experimental diet were 76.19 dry matter(DM), 78.23 organic matter (OM), 92.84 crude protein (CP), 47.21 crude fibre (CF), 83.40 ether extract (EE) and 77.50 nitrogen free extract (NFE).

4.5.2 Digestible nutrients and total digestible nutrients (TDN)

Table (13) shows values of digestible nutrients and total digestible nutrients of the molasses concentrated diet were as crude protein (CP) 23.00, crude fibre (CF) 5.47, ether extract (EE) 3.74, nitrogen free extract (NFE) 39.25 and total digestible nutrients (TDN) 71.46.

4.6 Carcass yield and characteristics

Means of the carcass yield and characteristics of Sudan Baggara bulls fed different levels of sorghum straw with molasses concentrated diet were summarized in table (14). The slaughter target weight was (260Kg) body weight.Althouhg the empty body weight (EBW) was higher in group A and B (230.13 Kg and 231.04 Kg) than group C and D (225.85 Kg and 227.79 Kg) and also the

warm carcass weight was higher in group A (138.91 Kg), group B (136.94 Kg) and group D (136.77 KG) than group C (135.28 Kg), the differences in the empty body weight (EBW Kg), hot carcass dressing percentage (%), warm carcass weight (Kg) and the total carcass weight (Kg) of the slaughtered bulls were not statistically influenced by the dietary treatments (sorghum straw 10% for group A, 20% for group B, 30% for group C and 40% for group D) with molasses concentrated diet. The statistical differences were not found to be significant (P>0.05)

4.6.1 Non carcass components

Table (15) gives the result of the analysis of the non carcass components of the slaughtered bulls subjected to dietary treatments sorghum straw (10% for group A, 20% for group B, 30% for group C and 40% for group D) with molasses concentrated diet as percent of the empty body weight (EBW), although the stomach weight (full) was lower in group A and B (29.72 Kg and 30.22 Kg) and higher in group C and D (31.80 Kg and 33.69 Kg),also the mesenteric fat was higher in group A ,B and C (1.16 Kg , 0.92 Kg and 0.93 Kg) and lower in group D (0.76 Kg), again also the omental fat was higher in group A and B (3.19 Kg and 3.03 Kg) than group C and D (2.22 Kg and 2.32 Kg),but all of the parameters investigated in this study were found not to be affected by dietary treatments and

the differences among treatments were found not to be significant (P>0.05), these parameters were the weights of head, hide, four feet, intestine, fore stomach, liver, heart, lung, mesenteric fat, omental fat, kidney, tail and genital organs.

4.6.2 Whole sale cuts yield

Table (16) shows a summary of data of the yield of the whole sale cuts of the slaughtered bulls in this study as a percentage of the empty body weight (EBW). The statistical analysis of the following parameters showed no significant (P>0.05) differences among the treatment groups. These are weights of shin, nick, chuck, clod, extended roasting ribs, thick ribs, thin ribs, brisket, thin flank, thick flank, leg, sirloin, rump and top and silver side.

4.6.3 Sirloin composition

Data describing the sirloin muscle composition as a percent of the cut are presented in table (17). Meat from bulls fed 20% sorghum straw with molasses concentrated diet. Group B appeared to contain more fat (6.93) than the other three groups .These differences were not found to be significant (P>0.05). The bone, muscle and connective tissue percentage of the meat obtained from these slaughtered bulls appear to be the same and no significant (P>0.05) differences were observed.

4.6.4 Some processing attributes of meat

Bulls meat quality attributes are presented in table (18). Bulls fed Sorghum straw (10% for group A , 20% for group B, 30% for group C and 40% for group D) with molasses concentrated diet showed higher water holding capacity (W.H.C) in group A , B and C (2.07 , 1.90 , 2.10) and lower (W.H.C) in group D (1.47).Also the cooking loss was lower in group A and B (34.68 and 34.93) and higher in group C and D (36.73 and 36.95), but statistically no significant (P>0.05) differences in cooking loss and water holding capacity (W.H.C).

4.6.5 Meat Chemical Composition

Data presented in table (19) showed the proximate analysis of the longismus dorsi muscle of the slaughtered bulls fed on different levels of Sorghum straw (10% for group A , 20% for group B, 30% for group C and 40% for group D) whit molasses concentrated diet values for the moisture ,ether extract , ash and crude protein percentage of the meat obtained from these bulls were the same and no significant (P>0.05) differences were found .

4.6.6 Subjective evaluation of the meat quality

Table (20) shows the color, flavor, juiciness, tenderness and over all acceptability of the cooked longismus dorsi muscle obtained from the four groups of bulls .The color and flavor were not significantly

different in the four groups of bulls .The juiciness and tenderness were higher in group A (6.79, 6.99) and B (6.40, 6.74) respectively than in group C (4.18, 4.40) and D (3.43, 3.76) respectively but no significant ($P>0.05$) differences were found.

The panelist score for over all acceptability was not significantly different in the four groups of bulls although it was higher in group A (6.50) and B (7.00) than in group C (4.00) and D (3.50) lower.

Chapter Five

Discussion

5.1 Feed lot performance

Table (7) shows the effect of different sorghum straw levels with molasses concentrated diet on feed lot performance. The experimental animals reached the target slaughter weight (260 Kg) at an average period of 60 days for group A, 62 days for group B , 67 days for group C and 66 days for group D .

This revealed that the animals reached target weight at different periods according to the level of sorghum straw with molasses concentrated diet offered although the period for target weight was not significantly ($P>0.05$) different between the four groups of bulls .

5.1.1 Feed intake

The voluntary feed intake varies with the animal and the diet characteristics, where weight, fatness, genotype and sex are the main factors affecting feed intake and environment (Branger and Micol, 1980). Another possible factor was the animal behavior as reported by (Huntington and Burns, 2007) that reduced dry matter intake (DMI) was attributed in part to animal’s behavior. for the Baggara Bulls pellets were new type of feed and animals often exhibits reluctance to accept a new feed as reported by (Cheeke2005, Chapple et al., 1987.similarly, Baker et al., 1955, Hale and

Theiruver 1995, Church 1998) reported that while pelleting high concentrated ration might markedly improved feed efficiency, gain was usually reduced due to the lowered feed intake. The reason for this is unknown but maybe due to shift in volatile fatty acid (VFA) production and this is found to be in line with Illius and Jessop (1996).

Table (7) described the data sets used to evaluate the feed lot performance in this study. The total dry matter intake (DMI) was higher for bulls in group C (707.10 Kg) and D (703.34 Kg) than in group A(658.41 Kg) and B (654.52 Kg). This finding could be attributed to the lower energy concentration (ME/Kg DM) of the diet in group C and D (table4).

These results were similar to those reported by Owem and Geay, (1992), Mc Donald et al., (2002), Keterlaars and Tolkamb (1999), Mertens (1985), Merchen et al., (1987) who calculated that ,ruminants eat that amount of feed that gives the optimum yield of net energy (NE) per unit of oxygen consumed I.e. feed intake increase as the concentration of energy in the diet decreased. This because of fact that animals eat until satisfying their energy needs. For the same breed and at almost similar dietary energy levels, similar results were reported by Mohamed (1999) and he concluded that cattle receiving low energy diets consumed significantly more feed than those receiving high energy diets. Earlier studies of Weir et al,.(1959),Beardsley et al., (1959),Church and Fox (1959), Mc

Croskey et al,.(1961) showed more variable results and depressed feed intake in cattle fed pelleted ration .bulls fed (Sorghum straw + molasses concentrates) diet spent more time chewing and secreted more saliva before swallowing the bolus .This might be related to the particle size of the pellet or to the increased neutral detergent fibers (NDF) of the diet which might lead to toughness of the pellet .This observation agreed with the findings of many researchers (Sudweek ,et al .,(1980) ,Beauchemin and Buchanan- Smith , (1990) ,Loginbuhl et al., (2000)) who reported that chewing time/Kg of DMI decreased as DMI increased and vice versa .Other workers (Kellems and Church ,1998; Beardsley ,1964; Reddy ,2004) stated that feed intake ,daily gain and feed efficiency of cattle and sheep were increased when roughage was pelleted.

5.1.2 Average daily gain (ADG)

The present findings indicated that ,the average daily gain (ADG)0.96 kg for group A , 1.02 kg for group B , 0.84 kg for group C and 0.91 kg for group D obtained by Sudan Baggara bulls fed (10% sorghum straw for group A ,20% sorghum straw for group B, 30% sorghum straw for group C and 40% sorghum straw for group D with molasses concentrated diet) was not influenced by the dietary treatment (table6) these findings were in the line with the average daily gain (ADG) reported for the same breed by many researchers (Elshafie and Mc Leory, 1964; Mukhtar and Eltiriefie, 1970; Eltahir ,1994; Guma, 1996). Similarly these results were found to be slightly lower than the average daily gain (ADG) values reported by (Gaili and Osman, 1977; Mustafa, 1990; Abdalgalil ,1997).

The difference in the (ADG) between group B (1.02 kg) and group C (0.84 kg)may be due to the large amount of crude fiber in group c diet than group B.

On the other hand the (ADG) reported in this study were numerically higher than those reported by other researchers ,these differences might be due to the initial body weight ,duration of feeding , Season of year , age of the animals and variations in the diet composition .

5.1.3 Feed conversion ratio (FCR)

Feed conversion ratio is the quantity of feed required to produce one unit live weight gain .the lower value of the feed conversion ratio , higher is the feed efficiency .In this study (FCR) was not significantly different between the four groups .The best performance is observed in group B(9.63) followed by group A(10.40) whereas the least performance is observed in group D (10.84) followed by group C(11.69) (table 7),and this is may be due to the amount of crude fiber in the diet (group A 10% Sorghum straw, group B 20% Sorghum straw , group C 30% % Sorghum straw and group D 40 % Sorghum straw).Ruminants eat the amount of feed that gives the optimum yield of net energy (NE) per unit of oxygen consumed. In this study the (FCR) values agreed with that of

Elkhidir and Ibrahim (1986-1996) who reported (FCR) ranging between 4.97 - 9.59 for the same breed. Morre (1991), also reported that (FCR) for Baggara cattle between (7.29 – 11.3) .

5.2 Degradability of Sorghum straw

Positive relation-ship between the length of incubation period and dry matter disappearance for Sorghum straw were observed.

Sorghum straw showed (48%) of dry matter disappearance table (8), these result were similar to findings by Hage Khidir (1988) who observed greater dry matter disappearance in animal fed concentrate diet than fed roughage. Also Ahmed and Elkhidir (1992) reported legumes forage had higher degradability than cereal forage in all forage components (DM, CP and CF). These results were in the line with the fact that DM disappearance of roughage was generally assumed to be lower than concentrate due to their slow break down in the rumen.

5.3 Digestibility coefficient of Sorghum straw

Table (10) shows apparent dry matter (DM) digestibility of Sorghum straw (62.065%). These results are similar to those reported by Mertrens (1985) that apparent digestibility of roughage (<65% DM digestibility), due to their bulk density (high fiber content) that limit feed and energy intake.

Apparent digestibility of DM, OM, CP and CF were not significantly different from other crop residues (e.g Groundnut hay, Pigeon pea hay) this could be attributed to similarity in their CF and CP content, which are the main factors contributing to the efficiency of digestion. Schneider and Lucas (1950) reported that 25 – 45 % of the total variability in digestibility of various samples was due to their variation in chemical composition.

Sorghum straw is characterized by high CF% which may lower the digestibility of the other nutrients. This agreed with Everts and Smith (1987) who reported that high CF lower apparent digestibility of other nutrient components of the diet.

Generally the apparent digestibility of CP was reduced when forage was fed in form of hay or silage. Sorghum straw showed digestibility (58%) of NDF and ADF. This is mainly affected by the Sorghum straw maturity stage which increases all wall material (quantity and quality) that depressed apparent digestibility of NDF and ADF. This result agreed with Kuan et.al,(1983) who reported that when cell wall material in the diet was increased, apparent digestibility of various organic materials were depressed.

5.4 Dry matter and crude protein degradation characteristics of molasses concentrated diet

The results of this study showed patterns of crude protein (CP) and dry matter (DM) degradability characteristics of the tested molasses concentrated diet. The effective degradability (ED) of DM was found to be decreased with the increase of the outflow rates. The immediately soluble fraction (a) of DM was more soluble. This could be related in part to physical form and method of preparation of the diet.

The degradable part of the dietary CP (b) was found to be lower in comparison to other diets (Pelleted) i.e pelleting increased the degradability of the dietary DM of the molasses concentrated diets.

The rate of crude protein degradation (P) was found to be slightly higher. This may be attributed to the higher crude protein degradability of the ingredients used in this diet.

This result was similar to those assigned by Intesar (2002) who studied the CP degradability of different protein sources, Ørskov and Mc Leod (1982), Stanton (1999), Abu Swar and Darag (2002) who reported that groundnut meal has a low by-bass protein and low crude fibre content.

Animals fed on Sorghum straw alone result in negative nitrogen balance (Tagel-Din et al, 1989). These negative aspects of cereal straws are believed to result from high neutral detergent fiber (NDF) content (resulting in high cell wall rigidity), and poor nitrogen content. Several treatments have been applied to try to increase intake and digestibility of cereal straws, perhaps the most widely used treatments are chopping the straw, addition of ammonia or urea N (Jackson, 1979, Dolberg et al.,1981, Ibrahim et al.,1987, Adu at al., 1990) anaerobic in-silo fermentation, treatment with ammonium hydroxide (Solaiman et al., 1979, Diarra, 1983) and supplementation with concentrates (Huston et al., 1988), or with good quality hay (Zan, 1989, Adu et al., 1990.

Results of cereal straw treatment with urea N appear to vary greatly. Urea supplementation usually results in higher dry matter intake and digestibility (Ibrahim et al., 1987, Nyarko-Badohu et al., 1994, Nianogo et al., 1997), however some authors (Ibrahim et al., 1987) have found no effect of urea treatment on animal performance. Supplementation with concentrates (Huston et al., 1988, Tagel-Din et al, 1989) or with legume hay usually improves straw utilization (Adu at al., 1990, Pouya, 1989, Zan 1989), although results may vary depending on the level of supplementation.

High levels of supplementation with concentrate have caused intake of the straw to decrease (Adu at al., 1990). Question appear to remain un answered on the effect of straw treatment on digestion and utilization at high levels of concentrate.

5.5 Digestibility and nutritive value of molasses concentrated diet

5.5.1 Apparent digestibility

Dispite similar values of energy and protein of experimental diets, there was a clear reverse trend in digestibility with increase of crude fibre (CF) level in the diets (highly fibrous diets has low digestibility). De La Cruz (1990). Plant fibre had a negative effect on nutrients digestibilities (Vansoest 1982 and Mc Donald et.al, 1995).

The Digestibility coefficient of molasses concentrated diet in this study was higher than those reported by Maglad and Lutfi (1985). These variations in apparent digestibility might be due to diet chemical and physical composition.

5.5.2 Digestible nutrients and total digestible nutrients

Digestible CP, CF, EE and NFE of molasses concentrated diet were increased and this might be due to the low level of CF content in the diet hence the total digestible nutrients (TDN) will also increase (because of the amount of the digestible components of the diet also increased.

5.6 Carcass yield

Data related to carcass yield did not show significant ($P>0.05$) differences between the different treatment (table14).Bulls in group A and B showed slightly increased empty body weight whereas group C and D showed slightly decreased empty body weight .This might be related in part to the high gut fill content (Sorghum straw 30% for group C and Sorghum straw 40% for group D) .This differences in gut fill were due to the differences in dietary fibre and that greed with Stobo (1964), who found an association between fibre content of diet and rumen fill ,where rumen in fill was found to increase as dietary fibre level increase .

5.6.1 Dressing percentage (D.P)

The economic value of beef cattle depends on the dressing percentage because it tells how much of the animal body may be sold as meat .The significance of dressing percentage for both consumer and producer is defined as the salable part of the animal (Stobo 1964) the most important factor that affect (D.P) include feed quality , weight of slaughtered animal ,breed and sex .

In this study the reported dressing percentages (table 14) were not significantly different , this similarity is due to the same weight of the slaughtered bulls .These findings agreed with Preston and Willis (1974) and Elkhidir et al., (1995) who reported that the carcass weight increased with live weight in a linear relationship.

The dressing percentage calculated in this study were similar to those reported by Eltahir (1994), Elkhidir (2004) and Ahmed (2003), for the same breed intensively fed on concentrates. This discrepancy of these results and that reported earlier might be due to the high forage diets which offered in this study. Preston and Willis (1969) indicated earlier that dressing percentage for Brahman cattle fed on high forage diets had an average dressing percentage of 52.0% compared with 55.8% when only concentrates were given. Bennett et al., (1995), found that there was significant differences between dressing percentage of steers fed concentrated diets and those fed forage diets. Also Preston et al., (1974), indicated that dressing percentage increases with increase of the degree of finishing; in this study target slaughter weight was low (260 kg). In addition, the slaughtered bulls in this study were not subjected to a fasting period so dressing percentage decreased; this finding agreed with Stobo, (1964), who stated that when slaughtered animals subjected to a fasting period before slaughtering gut fill was reduced hence dressing percentage increased; which indicated the effect of rumen fill on dressing percentage.

5.6.2 Carcass Shrinkage

The data present in table (14) showed the percentage of shrinkage. The experimental bulls had the same slaughtered weight so shrinkage is not significantly different. This finding is consistent to that reported by Mohammed (2004) and Eltahir (2007), who reported that chilling shrinkage is mainly affected by slaughter weight because carcass fat deposition increases due to increase of live weight, the subcutaneous fat reduced the moisture evaporation.

5.7 Non – carcass components

Data presented in table (15) given non carcass components expressed as percentage of empty body weight. It was suggested by Palsson and Vergas (1952) that due to the great variation in contents of the alimentary tract, the empty body weight represent live weight, when comparing relative developments of different parts as there is no relationship between the weight of gut content and the true growth. The gut fill weight was found to vary according to the type of feed. Development of non carcass components is affected by age, breed and nutrition (Wise et al., 1961).

In this study the four feet, heart, genitalia, hide, heart, omasum empty, intestine empty, gastrointestinal tract empty and gut fill were not significantly different among the different roughages. This finding agreed with that of Gaili and Osman (1977), who reported that differences between non-carcass components were small and non-significant. Ahmed (2003) also found no significant differences in non-carcass components for Western Baggara bulls fed different levels of energy and protein in their diets.

The growth of non – carcass components in this present study exhibited similar patterns of relative growth with no significant (P>0.05) differences among the treatment groups (table 8).This was in agreement with the results reported by Gaili and Nour (1980); Eltahir (2007) for the same breed .

5.8 Whole sale cuts yield

The data collected on table (16) represents Whole sale cuts from bulls fed different levels of Sorghum straw with molasses concentrated diet (as percent of left side weight).There were no significant differences between the neck , clod , shin , thin , ribs , thick ribs , extended roasting ribs ,chuck , brisket , thin flank , thick flank , sirloin , rumb , top side and silver and leg .The fact that there were no significant differences in whole sale cuts in agreement with Callow (1961) and Berg and Butter field (1966), who found that no differences in whole sale cuts proportion when comparing different breed on different planes of nutrition .The values of cuts weight in this study showed almost similar values and were not influenced by the dietary treatment and this in agreement with Eltahir (1994) who compared Baggara bulls and 50 Friesian crosses .

5.8.1 Sirloin composition

Data describing the dissection of the sirloin muscle to predict carcass composition is presented in table (17). This method is preferred in this study to reduce the costs of the dissection process and saving time .In the present study of sirloin muscle showed no significant differences in muscle , bone , fat and connective tissue between the four groups .This finding was in line with those of Reid (1972) , who indicated that the variation in fat content (higher in group B (6.93) than the other three groups of the body reflex as variation in body chemical composition I .e. fat is later maturing tissue (Hammond , 1932) and these animals slaughtered at less than 300 Kg which put them in the category of light weight .

5.9 Meat chemical composition and processing attributes

5.9.1 Meat Chemical Composition

In the present study the chemical composition of longismus dorsi muscle (table 19) showed no significant differences between the four groups. This finding was in line with those of Reid (1972), who indicated that the variation in fat content of the body reflex as variation in body chemical composition.

Similar values of crude protein percent was obtained by Ahmed (2003), Elkhidir (2004) and Mohammed (2004).

The ash content of the meat in this study was higher than that reported by Mohammed (2004) and Elkhidir (2004). Lawrie (1978), indicated that ash percent increased as dietary energy decreased. In this study the ether extract percent of the meat was (2.06); this value is similar to that obtained by Mohammed (2004). Callow (1962), reported that high growth rate increased chemical fat, and decreased protein and water content of boneless carcass tissue.

Moisture percent in the current study was similar to that found by Ahmed (2003), Mohammed (2004), Elkhidir (2004). (table 12).

The values for proximate analysis reported higher for Sudan Baggara bulls meat agreed with that reported by Agag (1994) for the same breed .In his study he found that the average values of moisture, protein and fat were 75%, 22.9 % and 2.15 % respectively.

5.9.2 Meat attributes

Meat quality attributes for the four groups showed no significant differences (table 18). In the same breed Ahmed (2003) reported that meat colour co-ordinates were affected by the levels of dietary energy , the redness (a) was significantly ($P<0.001$) greater in the high and medium energy level and yellowness (b) was significantly ($P<0.05$) greater in the low energy diet .The author reported that bulls fed high energy and high protein levels showed improved higher water holding capacity and lower cooking loss than those fed low levels .

5.9.3 Subjective evaluation of Sudan Baggara bulls meat

Colour, flavor, juiciness, tenderness and overall acceptability were not significantly ($P>0.05$) difference between the four groups of bulls in this present study (table 20) although the juiciness and tenderness were lower in group C and D than group A and B (higher) and this is reasons for panelist to prefer the meat of group A and B than the meat group C and D .

Chapter Six

Conclusion and Recommendations

From this study it could be concluded that, different higher levels of roughage (Sorghum straw) could be used satisfactorily in fatting beef cattle in feedlots around towns and big cities , especially during periods of feed shortage . Different higher levels of Sorghum straw with molasses concentrated diets for fatting cattle to decrease the cost of feeding and making fatting business profitable as Sorghum straw is available in Sudan as cheap feed ingredient.

Diet for bulls up to 260 Kg of live weight that needed for satisfactory live weight gain and feed efficiency was found of Metabolizable energy (ME) range from 9.5- 10.5 MJ /Kg/DM less than 19 % C.P level could be Sufficient of fatting Sudan Baggara bulls for the same live weight. Recommended levels were 12-14% .

The poor nutritive value of Sorghum straw could be improved by pelleting to encourage its intake, increase the feed conversion ratio (FCR) in addition to reduce the wastes, cost of labour and transport.

REFERENCES

Abd EI-Rahman, K. M. and Ahmed, B. M. (1981). The Use of Treated Poor Quality Roughages in Growing Animal's Ration. VI Conf. Egypt, Soc. Anim. Prod. Sep. 11-18.

Abdalgalil, F.S. (1997). Blood meal versus groundnut cakes in diets for fattening Western Baggara cattle. M.Sc. Thesis, University of Juba.

Abuswar, A.O. and Darag, A. (2002). Study for integration of production and processing of forage in Arab region. Sudan case. Arab Organization for Agricultural Development. Khartoum, (in Arabic).

Adu IF., Fajemisin BA., Adamu AM. (1990). The utilization of Sorghum stover fed to sheep as influenced by urea graded levels of lablab supplementation. In *Proceedings of the First Biennial Coriference of the African Ruminant Research Network.* Nairobi, Kenya ILRAD 10-14, p 367-373.

Aerts, J.V., Barbander, D.L. Cottyn, B.G. and Buyssee, F.X. (1977). Comparison of laboratory methods for predicting the organic matter digestibility of forages. Anim. Feed Sci. Technol. 2:337.

Agag. R.A (1994). Carcass characteristics, meat yield and quality of different types of Western Baggara cattle. M.S.c. Thesis, University of Khartoum.

Ahmed, B.A. (2003). The effect of different levels of energy and protein on growth and carcass composition of Western Baggara bulls. Ph.D. Thesis, University of Khartoum.

Ahmed, F.A. and El Khidir, O.A. (1997). Rumen degradability of dry matter, crude protein and crude fiber of cereal and legume forage grown in irrigated areas of the Sudan. Sudan. J. Anim. Prod. 5:25-39.

Ahmed, F.A.; Elshafie, S.A. and Osman, H.A. (1977). Fattening of Baggara cattle on rations of conventional concentrate agricultural byproducts. Acta Veterinaria (Beogard), 27: 21-27.

Allen, M.S. (1996). Physical constraints on voluntary intake of forages by ruminants. J. Anim. Sci. 74: 3063-3075.

AOAC (1975). Official Methods of Analytical Chemists, W. Howritz (ed.), 12th ed., Washington, D.C.

AOAC (2000). Official Methods of analysis, 17th ed. Association official of analytical chemists. Washington. DC.

AOAD (2001). The yearbook of agricultural statistics, Arab organization for Agricultural Development.

ARC (1980). Agricultural Research Council. The nutrient requirement of ruminant livestock. London, U.K. Agric. Res. Council Common-wealth. Agric. Bureau.

ARC (1982). Agricultural Research Council. The nutrient requirements of beef cattle. London, UK.ARC ,Commonwealth. Agric. Bureau.

Babiker, S.A. and Lawrie, R.A. (1983), Postmortem electrical stimulation and high temperature aging of hot-de boned beef. Meat Sc., 8:1-20.

Barreveld, W.H. (1982). Alternative end use of agricultural and agro-industrial residue in: F AO animal production and health, paper No. 32, pp. 127.

Bayley, H.S., Figueroa, V., Maylin, J.L. and Perez, A. (1983). Utilization of sugarcane final molasses by the pig. Energy metabolism. Can. J. Anim. Sci. 63: 455-462.

Beardsley, D.W. (1964). Symposium of forage utilization: nutritive value of forage as affected by physical form. Part 2 .Beef cattle and sheep studies. J. Anim. Sci. 23 -239.

Beardsley, D.W., McCormick, W.C. and Southwell, B.L. (1959). Steer performance and rumen effects of different concentrate roughage ratios in pelleted and unpelleted mixed fattening rations. J. Anim. Sci. 18: 1507.

Beauchemin, K.A. and Buchanan-Smith, J.G. (1996). Effects of fiber source and method of feeding on chewing activities, digestive function and productivity of diary cow. J. Dairy Sci. 73: 749-762.

Bennet, J. and Hewison, B. (1952). Animal Husbandry, In: Tothill, J.D. (ed.). Agriculture in the Sudan. Oxford University Press, U.K. pp. 633-667.

Bennett, S.C.J., John, E.R. and Hewison, J. W. (1954). Animal Husbandry. In: Agriculture in the Sudan, Tothill, J.D. (ed.), pp. 633-667, Oxford University Press, U.K.

Beranger, C. and Micol , D. (1980). Intake in Relation to The Animal. Ann, Zooteech.: 29: 209-226.

Berg, R. T. and Butterfield, R.M. (1966). Muscle Bone Ratio and Fat Percentage As Measures of Beef Carcass Composition. Anim. Prod., 8: 1-11.

Broderick, G.A., Wallace, R., 0rskov, E.R. and Hansen, L. (1988). Comparison of estimates of ruminal protein degradation by in vitro and in situ methods. J. Anim. Sci. 66: 1739-1745.

Butterworth, H.M., Chintsanya, C.C.N, Phiri, H.J.K and Mitengo-Gama, S.WP. (1984). Stall-feeding beef cattle with agricultural by-products in Malawi. Trop. Agric. (Trinidad) 61 (1): 25-28.

Callow, E. H. (1961). Comparative Studies of Meat.7: A Comparison Between Hereford, Diary Shorthorn And Friesian Steers on Four Levels of Nutrition. J. Agric.Sci. (Camb), 56: 265-282.

Callow, E. H. (1962). The Relationship Between The Weight of A Tissue in A Single Joint And The Total Weight of Tissue In A side of Beef. Animal. Prod 4: 37-46.

Chapple, R.S., Wodzicka-Tomaszeweska, M. and Lynch, J.J. (1987). The learning behavior of sheep when introduced to wheat. II. Social transmission of wheat feeding and the role of the senses. Appl. Anim. Behav. Sci. 18: 163-172.

Cheeke, P.R. (2005). Applied animal nutrition: Feeds and feeding. 3rd ed Upper Saddle River, New Jersey, USA.

Church, D.C and Fox, C. W. (1959). Effect of pellet size and roughage grind on performance of lambs. J. Anim. Sci. 18: 1168.

Church, D.C., Kellems, R.O. (1998). High energy feedstuffs, in Kellems. R.O. and church, D.C. Livestock Feeds and Feeding 4th ed. Prentice Hall, New Jersey, USA.

Cobic, T., Bac Vanski, S., Vucetic, S. (1980). The influence of protein levels on growth rate and feed efficiency. Ann. Zootch., 29: n.h.s: 251-259.

Cordova, H. (2001). Quality protein maize: Improved nutrition and livelihood for the poor, pp. 27-31, In, S. Pandey (ed). Maize Research Highlight, 1999-2000 CIMMYT Technical Bulletin. 6815. Mexico.

Crampton, E.W. & L.E. Harris, (1969). Applied Animal Nutrition. 2nd edition. Freeman and Company, San Francisco.

Darag, A., El Khidir, O.A. and Kheir, M.A. (1995). Pasture and other animal feed resources used in feeding animals. Conference of Development of the Pastoral Sector in Sudan. Kosti, Sudan (in Arabic).

De La Cruz, H.O. (1990). Steam treated bagasse for fattening cattle. Effect of supplementation of Clircilia Sepium and Urea/molasses, Livestock Research for Rural Development (C.I.P. AV.).

Diarra B. (1983). Effect of ammonium hydroxide treatment on digestibility of nutrients in soybean straw by steers. Master of science thesis. Agricultural and Mechanical University, Alabama, USA, 44 p.

Dinius, D.A., Oltjen, R.R., and Rumsey, T.S. (1975). Pelleted forage diets plus supplemental energy and feed additives for finishing cattle. J. Anim. Sci. vol. 41 No 3, 868-875.

Dolberg F., Saadullah M., Haghe M., Ahmed R. (1981). Storage of urea-treated straw using indigenous material. World Anim. Rev. 38, p.37-41.

EI khidir, I. A. (2004). Utilization of Sugar Cane Bagasse for Fattening Cattle. Ph.D. Thesis, U. of. K.

El Hag, G.A. and George, A.E. (1981). Performance of Western Baggara bulls fed on rations containing high levels of poor quality agro-industrial byproducts. East Afr. Agric. Forest. J. 47 (2): 43-48.

El Khalifa, M.D., Richard, F. and Khogali, M.M. (1985). Sudan's southern stock route. Khartoum and Worcester, Massachusetts.

El Khidir, O.A., El Khidir, I.A. and Ibrahim, S.E. (1995). Cattle fattening in the Sudan 1: Baggara cattle. Tech. Bulletin Anim. Prod. Cent. Res. State, Kuku, Sudan, 38 p.

El Khidir, O.A., Khalafalla, A.M., Guma, A.Y. and Osman, O.K. (1984). High levels of molasses and peanut hulls with urea supplemented diet for sheep fattening. World, Rev. Anim. Prod. 20: 72-77.

El Khidir, O.A., Khalafalla, A.M., Suliman, Y.R. and Morgos, F.I. (1988). Effects of traditional and unconventional fattening diets on feedlot performance of Kenana bull calves. Sudan. J. Anim. Prod. 1 (1): 1-6.

Elkhidir, O.A. and Ibrahim, S.E. (1986-1996). Molasses Cubes Production and Distribution Scheme. Animal Production Research Centre Kuku. p. 23(in Arabic).

Ellis, N. (1981). The nutrient composition of Sudanese animal feeds. Bull. No.1. northern and central Sudan. Central Nutrition Res. Lab., Kuku, Khartoum North.

Elshafie, S.A. (1966). Further observation of fattening of Sudan zebu cattle. Sudan. J. Vet. Sci. Anim. Husb. 7: 22-27.

Elshafie, S.A. and Mcleroy, G.B. (1964). Carcass characteristics of feedlot fattened northern and western Sudan zebu cattle. Sudan J. Vet. Sci. Anim. Husb. 6: 3-11.

Eltahir, I.E. (1994). Beef production potentials of western Baggara and 50% Friesian crossbred. M.Sc. Thesis, University of Khartoum.

Eltahir, I.E. (2007). Growth and development of body tissues and characteristics of major muscles of Western Sudan Baggara bulls. Ph.D Thesis, Sudan Academy of Science (SAS). Animal Resources Research Council.

Eltayeb, A.E., Mohammed, T.A. and Mohammed, H.K. (1990). Growth performance, feed intake and nutritive digestibility of western Baggara cattle fed Sorghum Stover with different levels of concentrate. Sudan J. Anim. Prod. 3 (2): 69-79.

Ensminger, M.E., Oldfield, J.E. and Heinemann, W.W. (1990). Feeds and nutrition. 2nd ed. Ensminger Publishing Company. California, USA, p. 319.

Epley, R.J., Zobrisky, S.E., Chrystal, B.B., Hutcheson, D.P., Hedrick, H.B. and Stringer, W.C. (1971). A note on dissectible lean, fat and bone of the fore shank as predictor of beef carcass composition. Anim. Prod., 13: 357-357.

Everts. H. and Smith B. (1987). Effect of Crude Fiber, feeding level, body weight and method of measuring on apparent digestibility of compound feed by sows. J. of world review of Animal Production Vol. XXIII No. 4.

FAO (2002). Protein sources for the animal feed industry. FAO, Anim. Prod. and Health (Proc) Exp. Consult and Workshops, Bangkok.

FAO (2004). Protein sources for the animal feed industry. FAO Anim. Prod. and Health. (Proc.). Exp. Consult. and Workshops, Bangkok.

Forbes, J.M. (1980b). A model of the short term control of feeding in ruminants. Effect of changing animal or feed characteristics. Appetite 1:21.

Forbes, J.M. (1996). Cited by Fisher, D.S (2002). In a review of key factors regulating voluntary feed intake in ruminants. Crop Sci. 42:1651-1655.

Fox, G.D., Dockerty, T.R., Johnson, R.R. and Preston, R.L. (1976). Relationship of empty body weight to carcass weight in beef cattle J. Anim. Sci., 43: 566-568.

Gaili, E.S.E. and Nour, A.F.Y.M. (1980). Development in Kenana cattle. I. Development of carcass and non-carcass components of the body. J. Agric. Sci. Camb., 94: 257-262.

Gaili, E.S.E. and Osman, A.H. (1977). Feedlot performance, feedlot, carcasses yield and offals of underfed range beef cattle rehabilitated on two different diets. Acta Veterinaria (Beogard), 27 (1): 29-35.

Gaili, E.S.E. and Osman, A.H. (1979). Effect of initial feedlot weight on the finishing performance and body composition of western Sudan Baggara cattle. Trop. Agric. (Trinidad), 51 (1): 69-74.

Galyean, M.L. (1996). Protein levels in beef cattle finishing diet: Industry application, university research and system results. J. Anim. Sci. 74: 2860-2870.

Gaskin, C.T., Preston, R.L. and Males, J.R. (1982). Feed requirements for maintenance and gain for crossbred bulls of two types. J. Anim. Sci. 55 (1): 67-72.

Gill, D.R., Owens, F.N. and Hicks, R.B. (1987). Impact of feed intake on performance of grazing and feedlot cattle. Symposium Proc. Feed intake by beef cattle. Anim. Sc. Dept. Agric. Exp. Sta. Div. of Agric., Oklahoma State University, July, 1987, MP 121: 360-368.

Griffin, C.L., Savell, J. W., Smith, G.C., Rhee, K.S. and Johnson, H.K. (1985). Cooking times, cooking losses and energy for cooking lamb roasts. J. Food Qual., 8(2): 69. Cited by Babiker, S.A., Elkhidir, I.A. and Shafie, S.A. (1990). Chemical composition and quality attributes of goat meat and lamb. Meat Sci., 28: 273-277.

Guma, A. Y. (1996). Beef production potentials of some northern Sudan zebu cattle. Ph.D. Thesis, University of Khartoum.

Gundriff, L.V., Gregory, K.E., Koch, R.M. and Dickenson, G.E. (1971). Genetic relationship among growth and carcass traits of beef cattle. J. Amin. Sci. 33: 50-53.

Hag El Khidir E. (1988). Intake, digestibility and degradability of forage by ruminant animal. M.sc. Thesis. University of Gezira.

Hale, W.H. and Therurer, C.B., Parrott, J.C. and Taylor, B. (1969). Feed preparation and processing, in digestive physiology and nutrition of ruminants. Vol. (3). Practical Nutrition, D.C. church. Published by D.C. Church. Corvallis Oregon 97331. USA.

Hall, H.T.B. (1962). A note on dressing percentage and percentage of pins in Sudanese cattle. Sudan. J. Vet. Sci. and Anim. Husb. Vol. 3 No. (1), p. 46-47.

Ham, R. (1960). Biochemistry of meat hydration. Adv. FD. Res. 10 - 355-463.

Hammond, J. (1932). Growth and development of mutton qualities in the sheep. Oliver and Boyd. London.

Hankins, O.G. and Howe, F.E. (1946). Estimation of the composition of beef carcasses and cuts. U.A.D.A. Technical Bulletin No. 926. Washington, D.C. USA.

Hanky, C. and Kay, M. (1988). A note on the food conversion and meat quality of crossbred Aberdeen Angus and Charolais heifers. Anim. Prod., 47: 497-500.

Hoffiman, P.C., Sievert, S.J., Shaver, R.D., Welch, D.A. and Combs, D.K. (1993). In situ dry matter, protein and fiber degradation of perennial forage. J. Dairy. Sci. 76: 2632-2643.

Hoffman, K. (1994). What is quality? Definition measurements and evaluation of meat quality. Meat Focus International, 73-82.

Huntington, G.B. and Burns, J.C. (2007). Afternoon harvest increases readily fermentable carbohydrate concentration and voluntary intakes of gamagrass and switch grass balege by beef steers. J. Anim. Sci. 85: 276-284.

Huston JE., Engdahl BS., Bales KW. (1988). Intake and digestibility in sheep and goats fed three forages with different levels of supplemental protein. Small Rum. Res. 1, p. 81-92.

Ibrahim MNM., Ketelaar RS., Tamminga S., Zemmelink G. (1987). Degradation characteristics of untreated and urea-treated rice straw in the rumen. In RM. Dixon, ed. Ruminant feeding systems utilizing fibrous agricultural residues. Proceedings of the Seventh Annual Workshop of the Australian-Asian Fibrous Agricultural Residues Research Network held at Chiang Mai University, Thailand, p. 123-126.

Illius, A. W. and Jessop, N.S. (1996). Metabolic constraints on voluntary intake in ruminants. J. Anim. Sci. 74: 3052-3062.

Intesar, Y.T. (2002). The effect-of different dietary protein sources on performance and characteristics of western Baggara cattle. Ph.D. Thesis, University of Khartoum.

Itidal, A.E. (2004). Utilization of sugarcane baggase for fattening cattle. Ph.D. Thesis, University of Khartoum.

Jackson, M.G. (1978). Treating straw for Animal Deeding. Food and Agriculture Organization Animal production and Health Paper No. 10, Rome.

Jespin, O. and Greek, M.J. (1976). Comparative fattening performance of two types of cattle in Ethiopia. World Review of Anim. Prod. XIII (I): 83-90.

Judkins, M.B., Krysl, V.J. and Barton, R.K. (1990). Estimating diet digestibility: A comparison of eleven techniques across six different diets fed to rams. J. Anim. Sci. 68: 1405-1415.

Kay, M. and Mcdearmid, A. (1973). A note on the effects of changing the concentration of the diet offered to fattening beef cattle. Anim. Prod. 16: 205-208.

Kellems, R.O. and Church, D.C. (1998). Livestock feeds and feeding. 4^{th} ed. Rev. ed. Of Livestock feed and feeding D.C. Church 3^{rd} ed. New Jersey, USA.

Ketelaars, J.J.M.H. and Tolkamp, B.J. (1996). Oxygen efficacy and the control of energy flow in animals and humans. J. Anim. Sci. 74: 3036-3051.

Khalil, I.M. (1961). Impact of tradition on livestock development in the Sudan. Sudan J. Vet. Sci. and Anim. Husb., 2(2): 166-175.

Koch, R. M., Dikeman, M. E., Allen, D. M., May, M., Crouse, J. D., and Campion, D. R. (1976). Characterization of biological types of cattle III. Carcass composition, quality and palatability. J. Anim. Sci., 43 :48-62.

Kousgaard, K. (1980). The influence of energy and protein level on the carcass and lean quality in young bulls. Ann. Zootech., 29 n.h.s.: 275-284.

KSC. (2009) Kenana Sugar Company Limited Abaid Khatim Street. Khartoum, Sudan.

Kuan K.K. Stanogias G. And Dunkir A.C. (1983). The effect of proportion of cell wall material from Lucerne leaf meal on Apparent digestibility, Rate of passage and cut characteristics in pigs. J. of Anim. Prod. Vol. 36- No. 2.

Lawrie, R.A. (1978). Biochemistry of Muscle in Relation to Growth in: De Boer, H. and Martin, J. (Eds), Pattern of Growth and Development in Cattle. Martinus Nijhoff . The ague, pp .57-71.

Lawrie, R.A. (1998). Meat Science, 6th ed. Programon Press, Oxford. London.

Ledger, H.P., Rogerson, A. and Freeman, G.H. (1970). Further studies on the voluntary feed intake of Bos indicus, Bos Taurus and crossbred cattle. Anim. Prod., 12: 425-431.

Levy, D. Holzer, Z. and Folman, Y. (1980). Protein requirements of male cattle fattened on diet differing in energy concentration. Anim. Prod. 30: 189-197.

Levy, D. Holzer, Z. and Volcani, R. (1968). The effect of age and live weight on feed conversion and yield of saleable meat of intact Israel Frisian male calves. Anim. Prod. 10 (3): 325-330.

Lippke, H. (1986). Regulation of voluntary intake of ryegrass and Sorghum forages in cattle by indigestible nutrient detergent fiber. J. Anim. Sci. 63: 1459-1468.

Loginbuhl, J.M., Pond, K.R., Burns, J.C. and Fisher, D.S. (2000). Intake and chewing behavior of steers consuming switch grass preserved as hay or silage. J. Anim. Sci. 78: 1983-1989.

M.A.A.I. (2001). Ministry of Agriculture, Animal Resources and Irrigation. Khartoum State.

MAFF (1976).Ministry of Agriculture., Fisheries and Food. Department of Agriculture and Fisheries for Scotland, Department for northern Ireland. Energy Allowances and Feeding Systems for Ruminants. Technical Bulletin 33, p 3.

Maglad, M.A. and Lutfi, A.A. (1985). The comparative nutritive value of sugarcane bagasse, sorghum stalks and groundnut hulls. WId. Rev. of Anim. Prod. Vol. XXI, No. 1, January-March, 15-17.

Mason, I.L. and Maule, J. P. (1960). The indigenous livestock of Eastern and Southern Africa. Common. Bur. Animal Breed Genet. Tech. Commun., No. 14. Commonwealth Agricultural Bureaux, Farnham Royal, U. K.

McCroskey, J.E., Pope, L.S., Stevens,G.S. and Weir, W.C. (1961). Effect of pelleting steer-fattening rations of different concentrate to roughage ratios. J. Anim. Sci. 20: 42.

McDonald, I. (1981). A review model for the estimation of protein degradability in the rumen. J. Anim. Sci. (Camb.), 96: 251-252.

McDonald, P. Edwards, R.A. and Greenhalgh, J.F.D. (1987). Animal Nutrition. 3rd ed. Longman Group, UK.

McDonald, P. Edwards, R.A., Greenhalgh, J.E.D. and Morgan, C.A. (2002). Animal nutrition. 6th ed. PearsonPrentiee Hall. Edinburgh gate, UK.

McLeod, M.N. and Smith, B.R. (1989). Eating and ruminating behavior in cattle given forage differing in fiber content. Anim. Prod. 48: 503-511.

Mehrez, A.Z. and 0rskov, E.R. (1977). Study of the artificial fiber bag technique for determining the digestibility of feeds in the rumen. J. Agric. Sic. Camb. 88: 650-654.

Mehrez, A.Z., EI-Schinnawy, M.M., AI-Ashry, M.A. and Ead, H.M.E. (1983). Assessment of the associative effect of roughage and concentrates. J. Anim. Sci. 57, Suppl. 1: 475-488.

Meissner, H.H, Van Staden, J.H. and Elma Protorius (1982). The description of genotype differences on two dietary treatments. S. Afr. J. Anim. Sci. 12: 331-345.

Merchen, N.R., Darden, D.E., Berger, L.L., Fehey, G.C., Titegemy, E.C. and Fernando, R.L. (1987). Effect of diet fed in the growing period on feed intake and performance of finishing beef cattle. Symposium Proc. Feed Intake of Beef Cattle, pp. 393.

Mertens, D.R. (1985). Factors influencing feed intake in lactating cows from theory to application using natural detergent fiber. Georgia Nutrition Conference, 1985, pp. 1-18.

Mills, H.D. (1953). The dwarf cattle of the Sudan. Vet. Rec., 65: 587-588.

MLC (1974). Meat and livestock commission. Cutting and preparing beef. Technical Bulletin No. 17, Queensway house. Queens Bletchlly, Milton Keynes, U.K.

MOARF (2006). Ministry of animal Resources and Fisheries, Sudan. Ann. Rep.

Mohamed, H.K. (1999). The effect of different dietary energy levels on performance, carcass characteristics and meat quality of Sudan Baggara cattle. Ph.D. University of Khartoum.

Morre, C.P. (1991) Dried Cassava Chips Versus Sugar Cane as Energy Source for Fattening Zebu Cattle. World Review of Animal Production 1991 26: 3,65-68,7,31 ref.

Mukhtar, A.M.S. and El Triefie, M.M. (1970). Feedlot performance of Sudan indigenous claves in different planes of nutrition. Annual. Vet. Conf., U.A.R.

Mukhtar, A.M.S. and Elshafie, S.A. (1972). Feedlot performance and carcass characteristic of individually fed zebu range calves. World. Rev. Anim. Prod., VIII: 49-53.

Mustafa, A.F., Mohamed, T.A. and El Tayeb, A.E. (1990). Effect of feeding millet Sorghum Stover in a conventional concentrate diet on performance of western Sudan Baggara cattle. Sudan J. Anim. Prod. 3 (2): 57-67.

NCS (1992). National comprehensive strategy. Ministry of Agriculture and Natural Resources, Sudan.

Newman, Y.C, Sollenberger, L.E, Kunkle, W.E. and Bates, D.B. (2002). Crude protein fractionation and degradation parameters of limpograss herbage. Agron. J., 94:1381-1382.

Nour, A.Y.M. (1982). Characterization of bovine carcasses, as influenced by potential mature size, ration, housing and slaughter weight. M.Sc. Thesis, Cornell university, New York, USA.

NRC (1984). National Research Council. Nutrient requirements of beef cattle, 6th revised. Ed. Washington, D.C. National Academy Press.

NRC (1985). National Research Council. Ruminant nitrogen usage. National Academy Press, Washington, D.C.

NRC (1989). National Research Council. Nutrient requirements of beef cattle. Washington D.C. National Academy Press.

NRC (1996). National Research Council. Nutrient requirements of beef cattle. 7th ed. Nat. Acad. Press, Washington D.C.

Oltjen, R.R., Rumsey, T.S., and Putunam, P.A. (1971). All forage diets for finishing beef cattle. J. Anim. Sci. 32- 327.

Ørskov, E.R. (1982). Protein nutrition in ruminants. Academic Press Inc., San Diego, CA, USA 175pp.

Ørskov, E.R. and McLeod, N.A. (1982). In protein metabolism and nutrition, Centre for Agric. Pub. Ad Docu. Wageningen. The Netherlands.

Ørskov, E.R., Hovel, F. D., DeB., and Mould, F.L. (1980). The use of the nylon bag technique for evaluation of feedstuffs. Trop. Anim. Prod. 5: 195-213.

Osuji, P.O., Nasahlai, I.V. and Khalili, H. (1993). Feed evaluation. ILCA Manual 5. ILCA Addis Ababa, pp: 9-14.

Owen, F.N. and Geay, Y. (1992). Nutrition of growing and finishing cattle. World Anim. Sci. C5.

Owen, J.B. (1979). Complete diets for sheep and cattle. 1st ed. Farming Press Limited, UK.

Palsson, H. and Vergus, J.B. (1952). Effect of Plan of Nutrition on Growth And Development of Carcass Quality In Lambs. Part 1: The Effect of High And Low Plans of Nutrition at Different Ages. J. Agric. Sci. 42 part 1 and 2.

Payne, W.J .A. (1970). Cattle Production in the Tropics. Vol. 1. Breeds and breed mg. Longman Group Ltd., London.

Pigden, W.J., Balch, C.C. and Graham, M. (1980). Standardization of analytical methodology for feeds. Summary and recommendations. In: Proc. Int. Dev. Res. Centre. Pigden, Ottawa, pp. -14.

Preston, T.R. (1987). Conference summary and overview, symposium proceedings. Feed intake of beef animals, pp. 387-391.

Preston, T.R. and Leng, R.A. (1987). Matching ruminant production systems with available resources in the tropics and subtropics. Armidale, Australia: Penambul Books.

Preston, T.R. and Wills, M.B. (1969). Sugar cane as Energy Source for The Production of Meat. Out book In Agnc. 6 : 29-35.

Preston, T.R. and Wills, M.B. (1974). Intensive Beef Production Second Edition. Pergamon Press Ltd., London.

Randal and Hall, H. (1999). Molasses as a feed ingredient. Livestock feed ingredients R and H Hall. Technical Bulletins, issue No.3, 1999. Online source www.rhhall.ie.

Raude, R.T., Boccard, R. and Cronje, D.E. (1975). Meat production trait in indigenous cattle. Animal and Dairy Science Research Institute. Irene South Africa Sarccus Meeting, 15 Sept. 1975.

Reddy, D.V. (2004). Principles of animal nutrition and feed technology. Oxford and IBH Publishing Co. PVT. L TD, New Delhi, India.

Reid, J. T. (1972). Body Composition in Animal Inter Specific Sex and Age Peculiarities and the Influence of Nutrition Oslo. Norway. pp 217-273 Proc. Cornell Nutr. Conference.

Reyneke, J. (1976). Comparative beef production from bulls, steers and heifers under intensive feeding condition. S. Afri. Anim. Sci. 8: 52-58.

Ribeiro, J.M.C.R. and Moreira, O.M.S.C. (2000). Comments on feed evaluation methods. (INIA), Vale de Santarem, Portugal.

Schneider. B.H. and Lucas. H.L. (1950). J. of Animal Sci.: 9: 504.

Snedecor, G. and Cohran, W.G. (1989). Statistical methods (8^{th} ed). Iowa State University Press Ames.

Solaiman SG., Horn GW., Owens FN., Ridder AR. (1979). Ammonium hydroxide treatment of wheat straw. J. Anim. Sci. 49, p. 802-810.

SSC. (2009). Sudanese Sugar Company. Elgamaa Street. Khartoum. Sudan.

Stat Soft, Inc. (1995). STATISTICA for windows (computer program manual). Tulosa, OK: StatSoft. Inc., 2325 East 13th Street, Tulosa, OK, 74 104, (918) 583-4149, Fax: (918) 583-4376 .

Stobo, I.J.F. (1964). Study in the Nutrition of Young Cattle with Special Reference to Rumen Development and Protein Requirement of The Weaned Calf. Ph. D Thesis. University of Reeding.

Stock, E.R., Binder, C. W., Deyoe, G.L., Allee and Behnke, K.C. (1983a). Effect of pelleting conditions on performance of pigs fed on corn soya bean meal diet. J. Anim. Sci. 57: 922-928.

Streeter, M.N., Hill, G.M., Wagner, D.G., Owens, F.N. and Hibbred, C.A. (1993). Effect of bird-resistant and non-bird-resistant Sorghum grain on amino acid digestion by beef heifers. J. Anim. Sci. 71: 1648-1656.

Sudweeks, E.M., Ely, L.O., Mertens, D.R. and Sisk, L.R. (1981). Assessing minimum amounts and forms of roughage in ruminant diet. Roughage value index system. J. Anim. Sci. 53: 1406.

Sudweeks, E.M., Ely, L.O., Sisk, L.R. (1980). Effect of intake on chewing activity of steers. J. Dairy Sci. 63: 152-154.

Sudweeks, E.M., McCullough, EM.E., Sisk, L.R. and Law, S.E. (1975). Effect of concentrate type and level and forage type on chewIng times of steers. J. Anim. Sci. 41: 219-224.

Suliman, G.M. (2004). Use of karkade *(Hibiscus sabdariffa)* seeds as a non-conventional protein source for cattle fattening. Ph.D. Thesis, University of Khartoum.

Tagel-Din AE., Nour AA., Nour AM., Abou-Akkada AR. (1989). Evaluation of diets containing different levels of rice or berseem straws and concentrates fed to sheep. Indian J. Anim. Sci. 59, p. 465-469.

Theissen, R.B., Hnizodo, E., Maxwell, D.A.G., Gibsin, D. and Tylor, C.S. (1984). Multi-bred comparison of British cattle, variation and body weight, growth rate and feed intake. Anim. Prod. 38: 323-340.

Theodoron, M.K., Williams, B.A., Dhanoa, M.S., McAllan, A.B. and France, J. (1994). A simple gas production method using a pressure transducer to determine fermentation kinetics of ruminant feed. Anim. Feed. Sci. Technol. 48: 104-111.

Thomas, M., Van Villet, I. and Vanderpoel, A.F.B. (1998). Physical quality of pelleted animal feed. 3. contribution of feedstuffs components. Anim. Feed. Sci. Tech. 70: 59-78.

Tibin, I.M. and Ahmed, D.E. (1997a). Feeding Sorghum grains substituted with molasses to desert lambs. Effect on feedlot performance, carcass and non-carcass characteristics. Sudan. J. Vet. Sci. Anim. Husb. 36: (1, 2).1-7.

Tibin, I.M. and Ahmed, D.E. (1997b). Feeding Sorghum grains substituted with molasses to desert lambs. Effect on meat chemical composition and quality attributes. Sudan J. Vet. Sci. Anim. Husb. 36: (1,2) 10-15.

Tilley, J.M.A. and Terry, R.A. (1963). A two stage technique for in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18: 104-111.

Van Soest, P .J. (1994). Nutritional ecology of the ruminant. Ithaca, NY: Cornell University Press.

Van Soest, P.J. & R.H. Wine, (1967). Use of detergents in the analysis of fibrous feeds. IV. Determinations of plant cell-wall constituents. J. of the A.O.A.C. 50:50-55.

Van Soest, P.J. (1966). Non-nutritive residues: A system of analysis for the replacement of crude fibre. J. of the A.O.A.C. 49:546-551.

Van Soest, P.J. (1982). Nutritional ecology of the ruminant. Corvallis Oreg. O. and B. Books.

Van Soest, P.J., (1964). New chemical procedures for evaluating forages. J. Anim. Sci. 23:838-845.

Veitia, J.L., Elias, A. and Garcia, J. (1979). Effect of deistic protein level for bulls fattening with high molasses level. 1: Weight gain, consumption and feed conversion efficiency. Indian J. Anim. Sci. 49 (12): 992-1000.

Von Keyserlingk, K.M.A.G., Swift, M.L., Puchala, R. and Sheford, J.A. (1996). Degradability characteristics of dry matter and crude protein of forage in ruminants. Anim. Feed Sci. Technol. 57: 291-311.

Weir, W.C, Meyer, J.H., Carret, W.N., Lofgreen, G.P. and Ittner, N.R. (1959). Pelleted rations compared to similar rations fed chopped or ground for steers and lambs.

Welch, J.G. (1982). Rumination, particle size and passage from the rumen. J. Anim. Sci. 54. 885-894.

Widdson, E. (1980). Definitions of growth. In: Lawrence, T.L.J. (ed) Growth in animals. Butterworth Ltd, London.

Wilfart, A., Mentagne, L., Simminus, P .H., Milgen, J. Van., and Noblet, J. (2007). Sites of nutrient digestion in growing pigs. Effect of dietary fibers. J. Anim. Sci. 85: 976-983.

Wilson, P.N. and Strachan, P.J. (1981). In recent development in ruminant nutrition (ed, W. Haresign and D, J .A. Cole) pp. 228-247, Butterworth, London.

Wilson, R.T. and Clarke, S.E.C. (1975). Studies on the livestock of southern Darfur, Sudan, Trop. Anim. Hlth. Prod. 7: 165-182.

Wise, M.B., Blumer, T.N., Matone, G. and Barrick, E.R. (1961). Investigation on the Feeding of All Concentrate Rations to Beef Cattle .J.Anim. Sci. 20: 560-565.

Wood, J.F. (1987). The functional properties of feed raw material and their effect on the production and quality of feed pellets. Anim. Feed. Sci. tech. 18: 1-17.

Woodford, S.T. and Murphy, M.R. (1988). Effect of forage physical form on chewing activity, dry matter intake and rumen function of dairy cows in early lactation. J. Dairy Sci. 71: 674-686.

Yan, T. and Agnew, R.E. (2004). Prediction of nutritive values in grass silage: II. Degradability of nitrogen and dry matter using digestibility, chemical composition, and fermentation data. J. Anim. Sci. 82: 1380-1391.

Yeates, N.T.M. (1965). Modern aspects of animal production, Butterworth, London.

Zhang, K., Xine, C., Min, J. An-rong, N. Huan, F. and Zhou, K. (2004). Straw bio-degradation by acidogenic bacteria and composite fungi. Journal of environmental sciences (abstract) vol. 4.

Table (2): Molasses Production in Sudan (Ton).

Season	Algenaid (Ton)	Halfa (Ton)	Senar (Ton)	Assalaya (Ton)	Kenana (Ton)	Total (Ton)
2002-2003	26907.00	27776.00	25850.00	24875.00	145043	250451
2003-2004	30464.00	29496.00	28245.00	31460.00	147028	266693
2004-2005	30384.00	23432.00	25725.00	33555.00	141854	254950
2005-2006	28857.00	26372.00	31050.00	34325.00	142019	262623
2006-2007	31840.00	29202.00	28255.00	31425.00	131806	252528
2007-2008	33836.00	27138.00	25615.00	32395.00	129836	248820

** The amount of molasses represented 33% from the production of the sugar cane.*

** Source Sudanese sugar company (SSC,2009) and Kenana sugar company (KSC, 2009).*

Table (7) Feed lot performance of Sudan Baggara bulls

Item %	Mean ± SD				Level of significant
	G.A	G.B	G.C	G.D	
Number of animals	9	9	9	9	N.S
Initial live weight (Kg)	202.78±5.65	198.89±5.46	202.22±9.05	202.22±7.12	N.S
Final live weight (Kg)	259.44±1.67	260.00±2.50	257.78±3.63	261.67±2.50	N.S
Average daily gain (Kg/day)	0.96±0.13	1.02±0.17	0.84±0.16	0.91±0.14	N.S
Total gain (Kg)	56.67±5.00	61.11±4.86	55.56±8.46	59.44±8.08	N.S
Total dry matter in take DMI (Kg/head)	658.41±66.27	654.52±57.22	707.10±61.34	703. 34±65.45	N.S
Dry matter in take DMI (Kg/head/day)	9.97±1.63	9.75±1.62	9.74±1.75	9.70±0.90	N.S
Feed conversion ratio FCR (Kgfeed/Kg)	10.40±0.92	9.63±0.75	11.69±2.06	10.84±1.65	N.S
Time of experiment (days)	60	62	67	66	N.S

Table (14) Carcass yield and characteristic of Sudan Baggara Bulls

Item %	Mean ± SD				Level of significant
	G.A	G.B	G.C	G.D	
Number of animals	9	9	9	9	N.S
Slaughter weight (Kg)	259.44±1.67	260.00±2.50	257.78±3.63	261.67±2.50	N.S
Empty body weight EBW (Kg)	230.13	231.04	225.85	227.79	N.S
Hot carcass dressing (%)	53%	52%	52%	52%	N.S
Cold carcass dressing (%)	51%	51%	51%	51%	N.S
Cold carcass (weight Kg)	134.67±5.05	133.31±6.16	131.95±3.90	133.70±3.29	N.S
Warm carcass (weight Kg)	138.91±5.26	136.94±6.34	135.28±3.69	136.77±3.11	N.S
Chiller shrinkage	3.32±0.48	2.96±0.37	2.66±0.63	2.60±0.87	N.S

Table (15) Body component (percent of empty body weight EBW)

Item %	Mean± SD				Level of significant
	G.A	G.B	G.C	G.D	
Body component %	9	9	9	9	N.S
Hide	20.45±1.98	20.36±2.25	20.30±1.42	19.27±2.60	N.S
Head	15.67±0.68	15.71±0.62	15.08±0.63	15.57±1.18	N.S
Four feet	5.99±0.52	5.85±0.33	5.97±0.35	6.08±0.47	N.S
Stomach weight (Full)	29.72±3.76	30.22±5.61	31.80±3.83	33.69±6.07	N.S
Intestine weight (Full)	15.44±1.86	14.20±1.69	15.62±2.32	15.20±2.56	N.S
Stomach weight (Empty)	8.14±0.81	7.83±1.03	7.98±0.92	7.840±0.89	N.S
Intestine weight (Empty)	7.71±1.22	7.63±0.86	7.51±0.91	7.17±0.89	N.S
Mesenteric fat	1.16±0.33	0.92±0.20	0.93±0.23	0.76±0.22	N.S
Omental fat	3.19±0.78	3.03±0.41	2.22±0.61	2.32±0.46	N.S
Kidney fat	2.37±0.72	2.44±0.46	2.22±0.54	2.30±0.54	N.S

Table (15) Body component (percent of empty body weight EBW)

Item %	Mean ± SD				Level of significant
	G.A	G.B	G.C	G.D	
Body component %	9	9	9	9	N.S
Kidney weight (Kg)	0.66±0.16	0.67±0.09	0.64±0.10	0.68±0.09	N.S
Liver	4.38±0.63	4.20±0.56	3.97±0.44	4.11±0.38	N.S
Heart	0.92±0.08	0.86±0.05	0.84±0.10	0.91±0.08	N.S
Genital organs	2.41±0.22	2.66±0.39	2.24±0.18	2.31±0.20	N.S
Tail	0.83±0.14	0.86±0.10	0.89±0.10	0.84±0.06	N.S
Lung and trachea	3.29±0.38	3.53±0.41	3.58±0.29	3.40±0.41	N.S
Diaphragm	1.43±0.15	1.37±0.12	1.36±0.11	1.41±0.10	N.S
Spleen	0.84±0.25	0.76±0.25	0.72±0.16	0.66±0.06	N.S
Pancreas	0.35±0.08	0.37±0.07	0.34±0.09	0.33±0.09	N.S
Blood	10.11±1.27	10.09±0.70	9.92±0.88	9.61±0.65	N.S

Table (16) Yield of whole sale cuts (percent of cold side weight)

Item %	Mean± SD	Level of

	G.A	G.B	G.C	G.D	significant
Number of carcasses	9	9	9	9	N.S
Shin	2.13±0.09	2.08±0.16	2.10±0.11	2.15±0.12	N.S
Neck	3.68±0.39	3.65±0.63	3.49±0.62	3.25±0.30	N.S
Chuck	6.84±0.98	7.09±0.99	7.30±0.43	7.08±0.71	N.S
Clod	4.18±0.63	4.01±0.41	4.13±0.50	4.29±0.41	N.S
Extended roasting ribs	4.09±0.64	4.18±0.58	4.61±0.63	4.37±0.71	N.S
Thick ribs	3.54±0.58	3.62±0.48	3.42±0.50	3.56±0.40	N.S
Thin ribs	2.06±0.33	1.93±0.32	1.99±0.21	2.01±0.18	N.S
Brisket	5.41±0.52	5.35±0.61	5.63±0.55	5.54±0.27	N.S
Thin flank	3.95±0.39	4.25±0.24	3.88±0.11	3.93±0.38	N.S
Thick flank	2.94±0.22	3.12±0.27	3.13±0.32	2.97±0.29	N.S
Leg	3.21±0.21	3.23±0.24	3.26±0.19	3.28±0.26	N.S
Sirloin	4.13±0.47	3.98±0.40	4.22±0.34	4.14±0.44	N.S
Rump	4.73±0.34	4.76±0.56	4.69±0.29	4.72±0.28	N.S
Top and silver side	11..23±0.41	11.17±0.65	11.26±0.42	11.74±0.49	N.S

Table (17) composition of high priced whole sale cut (9 - 10 and 11th rib cut) as percent of the cut weight

Item %	Mean ± SD				Level of significant
	G.A	G.B	G.C	G.D	
Number of samples	9	9	9	9	N.S
Muscle	61.22±5.56	58.34±5.71	9.38±5.76	60.75±2.96	N.S
Bone	25.31±3.43	25.03±4.40	26.67±5.47	24.83±2.35	N.S
Connective tissue	7.74±3.06	7.58±2.65	6.70±1.41	7.18±1.23	N.S
Fat	4.84±1.82	6.93±2.56	4.77±0.81	4.93±2.59	N.S

Table (19) Meat chemical composition of Sudan Baggara bulls (percent of fresh muscle weight)

Item %	Mean± SD	Level of

	G.A	G.B	G.C	G.D	significant
Number of samples	9	9	9	9	N.S
Moisture %	74.87±0.65	75.26±1.07	75.56±0.31	75.17±0.82	N.S
Ash %	1.57±2. 05	0.88±0.25	1.00±0.43	0.90±0.19	N.S
Crude protein %	22.14±1.66	22.62±1.10	21.92±1.05	22.60±1.40	N.S
Ether extract %	2.07±1.06	2.43±1.11	1.59±0.46	2.18±0.94	N.S
Water holding capacity W.H.C	2.07±0.45	1.90±0.41	2.10±0.22	1.47±0.30	N.S
Cooking loss	34.68±0.38	34.93±0.49	3673±0.73	36.95±1.93	N.S

Table (18) Meat quality attributes of Sudan Baggara bulls

Item %	Mean± SD				Level of significant
	G.A	G.B	G.C	G.D	
Number of samples	9	9	9	9	N.S
Colour [a] L A B	 33.23±2.31 19.36±1.65 8.28±0.92	 33.98±1.33 18.80±1.56 7.86±0.83	 34.18±1.46 18.31±2.61 8.00±0.32	 34.01±1.75 18.53±2.59 8.09±1.36	 N.S N.S N.S
Water holding capacity W.H.C	2.07±0.45	1.90±0.41	2.10±0.22	1.47±0.30	N.S
Cooking loss	34.68±0.38	34.93±0.49	3673±0.73	36.95±1.93	N.S

Table (20) subjective evaluation of Sudan Baggara bulls meat

Item %	Mean± SD				Level of significant
	G.A	G.B	G.C	G.D	
Number of samples	9	9	9	9	N.S
Colour	5.34±0.44	6.23±0.64	5.44±0.50	5.04±0.39	N.S
Flavor	4.43±1.01	4.77±0.44	5.36±0.34	5.01±0.46	N.S
Juiciness	6.79±0.25	6.40±0.68	4.18±0.53	3.43±0.44	N.S
Tenderness	6.99±0.16	6.74±0.42	4.40±0.35	3.76±0.64	N.S
Over all acceptability	6.50±0.17	7.00±0.50	4.00±0.44	3.50±0.38	N.S