$<\pm 0.01$

$\pm 0.01 \pm 0.01 \pm 0.01 \pm \mathbf{0.01} \pm 0.01 \pm 0.01 \pm 0.01 \pm 0.01 \pm 0.01 \pm \mathbf{0.01} \pm 0.01$

$\pm 1.15 \pm 0.01 \pm 0.01 \pm$

INTRODUCTION

Numerous multipurpose browse trees and shrubs have been identified as animal fodder in the Sudan such asTabaldi (*Adansoniadigitata*), (Randa ,*etal*, 2012). Leaves and Shooting Branches of Sidder (*Ziziphus spinachristi*) trees. (Mohammed,*etal*, 2012). And*Balanites aegyptiaca* (HEGLIG), (Morkaz, *etal* 2011). Leguminous fodder trees and shrubs have the potential abilities to alleviate nitrogen and minerals deficiencies of ruminant diets on pasture/crop residue (Makkar and Becker, 1997).

However, about 90% of the animal resources in the Sudan are owned by the migratory pastoralists. Furthermore, the livestock populations of the Sudan are mostly raised under open range grazing conditions, where the tropical grasses are characterized by early maturity, high fiber, high lignin and low protein contents. All of these have an influence on livestock reproductive and productive performance of the animals. The main problems related to these conditions are late sexual maturity, short reproductive live and low milk yield and meat production. Consequently, supplementary feeding of ruminant livestock in the Sudan requires special attention in many circumstances in order to improve their productivity.

The non-availability of forage during the dry season affects sedentary livestock more, as they lack the advantage of mobility exercised in the transhumant and nomadic systems.

The past few years have witnessed an increase in supplementation of natural forage grazing, by collection and storage of hay, utilization of crop residues and agro-industrial by-products and irrigated fodder. The role of fodder trees and shrubs (*Acacia*, *Cadaba*, *Maerua* etc) as a dry season source of feed (pods, leaves and twigs) should not be under-estimated. They are particularly valuable in the Semi-desert and Low Rainfall Savanna zones.

Guddaim (*Growia tenax*) one of the valuable plant species in Sudan .It is largely spread in arid area parts, especially in savanna plantation area at the northern and middle of Sudan. FAO (1988). Fruits and other parts of G.tenax contribute

significantly to the food and energy needs of rural populations in multiple ways (El-Siddig *et al*. 2003; Vogt 1995). Its leaves and twigs are palatable fodder for livestock (Gebauer *et al*. 2007).

The use of the in situ Dacron bags feed evaluation method developed by Qrskov and McDonald (1979) is an important tool in the measurement of the quality of ruminant feeds by ruminant nutritionists. The general aim of this study was to evaluate the degradability characteristics of dry matter and crude protein of *Growia tenax* by using the in situ and in vitro techniques. On the other hand, supplementary feeding which is not frequently practiced, need to be considered.

The general objective of the study:

a) To introduce an alternative protein sources from the local non wood forest products.

b) The specific objectives of the study:

1-To evaluate the nutritional valueof seed,flesh,leaves and shooting branches of Gudaim (*Growiatenax*) through experimental trails

2- To evaluate the rumen degradability (in Sacco) 0f dry matter and crude protein and in vitro gas production of Gudaim (*Growiatenax*), and to estimate the effect of feeding of different level of Gudaim (*Growiatenax*) on rumen environment of local Sudanese steers.

CHAPTER ONE

LITERATURE REVIEW

1.1. Ruminants:

Ruminants are mammals that are able to acquire nutrients from plant-based food by fermenting it in a specialized stomach prior to digestion, principally through bacterial actions. The process typically requires the fermented ingesta (known as cud) to be regurgitated and chewed again. The process of reshowing the cud to further break down plant matter and stimulate digestion is called rumination. (AOAD, 1994, Fadlalla B. 1987).the word "ruminant" comes from the Latin *ruminant*, which means "to chew over again".

There are about 150 species of ruminants, which include both domestic and wild species. Ruminating mammals include cattle, goats, sheep, giraffes, yaks, deer, camels, llamas, antelope, and some macro-pods.

Taxonomically, the suborder Ruminantia (also known as Ruminants) is a lineage of herbivorous artiodactyls that includes the most advanced and widespread of the world's ungulates.(Harrison M.N. and Jackson J.K. 1958) The term 'ruminant' is not synonymous with Ruminant. Suborder Ruminant includes many ruminant species, but does not include tylopods and marsupials, which are technically ruminants.

1.1.1 Ruminant physiology

Ruminating animals have various physiological features that enable them to survive in nature. One feature of ruminants is their continuously growing teeth. During grazing, the silica content in forage causes abrasion of the teeth. This abrasion is compensated for by continuous tooth growth throughout the ruminant's life, as opposed to humans or other non-ruminants, whose teeth stop growing after a particular age. Most ruminants do not have upper incisors; instead

they have a thick dental pad to thoroughly chew plant-based food.Jaddalla, Juma Barram (1994).

1.1.2 Rumenmicrobiology

Vertebrates lack the ability to hydrolyse the beta [1-4] glycoside bond of plant cellulose due to the lack of the enzyme cellulose. Thus ruminants must completely depend on the microbial flora, present in the rumen or hindgut, to digest cellulose. Digestion of food in the rumen is primarily carried out by the rumen micro-flora, which contains dense populations of several species of bacteria, protozoa, sometimes yeasts and other fungi it is estimated that 1mL of rumen contains 10-50 billion bacteria, 1 million protozoa as well as several yeasts and fungi.(Russell,. 2002).

Since the environment inside a rumen is anaerobic, most of these microbial species are obligate or facultative anaerobes that can decompose complex plant material, such as cellulose, hemicelluloses, starch, and proteins. The hydrolysis of cellulose results in sugars, which are further fermented to acetate, lactate, propionate, butyrate, carbon dioxide and methane.

As bacteria conduct fermentation in the rumen, they consume approximately 10% of the carbon, 60% of the phosphorous, and 80% of the nitrogen that the ruminant ingests William O. Reece (2005).To reclaim these nutrients, the ruminant then digests the bacteria in the abomasum. The enzyme lysozymehas adapted to facilitate digestion of bacteria in the ruminant abomasum. Ditchkoff, S. S. (2000).Pancreatic ribonucleic also degrades bacterial RNA in the ruminant small intestine as a source of nitrogen.(Reinhold R Hofmann, 1989)

During grazing, ruminants produce large amounts of saliva - estimates range from 100 to 150 litres of saliva per day for an adult cow. (Hackmann. T. J., and Spain, J. N. 2010). The role of saliva is to provide ample fluid for rumen fermentation and to act as a buffering agent. Callewaert, L.; Michiels, C. W. (2010) Rumen fermentation produces large amounts of organic acids and thus maintaining the appropriate pH of rumen fluids is a critical factor in rumen fermentation. After digest a pass through the rumen, the omasum absorbs excess fluid so that digestive enzymes and acid in the abomasum are not diluted.Clauss, M.; Rossner, G. E. (2014).

Ruminant livestock production, from small tropical farmers is based predominantly on animals grazing natural pasture, which have often low nutritive value especially during the dry season. Grasses grow rapidly during the summer, but later become fibrous, coarse, and highly lignified which decrease their digestibility. This results in loss of palatability and ineffective utilization of the pastures by the animals, thereby causing nutritional stress (Owen and, Jayasuriya, 1989).

As a result of these adverse conditions in the dry tropics, animals can lasso's weight and body condition mainly during the dry season. This situation represents a heavy economic losses for cattle farmers (Pigden and Bender, 1978), Because the ability of ruminal microorganisms to degrade fiber, ruminants can then derive nutrients from products or by-products of other local agricultural and industrial processes and can be used to improve the nutrition of ruminant live stock during the dry season of strategic supplementation for low quality forage (Hennessy and Williamson, 1990, Duarte *et al*. 1996).

The abomasums in the ruminant's true or glandular stomach. Histological it is very similar to the stomach of mono-gastric.

According to Smith and Oldham (1983) the ideal environment for maintaining stable microbial population in the rumen of adult ruminant animal it is worm (39-42 c^{o}) aerobic, chemical reducing environment .Rich in organic matter , rumen content is approximately 5.5 to 6.5 . and this sodium and potassium bicarbonate and urea , and also by absorption through rumen wall in to blood stream of volatile fatty acids (VFA) and ammonia (NH3) produced during fermentation . Related to the above mentioned, the types of microorganism that can exist in the rumen are constrained by temperature, oxidation reduction potential and pH, these microorganisms is clued bacteria.

According Hungate (1975) the microbial ecosystem in rumen is very within animal with time and feeding ,between days in the same animal and apparently in the animal of different counties fed similar diet for the growth of bacteria protozoa and possibly other microbes that produce cellulose enzyme similarly (Preston, and long 1987).noted that rumen environment appear to be controlled by type and quantity of food eaten , periodic mixing salvation rumination diffusion of secretion in to the rumen absorption of nutrient from the rumen and passage of material down the digestive tract (Preston and Long 1987).

Rumen contents reaction, of pH is undoubtedly one of the most important parameters describing rumen fermentation. the relationship with feeding time, rumen movements and ruminating are considered among the factors conditioning this phenomenon,it was determined that rumen content pH after feeding change in characteristic way, that is begging decreasing reaching its lowest value about 4 hours after feeding (fermentation peak greatest VFA production); then increases gradually until reaching again initial values (Fenner *et al*, 1967).

Ammonia exists as free NH3 at high but as the ammonia ion (HN4) at a lower pH (Bartly and Adeyoe, 1981) Because this tissue membranes are permeable to the lipid soluble NH3 form impermeable to the charged NH4 form, most ammonia is absorbed and high pH that at low pH (Hogan 1961, Bloomfied *et al*, 1963). The significant of this is that a large NH3 pool can be maintained in the rumen for microbial protein synthesis. A decrease in normal pH induced by the formation of VFA from starch caused a decrease in the rate of NH3 liberation and an increase in protein biosynthesis (Reis and Reid, 1959).

It has ban demonstrated repeatedly that NH3 does not pass repeatedly through the wall of rumen unless the pH is high enough (above7.3) to favor the presence of appreciable amounts of unionized NH3.

The microbial ecosystem in the rumen is very within animals, within time after feeding between days in the same animals and apparently in the animal of different countries fed similar diet for the growth of bacteria, protozoa, and other microbes that produce cellulose enzyme similarly (Hungate, 1975. Priton and long ,1987) noted rumen environment appear to be controlled by type and quality of food eaten periodic mixing salvation ,rumination diffusion of secretion in to the rumen absorption of nutrient from rumen and passing of material down the digestive tract (Priston and Long , 1987). The microbiology of the rumen is an extremely a complex subject due to the large number of organism present. their diverse nature and shifty population that result from change in the diet of the host animals in addition marked change maybe noted within and between animals on the same or similar diet (Key and Hobson,1963).

The ruminant possesses four statements the first the reticulum, the second rumen, the third the omasum and the fourth the abomasum

only the abomasum has the characteristics of a true stomach, because it secrete a digestion fluid, whereas the liming epithelium of other three compartment is devoid of secreting calls of any kind,furthermore, the first three pouches arise from the caudal end of the wall of esophagus.

These pouches are rudimentary at birth and during suckling life, but they develop rapidly after the animal begins to eat coarse fodder .The term "far stomach" (Vormagen of German workers) is war appropriate. They are not secreting organs, and the any digestive juice present normally in them is saliva, this has been shown to contain no ptyalin so that the only chemical changes, which can occur in the fore stomachs, are these due to fermentation. The contents of the reticulum and rumen are always fluid , and these is no doubt that the organs represent chambers where mixing and fermentation occur , the two pouches communicate free by with each other and the term reticulo-rumen can be correctly , applied to the combined cavity by them .

Schalk and Amadon,(1928) have shown by experiments an cows with ruminal fistula (in the living animals), the contents of these cavities are arranged in accordance with the density of their constituents, these heavy grains are found to lie ventrally, while light material, such as hay, float an top the omasum epithelial liming in to numerous folds or laminate of varying length, which almost fill the vises .The entrance and exit are very close together.

The entrance or reticula-omasal orifice is situated at the distal extremity of the esophageal groove, which is all that remains in the adult of this portion of the original gullet.The esophageal groove as Waster , (1926), Schalk and Amadon , (1928) have shown can by contraction of lips , from a chased tube , which acts as a direct

communication from month to omasum during the period of suckling , but in the adults is hardy is ever functions in this way , this rudimentary structure is the starting point of these peristaltic waves which pass over the reticulum and rumen in are redirection and over the omasum in the other further , when the lips of the groove over contracted they shat the omasum off from the reticulum the reticula-omasal orifice is normally below the level of the contents of the reticulum and rumen (Wester , 1926) .

The free borders of the omasal laminaseecatch on the groove.The sulcus omasal, which passes obliquely downward and backward from the entrance to the omasum-abomasl orifice.The later opening is not gander by sphincter of any kind, so that trams faience of food from omasum to abomasum's appears to depend gravity and on the native force of the omasal contractions.

The muscular wall of the abomasum as compared with that of omasum is thin end weak , and an this difference in contractile power , as well as an gravity , would appear to depend the absence , normally of regurgitation from the former in to the latter viseus . The pyloric portion of the abomasum is tubular and at it's into the duodenum, there is a well-developedsphincter.

The abomasl contents are flied and the solid matter always finally comminutedthe omasal contents on the contrary are always dry and solid in comparison and consist of particles of much large size, it is obvious therefore, that the chief function of the omasum are to filler off the course pieces from the fluid ingstatransmited from the reticule-rumen. The fluid and fine particles pass on to the abomasum’s , which the coarser material is caught between the laminas by the movement of which it is ground down to a condition so fire that it is swept into abomasum’s by the fluid from the next intake of material from reticule-

rumen . The abomasum is lined with glandular epithelium and is therefore the homologue of stomach in man (Magee 1932).

1.2 Carbohydrate Digestion

1.2.1Carbohydrate digestion and rumen fermentation.

The major sources of carbohydrates in pig diets are feeds rich in starch, whereas in ruminants fibrous feeds containing cellulose and hemicellulose and grains rich in starch are the primary carbohydrate sources. In swine, most dietary carbohydrates (e.g., starch) are hydrolyzed to monosaccharides in the small intestine, whereas ruminants have most of their dietary carbohydrates (e.g., starch and cellulose) fermented in the rumen by microorganisms, and only 5 to 20% of consumed dietary carbohydrates are digested in the small intestine (Huntington GB, 1997).

As early as 1883, Tappeiner (Annison E, Lewis D, 1959) demonstrated that in cattle dietary cellulose was fermented to volatile fatty acids (VFA),2 most of which was acetic acid. Subsequent work of Kellner (Annison E, Lewis D, 1959) showed that starch and cellulose have the same energy value in cattle but not in swine. Numerous ruminant nutritionists have confirmed these observations and have shown that the major source of energy to the ruminant is the VFA absorbed from the rumen and other parts of the digestive tract. A major breakthrough in the development of VFA biochemistry in ruminants occurred with the development of gas-liquid chromatographic quantification of VFA by (James and Martin in 1952). Later research documented that lesser proportions of VFA are also produced from dietary proteins, pentose of nucleic acids, and glycerol of glycerophospholipids. Studies on the VFA production rates and metabolism have increased in number and

sophistication as a result of the development of an artificial rumen by Hungate with Carroll in (1954).

As summarized by (Baldwin R. L, *et al*. 1965), confirmed acetate as a majorendproduct of fermentation, elucidated pathways for synthesis of each VFA and lactate, showed how diet composition (e.g., starch and cellulose ratios) influences proportions of each of the endproducts of fermentation, demonstrated that about half of butyrate is converted to *β*-hydroxybutyrate during absorption of butyrate from the rumen into blood, and showed that branched-chain organic acids are derived from amino acid fermentation. In addition, (Baldwin RL, *et al.* 1965), using radioactively labelled lactate, showed that high-starch diets increased the flux of lactate to propionate via the acrylate vs. the succinct pathway of pyruvate conversion to propionate. Later, Baldwin's research group published their first (Baldwin RL, 1995) of several publications on modelling of metabolic pathways in the rumen and other tissues of dairy cattle that led to the development of the MOLLY program for whole-body metabolism (Baldwin RL. 1995).

1.3. Proteins:

Proteins are complex organic compounds of high molecular weight, containing carbon, hydrogen, oxygen, nitrogen and generally sulphur. Proteins are made from a pool of 20 amino acids about 10 of which are essential. Amino acids are joined by a peptide linkage between a – carboxylic group of one acid and the amino acid group of another. The primary structure of the protein refers to as the sequences amino acids in the polypeptide chain. The information of the chain is the result of hydrogen bonding in the secondary structure, folding of the chain gives the tertiary structure; the quaternary structure refers to the

configuration of those proteins with more than polypeptide chain (Church, 1976).

The animal must receive sufficient quantities of both essential and nonessential amino acids, to meet its metabolic demand. Considerable degradation and synthesis of protein in the rumen of ruminants, and the material, which finally becomes available for digestion by the animal may differ considerably from the originally present in the food.

Crude protein is a measure of food protein calculated as the nitrogen content multiplied by 6.25. Digestible crude protein (DCP) is calculated as 6.25 times the difference between nitrogen intake and nitrogen voided.

Protein requirements for the ruminant animals are stated, in terms of effective rumen degradable protein and Metabolisable protein. In ruminants, the evaluation of protein sources, account must be taken for the degradability of protein within the rumen, which can be done through degradability studies in fistulae animals (Waterlow *et al*.; 1978).

1.3.1-Proteinsdigestion:

Proteins ore complex organic compounds of high melee wall weight. They contain carbon, hydrogen,oxygen, nitrogen and sulphuric in addition some proteins contain phosphorus , iron, zinc and copper, proteins are of and in all living cells and each specific has it is own specific proteins and single organism has many different proteins (Mc Donald 1981).

Proteins are made up of amine acids which one produced when proteins one hydrolyzed by enzymes , acids or alkalis, Amino acids

one characterized by having a basic into genie group on amino group – NH3 and acidic carboxyl unit , (COOH).

Proteins one built up from amino acid by linkage between theα - carboxyl of amino acid and α – amino groups of anther acid, this linkage is known us the peptide linkage proteins are classified into these groups according to their shape,solubility and chemical composition.

1.4. Ruminal Degradability:

Ruminal digestion is dynamic process that characterized by the entry of food in the rumen fluid and output of fluids, microorganisms and undegraded food (Van Soest, 1994). The feed that ruminant intake can be divided into two fraction: undegradable fraction and potentially degradable fraction, which degraded by microbes to a certain speed or rate (Gonzalez *et al*., 1991). The food fraction that is hydrolyzed in the rumen to provide energy (fermentable carbohydrate) or a peptides mixture, amino acid and ammonia (NNP and protein) for growth and synthesis of microbial protein is referred to as degradable fraction. The portion of protein that reach intestine, is food protein that undegraded in the rumen. The ruminal degradation of food nutrient, is influenced by several factors, such as, the characteristics of the diet, related to amount of potentially degradable nutrients, the food intake level, the food retention time in the rumen and food exposure to microorganisms and rumen environment (pH, NH_3 concentration) which affect the activity and survival of microorganisms (Ørskov, 1988).

1.5. In vitro digestion techniques:

In vitro digestion techniques (Minke *et al*., 1979) in which gas produced from fermentation of a substrate was used to estimate digestibility and metabolisable energy content. Using gas production

technique a high relationship may be established between in vitro gas production and in vivo digestibility. The gas production technique and its variants are superior to digestibility and degradability technique because they account for contribution from soluble and insoluble feed fractions while providing information on the dynamics of forage fermentation. Additionally when nutrient content is not limiting, gas production measure microbial growth. The technique is important in evaluation of feedstuff posses secondary metabolites. Gas production is positively related to microbial protein synthesis (Krishnamoorthy *et al*., 1991), in vivo digestibility and intake (Blümmel and Ørskov, 1993) Although gas production is a nutritional wasteful product but provide a useful basis from which methane, metabolizable energy, organic matter digestibility, short chain fatty acids and molar VFAs may be predicted (Aiple *et al*., 1996). Gas produced when substrate is fermented to acetate and butyrate. The gas that released with generation of propionate is the only indirect gas produced from buffering, therefore relatively lower gas production is associated with propionate production. The gas produced in vitro is closely related to digestibility and therefore to the energetic value of feedstuff for ruminants. The technique involved fermentation of feedstuff with buffered rumen fluid, ruminally canullated animals are required which are expensive to maintain and in some circumstances unavailable. Uniform diet should be fed to exclude the impact of inoculate on the results and the requirement for several incubation vessels for each feed at each sampling time. Furthermore, degradability is generally estimated after single incubation, giving inadequate information of degradation pattern over time. The gas production technique as index of the nutritive value is hampered by the dependence of total gas production on sample size, sample form and the composition of the

end product of fermentation. A mark shift in the proportion of VFAs produced can occur when feed with different composition are fermented (Merchen, 1988). Gas is produce mainly when substrate is fermented to acetate and butyrate. The gas that released with generation of propionate is only the indirect gas produced from buffering therefore relatively lower gas production is associate with propionate production.

The nutritive value of six species of mesquite (Prosopis) including P. chillness was investigated (Lyon *et al*, 1988). Chemical analyses indicated that all of these are suitable sources of forage. However, in vitro digestibility's are negatively correlated with content of phenolic compounds. Species with high concentration of phenolics (P alba and P chillness) are significantly less digestible than other species with lower phenolic content. The enzymatic digestibility with cellulose plus protease was only 22-26% in leaves with high phenolic content, but is 39-47% in leaves with low phenolics. Joshi,*et al* (1985) has reported low in vitro dry matter digestibility's of leaves of P. cineraria caused by high tannin content. Data in ruminal and intestinal degradability of mesquite pods was indicated by (Batista *et al*, 2002).

1.6. **Nylon bag technique.**

This method provides a means of ranking feed according to the rate and extent of degradation of DM, OM, N or other nutritional parameters (Broderick and Cochran, 1999). The disappearance values are fitted into a model to determine the characteristics of the feeds. The nylon bag method (Orskov and McDonald, 1979) is widely used for the determination of the percentage of undegraded dietary protein in the rumen. Describing N degradation in the rumen the method become basis to estimate nitrogen requirement of ruminant in several feed system. The methods requirefistulae animals and cannot

produce information about the product of digestion. There are many sources of variation in the results from this technique (Lopes, 2005). Two studies were conducted to investigate the roasting effects in the composition, in vivo digestibility and in situ degradability of fiber fraction (NDF and ADF) of mesquite pods (Andrade-Montemayor, 2009). The results revealed that roasted mesquite pods can modify their nutrient content, as it can modify NDF gradation kinetics, increased the fractional degradation rate and effective degradation. The nutritive value of Prosopisfarcta fruit was evaluated using in situ nylon bag technique in fistulae male cattle (Ansari nik *et al*, 2013). The dry matter degradability (DMD), fast degradation (a), digestible particles over the time (b), potential degradability (a+ b) and effective degradability (ED) were measured at 57.05, 18.62, 38.63, 57.26 and 38.85 percent respectively at incubation time of 96 h. In this technique, the disappearance of the material sample is equal to the degradability. The results showed that P. farcta fruit (dwarf mesquite) has desirable nutritive value and can be used as a part of the forage diet for ruminants. The reduced dry matter degradability of P. farcta fruit in various stages of incubation in mentioned experiment were due to high ADF and NDF of the sample and presence of secondary plant materials including lignin, tannin and saponin. The effective degradability of dry matter of all plants was in range of 0.33- 0.62 (Ramirez, 2009). It seems that the increase in crude protein of the plant has appositive impact on dry matter disappearance in the rumen, because effective degradability increased by increasing the protein content of plant species. Riasi et *al*, (2008) attributed the reduced dry matter degradability of feedstuff to factors such as low ash and high NDF content. The in Sacco dry matter digestibility of prosopis seedpod meal was higher than that of hay, 74.5 and 56.8, respectively

(Kipchirchir *et al*. 2011). This result was attributed to the high crude protein present in P. juliflora compared to that present in hay. In situ ruminal and intestinal digestibility of dry matter, crude protein and neutral detergent fiber from as collected and dried (80ºC for 2h) mesquite pods was determined using two steers fitted with ruminal and duodenal cannulae (Batista *et al*, 2002). Drying at (80ºC for 2h) reduced ($p < 0.05$) the in situ soluble CP fraction and increased ($p < 0.05$) the slowly degradable CP fraction and its rate of degradation. However, ruminal degradability of both CP and DM of mesquite were not affected by drying. Post –ruminally digestibility of rumen undegraded CP and NDF were low and unaffected by drying. Total tract digestibility of DM, CP and NDF were similar for as collected and dried mesquite pods, averaging 68, 78 and 9% respectively. It was concluded that the rumen is the main site of digestion of mesquite pods and that drying had no adverse effect on their intestinal or total tract digestibilities.

1.7. Gudaim (*Growia tenax*):

Gudaim (*Growia tenax*) one of the valuable plant species in Sudan .It is largely spread in arid area such as sand and mountains, especially in savanna plantation area at the northern and middle of Sudan. FAO (1988), reported about Gudaim growth destinations and it has a discontinuous availability at arid area in India, Elgazira southern area, and the Eastern of Africa. Gudaim is a shrub its mature orange fruits are often 2-3-4 lobed (Andrews 1950). Gudaim plant requires 200mm of seasonal rainfall and it well resistant to soil salinity and its productivity about 1500 grain per Kg.

1.7.1. Botanical Description:

Growia tenax is also known as dune fixing species because of its dense fast growing root system. It is a deciduous fruit-producing shrub

or small tree that may attain a height of 1 to 3 m. Leaves are alternate and ovate to sub-orbicular with sharply toothed edges on stalks up to 1 cm long. The size of the leaves is up to 4.5 cm in width and5.5 cm in length. Flowers are small, white, pestiferous, solitary or rarely paired with long stamens and even longer pistils. It bears glucose, glabrous, fleshy,edible fruits arranged in 2-4 pairs. The fruit's color turns green to shiny orange or bright red when ripe containing one to two seeds in each fruit (Gebauer *etal.* 2007).

Fruits and other parts of *G. tenax* contribute significantly to the food andEnergy needs of rural populations in multiple ways (El-Siddig *et al*. 2003; Vogt1995). The fruit is eaten fresh but has commercial potential for consumption from beverages to ice cream, yogurt, porridge and confectionery. The juice made from its fruit is used as refreshing drink during the hot summer season. Because of its high iron contents, fruits of *G. tenax* are often used in special diets for pregnant women and anemic children. Its leaves and twigs are palatable fodder for livestock (Gebauer *et al*. 2007). Leaves and twigs of *G.tenax* are also an important component of folk medicine for the treatment of trachoma, tonsillitis, infections and are used as a poultice to treat swelling.

1.7.2. Ecology and Distribution:

G. tenax is highly drought resistant and occurs in the driest savannas at desert margins and regions of higher rainfall, where it grows in thickets on termite mounds in otherwise seasonally flooded country. In the Sahel it grows in rocky places on hills and slopes, in regions with 100-600 mm of rain per annum ***(***Orwa *et al*.2009).

Growia tenax belonging to the Tiliaceae family is distributed throughout thewestern and eastern Sahelian zones, northern and southern Africa, theArabian Peninsula and is also reported to grow

from Iran to India (Von Maydell1990). It is a typical tropical plantspecies which can tolerate seasonal drought and withstand temperatures ofmore than 50°C (Gebauer *et al*. 2007).

1.7.3. Food Value:

In the present study the nutritional evaluation of Gudaim fruits, seeds and pulps was carried out, the contents of moisture, ash, fat, fiber, protein and carbohydrate were 7.20%, 3.50%, 0.13%, 14.0%, 8.20%, 66.97%,7.30%,3.0%, 0.92%,14.85%, 7.5%,66.43% and 7.60%, 3.30%, 0.10%, 13.60%, 8.80% and 66.6% for the fruits, seeds and pulps, respectively. Gudaim fruits were found to contain about 25.5% D-fructose, 15Mg/100g ascorbic acid, 25 mg/100g iron and 40 mg/100g calcium. The effect of soaking periods on juices quality was investigated (Mohammed,A.Y.*et al*, 2011).

1.7.4. Main Uses:

FAO (1988) proved that Gudaim plant is used in traditional medication and treatment in Sudan; it used to tread flesh irritation and skin inflammation for both human beings and animals. Gudaim fruits may be eaten ripe or kept for later usage because it consists of great proportion of carbohydrates in liquidized form, and a great amount of iron and calcium some efforts were made to promote Gudaim fruits and its industrial utilization (Elamin, 1995). From Gudaim fruit, people prepare drink for pregnant women, the fruits are highly recommended and one sack of Gudaim equal in price to three sacks of wheat in Khartoum market (Gebauera *et al*; 2002). In *Kordofan*, a drink was prepared by soaking the fruits overnight , hand pressing, sieving, and

sweetening .A *Nesha* was also prepared from this drink , by addition of custard and flour , the *Nesha* is given to mothers to improve their health and lactation (Abdoelmuti *et al*; 1991; Gupta *et al* ;1968 ; Saxena 1979) . Gudaim fruits, both fresh and dry, are favored extensively consumed by the Sudanese population.

CHAPTER TWO

Materials and Methods

2.1. Study site:-

This study was conducted in at Dairy Farm, of Sudan University of Science and Technology (SUST) at *Hilat Kuku*, Khartoum North, and Sudan during May 2011 – November 2013.

2.2: Sample collection:-

The *Grewia tenax* ripened fruit (Appendix 4) were collected from local markets in *Kordofan* and *Darfur*. The leaves and green shoot were collected manually from the tree (Appendix 1). The seed mash was obtained by mechanical crushing of the ripened fruit (Appendix 4).

2.3.: Experiment one:

2.3.1: A proximate analyses of samples:-

Samples of experimental diets were ground to pass 1mm sieve and stored for further analysis. The determination of their proximate components, DM ash, CP, CF and EE was done according to AOAC (1990).The samples were dried at 105c^{o} overnight to get dry matter ,the ash was determined by igniting the sample in muffle furnace at 525c^{o} for 8hr. Nitrogen (N) content was determined by the Kjeldahl (AOAC 1990) . Crude protein (CP) was calculated as N×6.25, Crude fiber (CF)

and Ether extract (EE) was determined by the methods described by (AOAC 1990). All chemical tests were carried out in duplicate.

2.4: Experimenttwo:

2.4.1-In vitro gas studies:-

Rumen liquor was collected from three rumen fistulae*Kenana* castrated calves, before morning feeding in thermos flask and send immediately to laboratory, homogenized in laboratory blender and filtered through four layers of cheese cloth. All laboratory handling of the rumen fluid was carried out under continuous flushing with Co2 and at 39°c.. Five different solution were prepared as media (anaerobic artificial saliva) and were mixed with rumen liquor at ($1{:}2\,v/v$) and kept at continuous flushing of Co2. The buffer solution used has previously been described by Menke *et al*., (1979). Air dried *Grewia tenax* samples were ground to pass 1mm screen using laboratory mill and subsamples of 200 g were obtained. About 200 g of feed sample were measured and carefully transferred into pre-warmed syringe after removing of the plunger. The plunger was returned by pushing the substrate upwards the syringes. Calibrated plastic syringes were used into each 30 ml of prepared inoculums (10 ml rumen fluid and 20 ml artificial saliva) were dispersed into the substrate through silicon tube. The silicon tube in the syringe was then tightened by metal clip. All syringe including the blank were crimped and placed in the incubator at 34c, shaking them at regular time. Each substrate was incubated in triplicate in three different runs in order to generate 9 measurements per substrate sample. Each run included in triplicate, a blank (syringe incubated with inoculums alone). The gas volume was recorded after 0, 3, 6, 12, 24, 48, 72 and 96 hours of incubation. To prevent gas volume in the syringe from exceeding 60 ml, the pistons were moved back to 30 ml piston after 12 h of

fermentation. The initial volume of material in each syringe was also recorded before the commencement of incubation of the samples.

Total gas values were corrected with blank was fitted to the model of Qrskov and McDonald (1979).

$Y= a + b (1-exp (-ct)$.

Where:-

a =the gas production from the immediately soluble fraction (ml).

b= the gas production from the in soluble fraction.

c =the gas production ration constant for in soluble fraction (b).

t = incubation time (N).

y = gas production in time (t).

Macro mineral content sodium hypophosphate + Magnesium hypophosphate.

Micro mineral content Calcium chloride +Cobalt chloride +Ferric chloride + Sodium chloride.

The organic matter digestibility OMD of forage was calculated using equation of (Meneke *et al*, 1979)as follows:

OMD (%) =14.88+ 0.889GP + 0.45CP +XA.

Where:

GP =is 24 hr. net gas production (ml/200 mg).

CP = crude protein (%).

XA = Ash content (%).

ME (MJ/Kg DM) was calculated using equation of Meneke*et al*, (1979) as follows:

ME (MJ/Kg DM) =2.20+0.136GP + 0.057CP + 0.0029CP2.

Where:

GP = is 24 net gas production (ml /200mg).

CP = crude protein.

ME = Metabolisableenergy.

MJ =Mega Jole

Kg DM =Kilogram .dry matter.

2.5: Experimentthree:

2.5.1: Rumendegradation:-

Samples of each the Growia tenax tree such asleaves, green shoots,fruits, and seed mash were prepared to be use in rumen degradability experiment were prepared to be use in rumen degradability experiment According to polyester bag technique of Mehrez and Qrskov, (1978), the bags were prepared fromnylon material of 35-40 µ m pore size and weighing 2-3 g. The empty bags were individually weighed and their weights were recorded. 5 grams of each the *Growia tenax* tree parts, that is ,leaves , green shoots , fruits ,and seed cake were putted in a bag tied with a nylon ribbon , attached to a plastic tube of 45.5 cm length , 0.8 cm diameter, and introduced inside the rumen .The bags (2 bags/ animals / period / fraction) . Was incubation for, 3, 6, 12, 24, 48, 72, and 96 hours each. the DM and CP content of the different fraction ,before incubation ,and of the residues after incubation were determined as described by AOAC ,(1980) .

Degraded dry matter percentage was calculated by the formula: -

$$\frac{\text{Weight of sample incubated – weight of residue after incubation}}{\text{Weight of sample incubated}} \times 100$$

Residual sample after incubation for each period were separately mixed, pooled and made ready for analysis.

Degraded protein was calculated according to the formula: -

$$\frac{\text{CP of incubated sample – CP of residue after incubation}}{\text{CP of sample incubated}} \times 100$$

The degradation kinetics of the different fraction was described by curve linear regression of DM or CP loss from the bags with time by the equation of Qrskov and McDonald (1979).

$P = a + b (1- \exp^{-ct})$.

Where: -

P = potential degradability (percentage).

a = the soluble fraction (percentage).

b= the potentially degradable fraction (percentage).

c = the rate of degradation of b(percentage /hour).

t = time (hour).

The effective degradability of the sample was calculated using the equation of Qrskov and McDonald (1979), at three rumen fractional outflow rates, of 0.02, 0.05 and 0.08 h.

2.6: Experiment four:-

2.6.1: Rumen environment:-

2.6.1.1: Experimental animals:

Twenty four Nubian kidswere used to study rumen activity. Kids were individually fed the experimental diet to maintenance level and have free access to clean water and mineral block throughout the study.

2.6.1.2: Experimental feeding:-

The ingredients of the rations were purchase from Kuku local market. The rations were formulated according to the NRC, (1991) to satisfy the requirement for maintenance and growth of the growing kids. Four rations, based on sorghum, Dura, molasses and wheat bran, were formulated with different level of *Grewia tenax*cake (0, 5, 10 and 15%). A sample from each of the four experimental rations, were sent to the nutrition laboratory for proximate analysis according to (AOAC, 1990).

The Chemical composition of *Grewia tenax* is shown in table (2), the ingredients of the experimental ration is shown in table (1).The adaptation periods was two weeks allowing calves to adapt to the experimental diets.

2.6.1.3: Experimental Design:-

Four treatments and four experiment periods. Each experimental period lasted 10days. The adaptation period was 6 days allowing kids to adapt to the experimental diets followed by 10 days of sampling.

2.6.1.4: Ration ingredients:-

Table (1):

Experimental ration ingredients (fresh basis) and ME and CP composition on DM basis of experimental rations

*Dietary rations containing Growia tenax*fruit as %				Percent of Gudieum
15%	10%	5%	0%	
				Ration ingredient
30.0	30.0	30.0	30.0	Sorghum (feterita)
24.0	29.0	34.0	39.0	Wheat bran
15.0	15.0	15.0	15.0	Molasses
15.0	15.0	15.0	15.0	Groundnut cake
01.0	01.0	01.0	01.0	Salt (Nacl)
100.0	100.0	100.0	100.0	total

				Analysis
11.01	11.04	11.68	11.11	ME (MJ/kg)
16.05	16.47	16.8	17.3	CP

ME = Metabolisableenergy.

CP = crude protein

MJ = Mega joule.

Kg = Kilogram.

2.6.1.5: Rumen environment:-

The twenty four Nubian kids were penned with free access to water and feed, and they were fed on maintenance level on the four treatments individually.

The rumen liquor was taken by using 20cc syringe and put in clean aseptic tube from the 3 calves at different four periods (0 , 2 , 4 , 6 and 8 hours) for each treatment . To study the following parameters:-

2.6.1.5.1: Rumen pH reading:

Sixty ml of rumen fluid was withdrawn from the rumen using 20cc syringe and the electronic pH meter wascalibrated, the rumen liquor was held in container and the pH meter was immersed inserted into the container shaken well until the reading stabilized in the pH meter and then the rumen pH was recorded.

2.6.1.5.2: Ammonia (NH3) determination:

As described by Conway (1957) using Conway units. In the outer chamber of each unit 2 ml of saturated potassium carbonate (K2Co3) were put while in the inner chamber 2 ml of mixed indicator were pipette (40g. Boric acid + (0.02g.Methyl red + 0.06g.Bcg in 100 ml ethanol) complete to 2000 ml with D.W).

Covers were then replace leaving small opening on the upper side of each unit through which 0.5 ml of the sample was added by a 0.05 ml pipette .

The opening was then closed and the titled unit set upright while shaking gently 2.3 times so as to ensure the through mixing of the sample with the saturated potassium carbonate in the outer chamber.

The units were left for 6 hrs.Or 40 minutes at 60 c^{o}. Weights were put on the top of each cover and the units were then carefully removed and the content of the inner chamber calculated against 0.01 N sulphuric acid solutions using a Conway micro burette. Then NH 3 in rumen liquor =T × N × 14 ×100 = mg /100 ml volume of the sample .where:

T = Titration.

N = Normality of acid.

2.6.1.5.3: Volatile fatty acids determination:

The volatile fatty acid was determined as described by Kroman *et al* (1967) the strained rumen liquor was deproteinizd by adding 10 ml of 0.1 normal Hcl to 10 ml from the sample 50 ml volumetric flask was then shaken thoroughly and filled to the mark with distilled water after a lapse of 5 minutes . The precipitate portion was then filtrated. 5 ml from otherphosphoric acid was added.

The distillation was continued until 50 ml. Distillations were collected in 100 ml conical flask receiver. The distillation was then recovered and 3 drops of 0.04 % phenol red indicator was added. Then the nitrogen was bubbled through the distillate to remove any carbon dioxide and then titration was made against 0.01 sodium hydroxide. From a burette the amount of mill equivalents VFA s in 100 ml of sample were calculated in the following manner = V × N × 100.

Where:

V = volume of NaOH .

N = normality of NaOH .

2.7: Statistical analysis:-

Statistical Package for Social Sciences Program (SPSS) was used for the analysis this study .The recorded data were subjected to one way analysis of variance to compare the DM and CP degradation kinetics of the different banalities tree parts. Significant differences among the parts were assessed using least significant difference (LCD) test according to Gomez and Gomez, (1984).

CHPTER THREE

RESULTS

3.1. Proximate composition of Leaves, Green shoots, fleshes and seeds mash of *Growia tenax*:

The Proximate composition of Leaves, Green shoots, flesh and seeds of Growia tenax is shown in Table (2).

The highest DM content was observed in the leaves (97.49%) while the Fleshy fruits showed the lowest D M content (91.04%). However, a

high CP content (23.33%) was found in the leaves, followed by the green shoots, and the lowest CP was observed in the seeds. Moreover,the crude fiber (CF) content was highest in the green shoots while the seed cake showed the lowest value. Ether Extract (E.E) content varied significantly ($p<0.05$) among the different parts. The highest content was observed in the leaves and seed cake and the lowest content in the green shoots. The Ash content was highest in the fruits while the leaves showed the lowest value. The nitrogen free extract (NFE) content was significantly ($p<0.05$) highest in the seed cakes (46.08%) while the green shoots showed the lowest value (21.53%).

Table (2):

Proximate composition of Leaves, Green shoots, flesh and seeds of *Growia tenax* (means $\pm SD$)

NFE%	ASH%	CF%	CP%	EE%	DM%	Parts
32.74±0.01 ^{b} ± 0.01	3.71±0.01^{d} ± 0.01	31.06±0.01^{b} ± 0.01	23.33±0.01 ^{a}	6.63±0.01^{a} ± 0.01	97.490.02^{a}	Leaves

21.53±0.01 c	11.61±0.01^{c}	43.42±0.01^{a}	19.66±0.01 b	2.07±0.15^{c}	98.97±0.01^{a}	Green shoots
34.25±0.01 b	18.79±0.01^{a}	24.06±0.01^{c}	9.16±0.01^{c}	4.78±0.01^{a} b	91.04±0.01^{b}	Flesh Fruits
46.08±0.01 a	15.21±0.01^{b}	21.41±0.01^{c}	8.58±0.02^{c}	6.63±0.01^{a}	97.91±0.01^{a}	Seed
2.62	1.68	2.57	1.94	0.58	0.94	SEM
*	*	*	*	*	*	Sig
a, b, c, and d Means within same Colum with different superscripts are significantly different (p0.05)						

DM = dry matter.EE = ether extract.CP = crud protein.CF = crud fiber.NFE = nitrogen free extract.Sig = significant level.SEM = standard error of means.SD = standard deviation.

3.2: Gas production for the Leaves, Green shoots, flesh and seeds of Growia tenax :

Gas production for the Leaves, Green shoots, flesh and seeds of *Growia tenax*at different incubation periods is shown in the figure (1) There are considerable variations in gas production rate at all incubation

times. The highest gas production was observed in the fruits, while the leaves showed the lowest gas production during all the incubation times.

Table (3) shows the soluble fraction (a) varied significantly between the green shoots and seed cake, while no significant difference were observed between the leaves and fruits. The highest soluble fraction was obtained in the green shoots, while the lowest value in the seed cake.

Gas production from the slowly degradable fraction (b) varied significantly between the leaves and other parts. While no significant differences were observed between the Green shoots, fruits and seed mash

Organic matter digestibility (OMD) varied significantly between the fruits and the other parts of *Growia tenax*. While no significant difference was observed between the green shoots, seeds and the leaves. The lowest value was observed in the leaves.

The calculated metabolisable energy (ME) content in the seeds cake was significantly lowest than the other parts. The leaves, green shoots and fruits have similar metabolisable energy value.

Figure (1):-

Gas production (ml/200mgDM) of experimental samples at different Incubation times in rumen liqure:

Series 1 = Leaves of Growia tenax.

Series 2 = green shoots of Growia tenax.

Series 3=fruits of Growia tenax.

Series 4 = seeds mash of Growia tenax.

Table (3):

kinetics characteristics of gas production, OMD and ME of Leaves, Green shoots, flesh and seeds of Growia tenax incubated in rumen liqure:

Samples	a	b	c	a+b	OMD	ME(Mj/kg)
Leaves	1.73±0.66^{b}	53.05±15.37^{a}	0.00±0.00^{b}	54.78±14.91^{a}	43.57±0.39^{c}	5.95±0.06^{a}
Green shoots	4.15±1.06^{a}	25.45±5.55^{b}	0.02±0.01^{b}	29.61±6.60^{b}	45.71±0.59^{b}	5.91±0.16^{a}
Fruit	1.11±1.26^{b}	22.22±2.20^{b}	0.05±0.01^{a}	23.33+1.17^{b}	54.39±0.78^{a}	5.51±0.12^{a}
Seeds	0.03±0.67^{b}	24.04±1.06^{b}	0.03±0.01^{a}^{b}	24.06±2.25^{b}	47.58±0.78^{b}	4.89±0.17^{a}
Sig	*	*	*	*	*	*

a, b, c and dMeans in the same column values have different superscripts are significantly different ($p<0.05$).

* = Significant.

a = the gas production from the immediately soluble fraction (ml).

b = the gas production from the insoluble fraction (ml).

c = the gas production rate constant from the insoluble fraction (b).

a+b = Potential gas production.

ME =Metabolisable energy.

OMD = organic matter digestibility.

SEM = standard error of means

3.3. Rumen degradation:

3.3.1. Dry matter Degradability for of Leaves, Green shoots, flesh and seeds of *Growia tenax*:

Tables (4 and 5) show the Dry Matter Degradability and degradation characteristic for of Leaves, Green shoots, flesh and seeds of *Growia tenax*: The degradation rate varied significantly ($P<0.05$) among the different tree parts. The highest degradation rate for the flesh at all incubation time and the lowest degradation rate were observed in the green shoots, through all the incubation periods. The washing loss and at 3 hrs incubation period the flesh fruit and the cake showed similar degradation rate.The soluble fraction (a) and (c) rate were similar for of Leaves, Green shoots, flesh and seeds of Growia tenax.

Table (4):

Rumen DMdisapperance (%) in of Leaves, Green shoots, Fruits flesh and seeds of *Growia tenax*.

Samples of *Growia tenax*					Incubation time (h)
Sig	Seeds	Fruits	Green shoots	Leaves	
*	7.27±0.29[b]	16.70±5.89[a]	2.83±0.09[c]	3.56±0.54[c]	Zero
*	19.33±0.73	53.79±1.01[a]	6.93±0.00[d]	14.95±0.00[c]	3
*	[b]	53.78±0.52[a]	8.78±0.31[c]	11.13±0.34[c]	6
*	18.43±2.44	60.48±1.43[a]	25.21±3.08	27.04±1.07	12
*	[b]	59.97±0.05[a]	[b]	[b]	24
*	25.34±0.87	59.48±0.12[b]	29.63±0.07[c]	41.09±2.51	48
*	[b]	59.29±0.24[b]	48.89±0.36[c]	[b]	72
*	24.08±0.02	64.23±0.79[a]	52.49±0.06[c]	62.48±1.55	96
	[d]		48.36±0.56[c]	[a]	
	28.98±0.47			67.35±0.59	
	[d]			[a]	
	21.63±0.41			57.26±0.07	
	[d]			[b]	
	19.41±0.06				
	[d]				

a, b, c and d : means within the same row followed by different superscripts are significantly ($p< 0.05$) different.

*: significant at ($p<0.05$).

SEM = standard error of means.

Zero time = wash loss

Table (5):

Kinetics characteristic of DM disapperance (%)of Leaves, Green shoots, flesh and seeds of *Growia tenax*

Samples of *Growia tenax*					Sample Kinetics Charact..
Sig	Seeds	Fruits	Green shoots	Leaves	
*	7.65±0.05^{b}	16.90±5.90	1.10±0.30^{d}	4.20±0.50^{c}	a.
*	16.10±0.30	^{a}	51.60±0.60	74.95±0.05^{a}	b.
*	^{d}	43.15±5.45^{c}	^{b}	0.03±0.00^{c}	c.
*	0.32±0.03^{b}	0.56±0.02^{a}	0.04±0.03^{c}	79.25±0.55^{a}	Pd.
*	23.71±0.30	60.03±0.45	52.02±0.30^{c}	48.36±0.04^{b}	Ed(0.02
*	^{d}	^{b}	35.87±0.48^{c}	31.53±0.03^{b}	)
*	22.79±0.34	58.57±0.59	24.45±0.68^{c}	23.99±0.06^{b}	Ed(0.05
	^{d}	^{a}	18.68±0.68^{c}		)

	21.54±0.42^{c} 20.48±0.47 bc	56.52±0.77 a 54.67±0.95 a			Ed(0.08)

a, b, c, and d : means within the same row followed by the different superscripts are significantly different ($p<0.05$).

* = significant at ($p<0.05$).

a = washing loss.

b = degradation of water insoluble.

c = rate constant of b function.

Pd = potential degradability (%).

Ed= Effective degradability at different and flow rate (0.02, 0.05 and 0.08).

SEM = standard error of means.

3.3.2. Protein disappearance percent of Leaves, Green shoots, flesh and seeds of *Growia tenax*:-

The degradation rate varied significantly among the of leaves, green shoots, flesh and seeds of *Growia tenax*shown by table (6 and 7), the highest degradation rate was for the fruits for the first six hours with incubation period, while the other parts were lowest at the first incubation period.

The effective degradability at the different flow rate (0.02, 0.05, and 0.08) was higher in fruits and lower in green shoots and seed mash.

Table (6):

Rumen disappearance percent of crude protein (%) in of leaves, green shoots, flesh and seeds of *Growia tenax*.

Samples of *Growia tenax*					Incubation time (h)
Sig level	Seeds	Fruits	Green shoots	Leaves	

*	14.00±1.00 c	20.75±5.45 a	16.45±0.05 b	17.00±4.50^{b}	Zero
*				35.25±7.65^{b}	3
*	20.35±1.55 c	57.25±2.15 a	20.50±0.10 c	31.65±1.05^{b}	6
*				41.15±0.65^{b}	12
*	25.10±1.40 c	63.20±2.00 a	24.20±0.20 c	55.50±0.30^{b}	24
*				72.05±0.55^{a}	48
*	33.15±1.55 c	64.35±2.05 a	30.85±0.25 c	79.85±1.05^{a}	72
	43.00±1.30 c	64.35±2.05 a	41.45±0.15 c		
	50.75±0.65 d	64.40±2.00 b	55.20±0.50 c		
	52.85±0.25 c	64.40±2.00 b	61.25±0.15 b		

a, b, c and d : means within the same row followed by different superscripts are significantly ($p< 0.05$) different.

*: significant at ($p<0.05$).

SEM = standard error of means.

Zero time = wash loss.

Table (7):

Kinetics characteristic proteindisappearance (%)in the of leaves, green shoots, flesh and seeds of *Growia tenax*

Samples of *Growia tenax*					Sample
Sig level	Seeds	Fruits	Green shoots	Leaves	Kinetics Charact..
*	14.00±1.00^{b}	20.75±5.45^{a}	16.45±0.05^{b}	20.20±1.70^{a}	a.
*	39.65±0.95^{d}	43.60±3.40^{c}	55.65±3.45^{b}	66.65±0.78^{a}	b.
*	0.06±0.00^{b}	0.61±0.17^{a}	0.03±0.02^{b}	0.03±0.03^{b}	c.
*	53.65±0.05^{d}	64.40±2.00^{c}	72.10±3.40^{b}	86.85 ±2.25^{a}	Pd.
*	43.05±0.85^{c}	63.00±2.10^{a}	47.25±0.65^{b}	60.90±0.90^{a}	Ed(0.02)
	34.75±1.25^{c}	61.05±2.15^{a}	24.45±0.68^{d}	45.95±0.75^{b}	Ed(0.05)
	30.10±1.30^{c}	59.30±2.30^{a}	18.68±0.68^{d}	39.10±0.80^{b}	Ed(0.08)

a, b, c, and d : means within the same row followed by the different superscripts are significantly different ($p<0.05$).

* = significant at ($p<0.05$).

a = washing loss.

b = degradation of water insoluble.

c = rate constant of b function.

Pd = potential degradability (%).

Ed= Effective degradability at different and flow rate (0.02, 0.05 and 0.08).

SEM = standard error of means.

3 .4: Study of rumen environment:

3 .4 .1: Rumen PH:

Rumen pH values of the animals fed the experimental diets are shown in table (8). No significant differences were observed between the animals fed on diet contains 0%and 5%, 10% and 15% *Growia tenax* seed mashes.

Table (8):

Rumen pH(Mean±SD) in the different incubation time (0 – 8hrs) of the kids fed different level of *Growia tenaxfruit* mash.

Duration of feeding in hours					G. tenax fruit level(%) in ration
8hrs	6hrs	4hrs	2hrs	0hr	
5.60±0.24^{a}	5.10±0.14^{b}	5.50±0.57^{a}	5.40±0.42^{a}	5.35±0.35^{a}	0
5.55±0.35^{a}	5.35±0.07^{ab}	5.40±0.14^{a}	5.05±0.21^{a}	6.00±0.14^{a}	5
5.25±0.21^{a}	5.35±0.07^{ab}	5.55±0.07^{a}	5.05±0.21^{a}	5.60±0.28^{a}	10
5.50±0.14^{a}	5.45±0.07^{b}	5.40±0.28^{a}	5.05±0.35^{a}	5.90±0.28^{a}	15
NS	NS	NS	NS	NS	Sig

a, b, c, and d : means within the same row followed by the different superscripts are significantly different ($p<0.05$).

Zero = diet content groundnut cake (control diet).

NS = not significant.

SD = standard deviation.

3.4. 2: Rumen ammonia (NH_3):

Therumen ammonia (NH_3) concentration of the animals fed the experimental diets at different times post feeding(Table 9). Ammonia concentration increased with the time past feedings. No significant variations were observed between the treatments, but the trend is that the control diet showed the lowest ammonia concentration, while animals fed on diet contain 5%and 10% *Growia tenax* seed mashshowed the highest ammonia NH_3 concentration.

Table (9):

Rumen ammonia (NH3) (mg/100) concentration (Mean± SD) in the different incubation time (0-8 hrs) of the kidsfed different level of *Growia tenax* fruits mash.

Duration of feeding in hours					G. tenax fruit level(%) in ration
8hrs	6hrs	4hrs	2hrs	0hr	
1.27±0.07	1.00±0.00	0.82±0.14	0.68±0.14	0.49±0.14	0
1.28±0.07	1.00±0.00	0.81±0.07	0.68±0.00	0.49±0.07	5
1.27±0.07	1.00±0.00	0.78±0.07	0.67±0.07	0.49±0.14	10
1.28±0.14	1.00±0.00	0.78±0.21	0.67±0.00	0.49±0.07	15
NS	NS	NS	NS	NS	Sig

a, b, c, and d : means within the same row followed by the different superscripts are significantly different ($p<0.05$).

Zero = diet content groundnut cake (control diet).

NS = not significant.

SD = standard deviation.

3 .4 .3: Volatile fatty acids (VFAs) production:

No significant difference were detected regarding volatile fatty acids (VFAs) concentration of the rumen liquor of animals fed on different levels of *Growia tenax* mash(Table 10).

Table (10):

Volatile fatty acids concentration (VFA) (mg/100 ml) (Mean± SD) in the different incubation time (0-8 hrs) of the kids fed different level of *Growia tenax* fruits mash.

Duration of feeding in hours					G. tenax fruit level (%) in ration
8hrs	6hrs	4hrs	2hrs	0hr	
1.65±0.07	0.89±0.07	0.71±0.14	0.39±0.14	0.21±0.00	0
1.65±0.07	0.88±0.07	0.72±0.07	0.39±0.14	0.20±0.00	5
1.65±0.07	0.88±0.07	0.70±0.14	0.41±0.07	0.21±0.00	10
1.75±0.07	0. 88±0.07	0.69±0.07	0.40±0.00	0.20±0.07	15
NS	NS	NS	NS	NS	Sig

a, b, c, and d : means within the same row followed by the different superscripts are significantly different ($p<0.05$).

Zero = diet content groundnut cake (control diet).

NS = not significant.

SD = standard deviation.

CHAPTER FOUR

DISCUSSION

The chemical composition of the *Growia tenax* was found to be varying among the different *Grewia tenax* parts. The variation between *Growia tenax* may be attributed to different environment and soil of *Growia tenax* used in this study was not decorticated and this might have lowered its CP and raised its fiber content. The CP content of *Growia tenax* cake was consistent with those reported by Shams Eldein,*et al*; (2011)Morkaz : *etal* (2011). For*Balanite aegyptica* and Elis(1980) for the same cakes in the Sudan. Generally, degradability increased with increasing incubation time and was higher for CP compared to DM. Similar observations were reported by many workers (Elamin and Babiker 2000) and Shamseldein*, etal*; (2011) for *Balanite aegyptica*. The DM content Grewia tenax leaves is higher than that reported in the leaves of banana (173.9 – 194.3g/kg), Fekadu and Ledin (1997), Acacia mellifera (285.7g/kg) and Zizyphus *abyssinica* (753g/kg) (Elamin and Babiker ,2000).

The fruits and seed cake showed a low protein content which is not enough to satisfy rumenant need for growth and production, while leaves and green shoots are characterized by their high protein content adequate to support both growth and production . Crude

protein (CP) of leaves of *Grewia tenax* was found 23.33% in this study, which is higher than the CP content in *Corchorus olithorus* , reported byShams eldein,*etal* ; (2011), Morkaz : *etal* (2011).for *balanite aegyptica and* (Ikhimioya *et al*, 2005),and lower EE than the present study are reported in Sudan browse trees leaves *Acacia mellifra* ,Elamin and Babiker (2000),*Acacia senegal* and *Acacia nilotica* (Mahala and Asaad, 2007).and *balanite aegyptica* (Shams eldein,*etal* ; 2011) .

Grewia tenax leaves have avery low Ash content espeially when compared with that of *Ficus sp* (110g/kg), *Acacia mallefra* (50g/kg), by Elamin and Babiker(2000) and *Acacia sanegal*(107g/kg), Mahala and Asaad,(2007).Shams eldein,*et al*; (2011), Morkaz : *etal* (2011).for *balanite aegyptica*

The Crude Fiber (CF) content of *Grewia tenax* seed cake are higher than that of sesame seed cake and groundnut cake (Afaf and Sulieman (1999) and in line with the report by Afaf and Sulieman (1999) for cotton seed cake (220g/kg) and sunflower cake (95g/kg). Shams eldein,*etal*; (2011), Morkaz ,*etal* (2011).for *Balanite aegyptica*

Ether extract (EE) content of *Growia tenax* seed cake and leaves is higher with the EE content of sesame seed cake (14g/kg), Omer *etal* (2002), in line with that repoted by Afaf and sulieman (1999) in groundnut cake (71.6g/kg), cotton seed cake (78g/kg), and lower than the sunflower cake (139g/kg). Shams eldein,*etal*; (2011), Morkaz,*etal* (2011).for *Balanite aegyptica*

The variation in chemical composition of peresent work and that of other reserearchers may be attributed to species difference, the plant part, the age of plant (Norton 1994); climatic condition, the state off hydration(fresh wilted or dry), (Palmar and Schlink , 1992) and drying procedure used (Dzowela *et al* , 1995).

Dry matter degradability of *Growia tenax* leaves at different time of incubation time increased from 6hrs incubation time and reached the maximum at 72hrs incubation time . those DM degradability values are comparable to that reported by Shams eldein,*etal*; (2011), Morkaz,*etal* (2011).for *balanite aegyptica* (Fekadu and Ledin , 1997) and (Tolera, andSundstol 1999). The effective degradability of leaves in this study at the different flow rate (0.02, 0.05,and 0.08) was lower than results obtained by Shams eldein,*etal*; (2011), Morkaz,*etal* (2011).for *balanite aegyptica* ,Fekadu and ledin (1997) and (Ikhimioyal *et al*, 2005) in banana leaves and in leaves of Ficus exasperate respectively .

The rate of degradability and effective degradability of DM in this study was higher in fruits and lower in seed cake than that result of DM degradability in leaves and green shoots . the effective degradability of Grewia tenax seed cake dry matter. In this study at the different flow rate k=0.02, k=0.05,and k=0.08 were 22.79%, 21.54%,and 20.48% these result are lower than the values in sesame seed cake (85.2%, 74.8%, and 29.43%) (Aplang, 2008) and groundnut cake (43.69%, 34.93% and 29.77%) (Nidaa *etal*, 2008).

The crude protein (CP) degradation charactaristic varid among the different plant fraction , this is in accords with the reports of Mahala and Assad (2007), that different part of browse vary in degradation kinetics, the leaves and fruits showed the highest soluble fraction (a) and the green shoots and seed cake showed the lowest effective degradability,the (c) value of the fruits protein was higher than the other parts. All different part of Grewia tenax showed lower (a) value to that in mesquitc pod (47.6) reported by Batista;*et al* (2002), and lower CP soluble fraction (a) than the master cake (MC) , groundnut cake (GNC) and cotton seed cake , reported by Sahoo *et al* (1993).

The variation in the kinetics of CP degradation of this study and that of the other may be attributed to species variation, method of oil extraction and stage of plant maturity.

The variation in the degradability kinetics of the different Grewia tenax parts of this work with those finding of other workers may be attributed to stage of plant growth and difference in chemical composition .

Although the nylon bag technique was widely used to determine the degradation charactaristics in the rumen (Qrekov and McDonald 1979), there are many factors which may cause variation between the different reserch laboratories.

In this study Gas production value of *Grewia tenax* leaves was 2.5, 3.5, 4, 6, 7.5 and 13.5 ml/200mg at 3, 6, 12, 24, 48, and 72 hours incubation time respectively, this result was showed lower gas production value than that reported by Conbolate *et al* (2005) in the quereus cerris leaves (20, 24, 35, 42, 46, and 48 ml/200mg at 3, 6, 12, 24, 48, and 72 hrs incubation time . gas production from quickly soluble fraction (a) degradable fraction (b) of*Grewia tenax* leaves in this study were 1.73% and 53.05%which was similer to the Morkaz *: etal* (2011).for *balanite aegypticta,*Randa (2013) for *Tabaldi* andQuerus cerris leaves (2.40% and 50.32%) (Conbolat *et al*, 2005). Gas production value of *Grewia tenax* seed cake was 3, 4, 6, 14, 17.5 and 21.5ml/200mg at 3, 6, 12, 24, 48 and 72 hours incubation time respectivly which was lower than the gas production value of *Bambara ground* seed (46, 55, 70, 91, 100 and 103ml/200mg at 3, 6, 12, 24, 48, and 72hrs incubation time respectivly,(Abdallah, 2007). Gas production from quickly soluble fraction (a), degradable fraction (b) and the rate of the gas production of *Grewia tenax* seed mash (c)

were (0.03%, 24.04%, and 0.03%) which was lower than the 5.76%, 60.31%, and 6.23% for *Bambara ground* seeds (Abdalla, 2007).

Organic matter digestibility of seed cake in this study was 47.58%which was lower than the organic matter digestibility of Bambara ground seeds (62.72%) (Abdalla, 2007), it was similar with groundnut cake 48.47%, (Menke, *et al* 1988). Metabolisable energy (ME) of the Grewia tenax seed cake was 4.89mj/kg DM is lower than the ME in Bambara ground seed 10.78mj/kgDM (Abdalla, 2007), groundnut cake 11.07mj/kgDM (Menke, *et al* 1988).

Although the nylon bag technique was widely used to determinethe degradation charactaristics in the rumen (Qrekov and McDonald 1979), there are many factors which many causes variation between the different reserch laboratories.

Addition adifferent levels of *Grewia tenax* fruits in to the ruminant ration at levels 5, 10, and 15 % to fixed similar percentage of groundnut cake was not found to affected rumen PH up to eight hours postfeeding, PHranged from 5.05 to 6.00 in this study, this result is on line with finding of many researchers in the present studys .

The mean PH of the rumen liquor was almost the same on the test dtets (6.00, 5.90 and 5.93), but was higher ($p<0.05$) for the control diet . rumen content PH was found to decrease after feeding , reaching it lowest value about 6hrs after feeding , this accord with results reported Morkaz, *etal* (2011),Fenner *et al* (1967) and Prakash *et al* (1996) who determined that rumen content PH after feeding changes in a characteristic way .

There was no difference ($p<0.05$) in PH of the rumen isoninogenous diets based on different natural protein source (Sehgal and Makkar ; 1994) Narsa and Reddy (1986).

The optimal PH of rumen protiolytic enzyme renges from 5.5 to 7.0 according to Kopecny and Wallance (1982); however, protein degradation was reduced as PH decreased . (Cordozo *et al* 2000,2oo2).

Rumen ammonia (NH_3) concentration in this study was not significantly affected by addition of different levels of Grewia tenax fruits in to ruminant ration at levels 5%, 10%, and 15% fixed equal percentage of groundnut cake in the present studies (0.67, 0.78, 1.00 and 1.28).

Rumen content of ammonia was found to be decreased after feeding reached in lowest value about 8hrs after feeding, Lana *et al* (1998) reported that decrease in ruminal from 6.5 to 5.7; reduced rumenal ammonia concentration, the rumen NH_3 often veries widely throughout the day depending on the feeding regime and feed quality, (Ciszuk 1973), , Tiwari 2001) reported Morkaz, *etal* (2011)

A decrease in the normal PH induced by the formation of VFA, from starch caused a decrease in the rate of NH_3liberation and an increase in protein biosynthesis (Reis and Reid, 1959). The NH_3 absorbed from the digestive tract is very efficiently converted by the liver in to urea and should there give a response in the concentration of the blood urea (Cizukm, 1973).

Ruminal Volatile fatty acid concentration (VFA) in this study was not significantly affected by addition of different levels of Grewia tenax fruits in to ruminant ration at levels 5%, 10% and 15%, fixed equal percentage of groundnut cake concentration , the VFA were highest at 8hrs post feeding and then declined slowly up to 36hrs post feeding .

Conversely, Briggs *et al* (1957) who demonstrated VFA in rumen of sheep before feeding (4.4±0.9) ; (4.5±0.7) and 3hrs after (7.1±1.3);

(7.7±1.6)and (7.6±1.3)mEq/dl. The effect of PH on VFA absorption influence absorption of NH_3.

Bloom Field,*et al* (1963), reported that when rumen PH was 7.55, 6.21, or 7.58 NH_3 absorption was 26.5 and 11 male/liter/hour and VFA was 4.18 and 4male/liter/hour respectively.

Hotgon (1961) found at PH on 6.5 that the transport of NH_3across the rumen epithelium increased with the concentration gradient and that NH_3 absorption was increased by absorption of VFA. Absorption of NH_3 was rapid at PH 6.5 but Negligible at PH 4.5.

Conclusions and recommendations

The chemical composition of *Growia tenax* parts was showed in this study has high Crud protein and dry matter content. But it has lower of gas production from quickly soluble (a), degradable fraction (b), gas production rate (c), OMD and ME content.Which can be used to reduce the shortage in livestock feeding during the dry season. Furthermore, effective utilization of *Growia tenax* fruit processing

waste could help in recycling of the by-product and contribute in clearing the environment and generating income. Additional on-farm studies are required to measure the intake and effects of feeding *Growia tenax* processing waste supplement on milk yield and growth performance.

Incorporation of *Growia tenax* cake into ruminants rations at level of 10% fixed equal percentages of groundnut cake had no significant effect on rumen environment (pH, NH3, VFA,),

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Appendices

Appendix (1)

***Grewia tenax* tree**

Appendix (2)

***Grewia tenax* green shoots**

Appendix (3)

Grewia tenax fruits

Appendix (4)

***Grewia tenax* fruits**

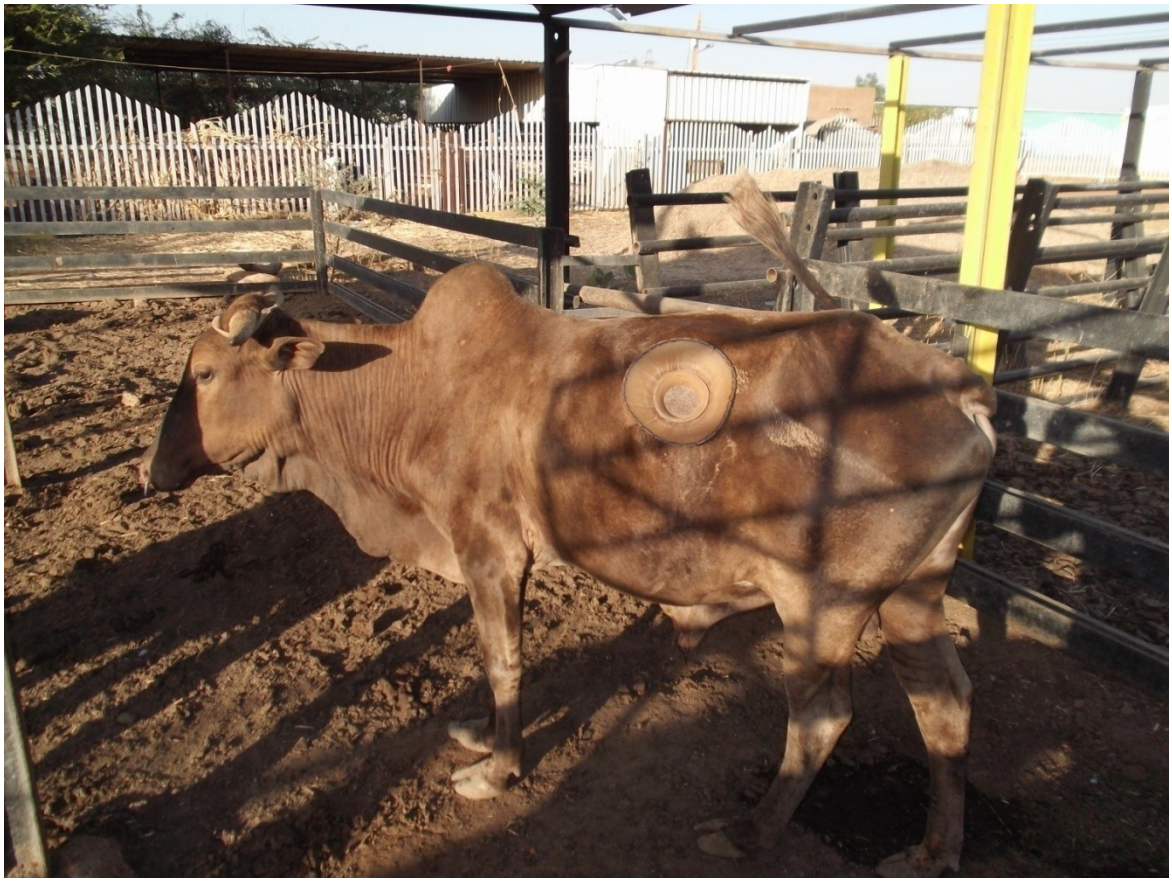
Appendix (5)

***Grewia tenax* dry leaves**

Appendix (6)

Flowering branch of *Grewia tenax*with scale in cm

Appendix (7)

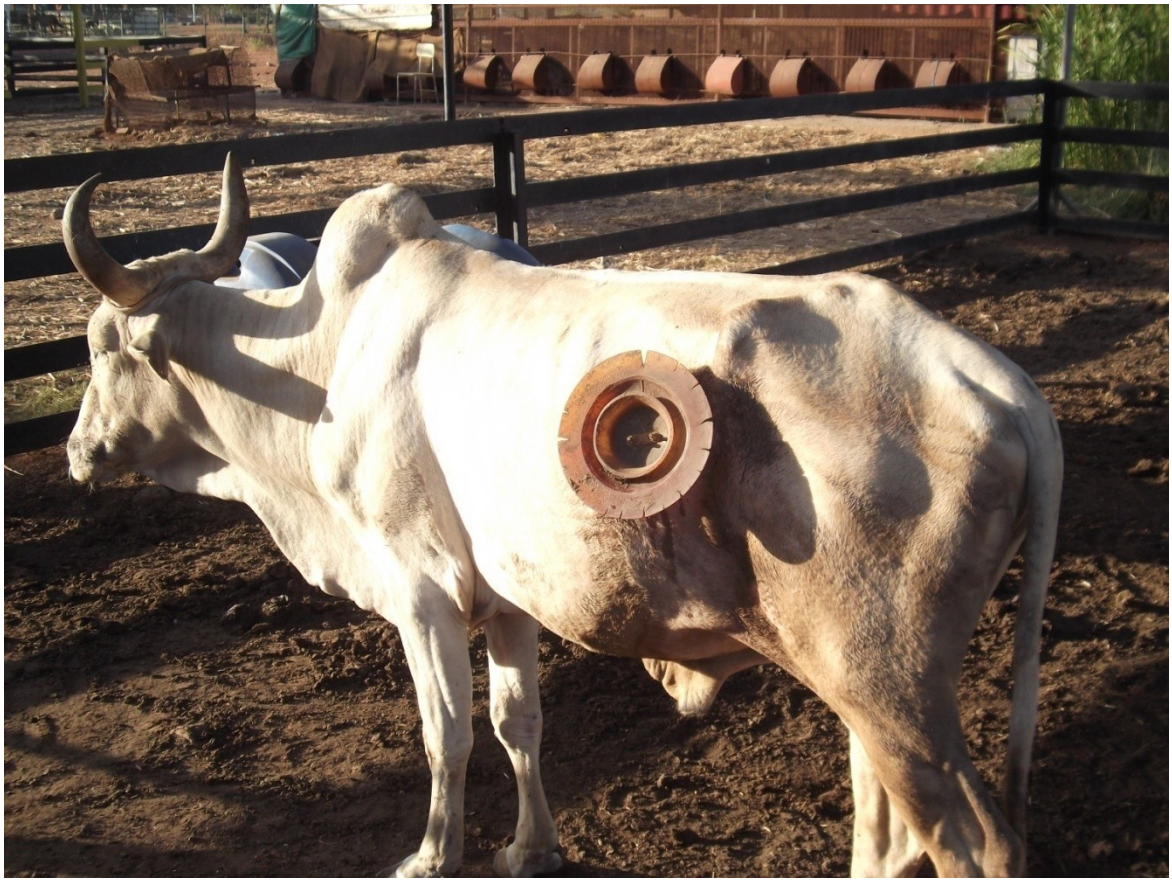


Fistulae Steer No (1)

Appendix (8)

Fistulae Steer No (2)

Appendix(9)



Fistulae Steer No (3)