Effect of *Molasses* Plus*Urea*, *Trona* and *Rabaa* (*Trianthema Pentandra* L.) Ashon Proximate Analysis and *in vitro* Digestibility of some Crop Residues

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DEDICATION

I would like to make a number of important dedications with this work.

First, to my mother and my father who have allowed me to become the person I am, and they were my eyes when I couldn’t see.

To my best dearest, my aunt (Hawa Adam Ali) for constant encouragement, limitless giving and great sacrifice helped me accomplish my study. For every dream she made come true. She has been my inspiration. Extra thanks are extended also to My brother Mohamed Moktar Ibrahim and Nima Moktar Ibrahim and Mama Dowlay Ibrahim for their moral support and encouragement.

To my beloved brothers and sisters

To my teachers … friends especially Moktar Adam Ibrahim (Mooda Moode) and Abdi Hamid Salad Hassan (Together), colleagues I dedicate this work because they always have been behind my success.

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Mohamed
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I am totally sure this work would have never become truth, without his guidance.

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Effect of Molasses Plus Urea, Trona and Rabaa (*Trianthema Pentandra* L.) Ash on Proximate Analysis and *in vitro* Digestibility of some Crop Residues

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Abstract

Forage physical and chemical characteristics make it nutritionally valuable for animal productivity. To benefit from these by-products, it is necessary to apply economical and effective treatments to improve their nutritive value. This study aimed at upgrading the chemical composition and *in vitro* digestibility of groundnut haulms, sorghum straw, sesame residues, and pigeon pea by treating them with molasses plus urea, trona and rabaa ash alkali. Pigeon pea residues, sorghum straw, and groundnut haulms crop residues were analyzed to determine their chemical composition and *in vitro* digestibility. Results revealed that molasses and urea treatment significantly increased crude protein content in pigeon pea residues and sorghum straw (15.84% and 9.92%, respectively). Crude fiber content decreased significantly in groundnut haulms and sorghum straw treated with rabaa ash alkali (20.78% and 25.90%, respectively), pigeon pea residues treated with molasses plus urea and rabaa ash alkali (22.24% and 22.53%, respectively) and sesame residues treated with molasses plus urea and rabaa alkali. Rabaa ash alkali increased ash content in groundnut haulms, pigeon pea residues, sorghum straw and sesame residues (23.19%, 19.45%, 20.51% and 15.75%, respectively), while molasses plus urea treatment decreased ash content in sorghum straw (9.80%). Energy value of pigeon pea residues treated with molasses plus urea increased and pigeon pea treated with rabaa and trona was decreased. All treatments decreased energy content in sorghum straw and groundnut haulms significantly, but increased energy content in sesame residues significantly. A significant increase in *in vitro* dry matter digestibility (IVDMD) was observed in groundnut haulms treated with molasses plus urea and rabaa ash alkali (67.33% and 83.33%, respectively). All treatments increased IVDMD in pigeon pea residues, sorghum straw and sesame residues. It is recommended to use rabaa ash or trona to upgrade the nutritive value of crop residues.
تأثير المولاس واليوريا، العطرن ورماد الربيعة على التحليل التقريبي والهضمية العملية

ملخص بعض المحايل

محمد سمو عبدى على

ملخص الدراسة

نوعية الأعلاف الهامة تجعلها ذات قيمة غذائية لنتائج الحيوانات. للاستفادة من هذه المخلفات فإنها من الضروري تطبيق معالجات اقتصادية وفعالة لتحسين قيمتها الغذائية. هدفت هذه الدراسة إلى تحسين التركيب الكيميائي والهضمية العملية لمخلفات القول السوداني وقصوب النزرة الرفيعة ومخلفات السمسم واللوبية العدسية وذلك بمعالجتها باليوريا زائد المولاس، العطرن وقلوي أملاء الربيعة. أجرى التحليل الكيميائي وتقدير الهضمية العملية للعينات. أوضحت النتائج أن معاملات المولاس واليوريا ادت إلى زيادة معنوية في محتوى البروتينات الخام ومخلفات اللوبيا العدسية وقصوب النزرة الرفيعة (14.84% و 9.92%, على التوالي). انخفض محتوى الألياف الخام بصورة معنوية في مخلفات القول السوداني وقصوب النزرة الرفيعة التي عوملتي بالقلوي إملاح الربيعة (20.18% و 25.91% على التوالي) واللوبية العدسية التي عوملتي بالمولاس زائد اليوريا والرمية (22.53% على التوالي) والسمسم المعالمة بالمولاس زائد اليوريا إملاح الربيعة، ومعاملات الربيعة زادت بصورة معنوية. المعاملة بالقلوي إملاح الربيعة ادت إلى زيادة معنوية في التحليل الكيميائي في مخلفات القول السوداني واللوبية العدسية وقصوب النزرة الرفيعة ومخلفات السمسم (23.19% و 19.45% < 20.5 و 15.75% على التوالي)، بينما أدت معاملة المولاس زائد اليوريا إلى نقص محتوى الألياف في قصب النزرة الرفيعة (9.8%). ارتفع محتوى الطاقة في اللوبيا العدسية المعالمة بالمولاس زائد اليوريا بينما انخفضت الطاقة فاللوبية العدسية المعالمة بالقلوي إملاح الربيعة والعطرن. جميع المعاملات أدت لخفض محتوى الطاقة في قصب النزرة الرفيعة ومخلفات القول السوداني بصورة معنوية ولكن أدت الى زيادة معنوية في محتوى الطاقة في مخلفات السمسم. لوحظت زيادة معنوية في الهضمية العملية لمخلفات القول السوداني المعالمة بالمولاس زائد اليوريا وقلوي إملاح الربيعة (67.33% و 83.33%, على التوالي). جميع المعاملات أدت الى زيادة الهضمية العملية لمخلفات اللوبية العدسية وقصوب النزرة الرفيعة ومخلفات السمسم. أوصت الدراسة باستخدام الربيعة والعطرن لتحسين قيمة العناية لمخلفات المحايل الزراعية.
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CHAPTER ONE
INTRODUCTION

Animal production is important in the Sudan due to the high animal population, economic and social impacts (MAW, 2005). Animal production sector in the Sudan is characterized by traditional system which is based predominantly on grazing natural pastures (MAW, 2002).

Livestock production has been the backbone of the Somali economy for many centuries. It is the most important source of food and income for the predominantly rural population, as well as the country’s biggest export commodity (ICPALD, 2015).

Crop residues are produced in large quantities in many countries. In mixed crop–livestock farming system such systems are limited, native grasses are seasonally available and ruminants graze on marginal land/ or on road sides to obtain feeds during the rainy season. During the dry season when pastures are scarce, crop residues and farm wastes represent an important source of feeds for ruminants in Tanzania(Aredo, 2006). In GhanaHowever, the increase in cropping land has led to increase in the availability of crop residues for animal usage in the dry season. (Adjorloloet al., 2002). Although crop residues are high in energy, the utilization of the energy component of such materials by ruminants is highly dependent on the ammonia concentration in the rumen (Preston and Leng, 2009).

In Somalia Cereal crops are grown during the two wet seasons of Spring "Gu" (April-June) and Autumn "Deyr" (Oct.-Dec.) and harvested and traded during the dry seasons. As cereal availability is highest during dry seasons, cereal prices tend to be lower resulting in reduced hunger (FSNAU, 2009). Baidoa is one of the most important markets in southern Somalia, conducting significant trade in local and imported cereals, livestock and non-food items. Baidoa is the main sorghum trading market in Somalia, as Bay region has the highest sorghum straw production in Somalia (FSNAU, 2009).

The coarse feeds mainly agricultural by- products are large in size and contain low levels of net energy and high content of crude fiber. They are characterized by low protein content, low nutritional value and low digestibility and hence low intake.
Farmers do not benefit from them, but they burn it or leave it on farms, therefore, these facts initiate the necessity of treating these by-products by using economical and effective ingredients to improve their nutritive value.

1.1 Main objective
This study aimed to upgrade the nutritive value of some agricultural by-products by using Molasses plus urea, Trona "Atron" and Rabaa (Trianthema Pentandra) ash and to explore the most effective treatment.

1.2 Specific objectives are to:
1) Determine the chemical composition of groundnut haulms, sorghum straw, sesame hulls and Pigeon pea "lubia adasi" residues.
2) Evaluate the effect of Molasses plus urea, Trona "Atron" and Rabaaash (Trianthema Pentandra) alkali treatments on their chemical composition and in vitro digestibility
3) Study the feasibility of these treatments and highlight the most economical and efficient one.
CHAPTER TWO
LITERATURE REVIEW

2.1 Background
Livestock sector globally is highly dynamic. In developing countries, it is evolving in response to rapidly increasing demand for livestock products. In developed countries, demand for livestock products is stagnating, while many production systems are increasing their efficiency and environmental sustainability. Historical changes in the demand for livestock products have been largely driven by human population growth, income growth and urbanization and the production response in different livestock systems has been associated with science and technology as well as increases in animal numbers. In the future, production will increasingly be affected by competition for natural resources, particularly land and water, competition between food and feed and by the need to operate in a carbon-constrained economy. Developments in breeding, nutrition and animal health will continue to contribute to increasing potential production and further efficiency and genetic gains. Livestock production is likely to be increasingly affected by carbon constraints and environmental and animal welfare legislation. Demand for livestock products in the future could be heavily moderated by socio-economic factors such as human health concerns and changing socio-cultural values. There is considerable uncertainty as to how these factors will play out in different regions of the world in the coming decades (Thornton, 2010).

2.2 Livestock in Africa
Livestock plays important socio-economic roles both at household and national levels in Africa (Kosgeyet et al., 2003). Animal feeds are usually produced from agricultural products or by-products such as grains, cereals and their residues. However, it is necessary to add micro-ingredients to improve levels of essential amino acids, vitamins and minerals (Edelstein, 1982). Utilization of crop residues as feed has been the subject of intense research and developments worldwide since the mid-1970s. It began
with technological developments for upgrading straw in Europe and North America and then moved rapidly to the developing tropics where something akin to "Residue Revolution" has taken place in the 1980s. Despite this there appears little evidence that the large research effort has resulted in greater utilization of crop residues in developing countries (Owen and Jayasuriya, 1989).

2.3 Livestock in Somalia

Livestock industry is of great importance to Somali economy as it is one of the main sources of food, employment and foreign currency. In general, livestock production has been the backbone of the Somali economy for many centuries (ICPALD, 2015). Somalia, livestock production accounts for 60-65% of the Gross Domestic Product (GDP). Based on FAO (2011), estimates of livestock numbers and past growth rates, in Somali about 1.69 million heads of camels, 4 million heads of cattle, 8.4 million heads of goats and 8.75 million of sheep in 2011. The Shebelle, Bay and Bakool regions account for about 75% of all livestock. The use of production based approach to estimate the contribution of livestock to economy of Somalia yielded an estimate of 8.157 Billion USD in 2013. This estimate is above the International Monetary Fund (IMF) estimate of Agriculture GDP of 5.7 Billion USD where livestock contributes 2.28 Billion USD, equivalent of 40% of Agriculture contribution to GDP. The total estimated value of goods and services provided by livestock i.e. direct use value of livestock to economy was 8.157 Billion USDs, including 93.6% derived from conventional goods common in agricultural GDP and 6.4% from financial services provided by livestock (ICPALD, 2015). Milk is Somalia’s most economically important livestock product, with a value of 6.58 Billion USDsin 2013, equivalent to 81% of livestock contribution to economy. About 6.4% of the direct benefits derived by livestock owners from their animals are attributable to the financial services provided by livestock and are always omitted in the quantification of economic functions of livestock at both household and national levels. Camel are Somalia’s most important source of red meat, supplying 52% of meat needed and contributing 266.1 Million USDs, equivalent to 3.3% of the livestock Contribution to the economy (ICPALD, 2015). Somali’s major livestock exports are sheep and goats, accounting for 91% of all animal exports. In 2010, a total of 2.352 million heads of sheep
and goats were exported through the Berbera port (including Ethiopian sources). Of this total, 1.612 million heads, equivalent to 69% of the sheep and goats population, were exported between September and November for the Hajj festivities (ICPALD, 2015). The livestock production system is exclusively nomadic pastoralism and rangeland is communal or free grazing throughout the country. With the exception of some salts, animals are not given any sort of supplementary feeding. The livestock number is subject to many factors that include vicious cycles of major droughts that sometimes reduces the national herd to more than half. Epidemic Disease also have an impact on herd size and productivity of animals. Information on the estimated animal population and its distribution in south and central regions of the country is the major source of household wealth by source (ICPALD, 2015).

2.3.1 Livestock Production in Somalia

Camels and goats generally herded together by the pastoralists produced over 75% of total milk production. The role of the camel in the pastoral subsistence economy is not primarily for the supply of meat, but for the provision of milk. Goat milk production is more than that of cattle. Goats and sheep (no milk data recorded even through milked in some regions) are kept largely as a means of generating cash in comes. Like meat production, milk production in the southern, primarily agricultural zone was the lowest (18.6%) of all the zones. In general, camels are primarily raised for milk production by the Somali pastoral societies (Ahmed, 1991).

2.4 Feed Resources

2.4.1 Feed Resources and Utilization

Livestock feed resources in Somalia are mainly natural pastures and browses, crop residues, improved pasture and agro-industrial by products (Alemayehu, 2003). Nevertheless the production of improved pasture and forages is insignificant and a considerable efforts have been made in the last two decades to test the adaptability of pasture and forage crops to different agro ecological zones and several useful forages have been selected for different zones and the contribution of agro-industrial by-products is also minimal and restricted to some urban and peri-urban farms (Mengistu, 2005).
Grazing is on permanent grazing areas, fallow land and cropland after harvest (Alemayehu, 2003). The availability and quality of forage are not favorable year round. As a result, the gains made in the wet season are totally or partially lost in the dry season (Alemayehu, 2003).

Inadequate feed during the dry season is a major cause for declining in the productivity of ruminants. Hay making is commonly used means of feed preservation technique in Ethiopia, which is expected to mitigate problems of livestock feeding during the dry period and therefore such experience is a good indicator that there are certain practices of efficient feed utilization (Alemayehu, 2003). However, the quality of the preserved hay is poor due to its improper handling and preservation techniques. Some improvements on handling and preservation are important to make more quality hay. High quality hay can be defined as forage that is dried without deterioration and retaining most of its nutrients (Greenham et al., 2007).

2.4.2 Feed Resources and Seasons

Animals will depend more on crop residues during the dry season. Besides natural pasture, the contribution of stubble and fallow land grazing is significant beginning from the end of cropping season just after harvesting. During this period, livestock can have free access to graze crop fields. Standing hay that is closed during the wet season is also open at the end of the cropping season (Oni, 2001). The availability of crop residues is also closely related to the farming system, the type of crops produced and intensity of cultivation (Oni, 2001). Livestock, therefore, depend on the straw from cereal crops, especially during dry periods when there are limited feed supplies from grazing lands (Bogale, 2004).

2.5 Forage Characteristics

The plant consists of cell contents and the cell wall. The cell contents are the most readily and highly digested components of the plant and include organic acids, proteins, lipids, and carbohydrates (Barnes et al., 2003). The fibrous portion, or cell wall of the plant, contains the structural carbohydrates including cellulose, hemicelluloses, and lignin. The fibrous portion is represented by neutral detergent fiber (NDF) content, which is the
forage’s total fiber content, and acid detergent fiber (ADF), which is an estimate of the cellulose and lignin in forage (Barnes et al., 2003). The ruminant animals are unique in its ability to use this fibrous material to meet their energy needs (Burns, 2008). Forage quality is the physical and chemical characteristics of forage that make it nutritionally valuable for animal productivity (Barnes et al., 2003). Productivity is the effect of intake, digestion, and utilization efficiency of absorbed nutrients (Smith et al., 1972). Forage quality is highly variable and plant species, plant maturity, climate, elevation, management, soil moisture, soil fertility, and weather all affect the forage quality factors which include digestibility, crude Protein content and palatability (Barnes et al., 2003; Bohnert et al., 2011). Quality of a forage is greatest while the plant is young and in the vegetative growth stage. As the plant develops and matures, ADF and NDF content increase in concentration to provide additional structure while digestibility and crude protein values decline (Barnes et al., 2003). With maturity, the leaf: stem ratio declines (Burns, 2008), which contributes to mature forages being of lower quality (Fontenotand Blaser, 1965).

Cellulose and hemicelluloses digestion rate limits intake (Burns, 2008), of forages of greater fibrous. Thus, mature forages of lower digestibility cause lower intakes compared to grasses in the vegetative state (Oba and Allen, 1999). In general Sorghum straw is considered the main type of crop residues which grow either by rain fed or irrigated. With the very high quantity availability of this plant, sorghum straw can be a good alternative of feed instead of concentrates for animal feed during the long dry season (Lang, 2001). Roughages and many agro-industrial by-products have certain inherent disadvantages in their nutritive value, they have low digestibility and are deficient in nitrogen and in many mineral elements, they may contain high amounts of indigestible lignin and silica and low digestibility associated with low nitrogen content of the feed limits intake. Animals on these diets alone are often in negative energy and nitrogen balance, it is therefore essential that these deficiencies are corrected when roughages and agricultural by products are used as feeds (Jayasuriya, 2001). In general the main Characteristics of roughages are:

1. Includes pasture, hay and silage, the crop may be the same but preservation can influence the nutrient value to the animal.
2. Higher in fiber (more than 18%) than concentrates and usually lower in energy and variable in protein content.

3. Needed for bulk in ruminant rations.

4. Higher in calcium and trace mineral elements than most concentrates.

5. Legumes are higher in protein and B-vitamins than some concentrates.

6. Better sources of fat soluble vitamins than most concentrates.

7. Palatable to ruminants.

8. Limited in beef finishing rations and in some high energy lactating rations

9. Required in lactating dairy cattle rations to help maintain normal fat level in milk

10. More variable in nutritive content and acceptability than concentrates due to variation in stage of maturity and harvesting and storing procedures.

2.5.1 Factors affect the Utilization of roughages

Leng (1990) stated that the efficiency of utilization of low-quality roughages by ruminants for productive purposes is altered by numerous factors which are associated with the feed or animals, these include:-

1) The availability of feed nutrients to microorganism to support an efficient microbial growth.

2) High rate and extent of digestion in the rumen which in turn optimizes intake.

3) The ratio of soluble cell wall carbohydrates in the forage. This ratio markedly affects the population density of micro-organisms in the rumen.

4) The physiological state and previous dietary and health history of the animal which determine the quantities demand for balance of nutrients required.

5) The thermal environment which determines the requirements for substrate oxidation for maintenance of body temperature and alters the balance of nutrients available for anabolic functions. The chemical and physical characteristics of forage which determine the proportion of feed digested by microbial fermentation.

6) The dietary nutrients that escape rumen fermentation and are available for digestion and absorption in the intestine.
2.5.2 Supplementation of roughages

Roughages are generally of low nutritive value. One way of improving the quality of the animal’s diet is to supplement them with other feed resources which are richer in energy and protein and/or superior in digestibility or intake. This supplement include: Urea which used for feedstuffs containing nitrogen in a form other than protein or polypeptides. Urea dominates the market, but other forms of NPN (non-protein nitrogen) include ammonium salts (such as biuret) and ammoniated by-products. Urea is very degradable in the rumen (Hadjigeorgiou et al., 2003).

2.6 Crop by-products

Farm crops are grown for one or more main product: for example grain, pulse, sugar and oil. Straw and crop leftovers after harvesting and after processing are by-products of the main crop. Whether left in the field or harvested, these by-products have value and farmers have traditionally used them in many ways. Sometimes the by-product is even more important than the crop itself, especially for mixed crop-livestock farmers in semi-arid regions. ‘Crop by-products’ is a general term used to refer to both fibrous by-products (e.g. straws, mature grass and tree leaves) and crop residues that are richer in nutrients, such as broken grain, bran, oil and seed cakes (Vink and sheire, 2015).

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 and agricultural by-products could be used as an alternative animal feed. However the energy content of these byproducts 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 hemicellulososes) and the digestible enzyme (McDonaldet et al., 2002).

Tambal (2006) indicates that sesame residues were not initially eaten by the bulls and were rejected. More likely, because of its bitter taste. Among feed resources, cereal crop residues, bush straws, legume crop residues (groundnut haulms, cowpea lentils), and agro-industrial by-products are feeds used by smallholder farmers in West and East Africa to fill the feed gaps during the period of acute feeds deficiency (Ayantundeet et al., 2007; Koralagamaet et al., 2008; Abdouet al., 2011).
2.6.1 Nutritive value of crop residues

Nutritive value of crop residues varies according to species, varieties, environmental conditions, stage of maturity and methods of harvesting storage and feeding among other factors (Hostville, 2013). The nutritive value can be determined by their chemical composition or by combination of chemical constituents and gas released on incubation of feeds in an *in vitro* or *in vivo* procedures (Aregheore, 2000). The major constraint to using crop-residues as a feed resource is their high fiber content, which tends to limit intake and digestibility in animals (Smith, 2002).

Crop-residues are also associated with low protein and mineral contents, which cannot support adequate microbial growth or meet the host animal’s nutrients requirements for increased performance. Animal with such feedstuffs can be poor due to low voluntary intake and digestibility, which result from low protein concentrations and high levels of indigestible or slowly degradable fiber (AbdelHameed, *et al.*, 2013 and Simbaya, 2002). Crop residues are generally of poor nutritive value (Zerbini and Thomas, 2003). Other studies have proved that when poor quality crop residues such as sorghum Stover is not treated chemically or otherwise prior to supplementation, response of animals' performance is poorly expressed (Ndemanisho *et al.*, 2007).

2.6.2 Straws

Fibrous crop by-products – also referred to as crop left over's or crop residues come in different forms and have different names. Grain crops yield either slender straws (barley, rice, rye and wheat) or coarse straws (maize, millet and sorghums). But sugar cane tops may also serve as animal feed, as can banana leaves and bean ‘straws’, all of which are also fibrous crop by-products. In some countries maize, sorghum or soybean stalks are referred to as ‘Stover’. The stalks or stems left over from peas, beans or potatoes are known as ‘haulms’. Straw can be used as animal feed if the following points are taken into account:

1) Ruminants can eat straw.
2) Straw is low-quality feed, to be avoided if possible in favor of grasses, tree leaves and/or concentrated feeds made from grain waste, bran, oilseed cakes (if affordable).
Straw can be useful, in specific conditions and/or for specific livestock, for example when there is a shortage of better feed, for low-production animals, or as special feed for highly productive animals (Vink and Shiere, 2015). According to Abrar et al. (2004), the digestibility and crude protein value of groundnut straw is superior to that of non-leguminous hays and is comparable to that of leguminous hay of cowpea. Groundnut hay has higher nutritive value and has been found to improve utilization of stovers (Ndlovu and Howell, 1989).

2.7 Concentrates
Definition of concentrate feeds. Concentrates are feeds that contain a high density of nutrients, usually low in crude fibre content (less than 18% of dry matter (DM)) and high in total digestible nutrients.

2.7.1 Groundnut cake
Groundnut cake is a residue remaining after oil is removed from oil seed. It is rich in protein and valuable foods for animals, contains approximate mainly 45-50% crude protein and quite deficient in lysine. It has been important on protein supplement peanut in Europe and Africa. It has several advantages in feeding, as it increases the organic matter intake, organic matter digestibility, intake of crude fiber and digestibility of nitrogen free extract (Bhatia and Pantayak, 1988).

2.7.2 Cereal grain
Maize, wheat and sorghum grains and are the main source of Concentrate rations. Sorghum grains are one of the essential cereal grains, which were fed for the livestock (McDonald, 2002).

2.7.3 Wheat bran
Wheat bran is by-product produced from wheat milling. It represents about 13% of the wheat grain. The wheat bran of 93.5% DM contains 16.83% CP, 7.91 MJ/Kg DM metabolizable energy (ME) (Cheeke, 2005). It is quite palatable and is well known for
its ability to prevent constipation and water holding capacities. It has an amino acid balance, good source of water soluble vitamin except niacin (Cheeke, 2005).

2.7.4 Sesame cake

Contains 40-50% oil, 20-25% protein, 20-25% carbohydrate and 5-6% ash (Salunkhe et al., 1992). Because of its composition, it has become one of the main sources of edible oil. It is also a good source of protein. Some studies have already been done showing how to prepare sesame protein from sesame meal using various methods of alkaline or salt extraction and isoelectric precipitation (pI) (Denchet et al., 1981; Rivaset al., 1981; Inyang and Iduh, 1996; Gandhi and Srivastava, 2007; Onsaard et al., 2010; Cano-Medina et al., 2011) or aqueous enzymatic sesame protein extraction (Latif and Anwar, 2011). Sesame meal has a composition of 7.92% moisture, 27.83% fat, 30.56% protein, 6.22% fiber, 5.27% ash and 28.14% carbohydrate. Extraction of oil has led to increased protein content of defatted sesame meal (41.15-49.58%) (DePadua, 1983; Onsaard et al., 2010). This meal can be used as a protein source ingredient in the food industry.

2.7.5 Pigeon pea

Pigeon pea (Cajanus cajan) is a locally available, affordable and underutilized grain legume of the tropics and sub-tropics. Pigeon pea varieties has protein content in the range of 23 - 26% (Nene et al., 1990; El-Tabey, 1992). The protein content is comparable with those in other legumes like cow pea and groundnut which have been used in complementing maize. It is rich in mineral quality and fiber content. Pigeon pea grows well in Nigeria but the hard-to-cook phenomenon and the presence of anti-nutrients have limited its utilization (Nene et al., 1990; El-Tabey, 1992).
2.7.6 Basal energy feeds

2.7.6.1 Sorghum

Sorghums in general can be classified into two types: Forage types (mainly for forage or animal feed) and grain types (mainly for human consumption).

The forage sorghums are further grouped into four types:

(a) hybrid forage sorghum.
(b) Sudan grass.
(c) Sorghum x Sudan hybrids (also known as Sudan hybrids), and
(d) Sweet sorghum.

The latter is used mainly for molasses but more recently for biofuel production as well (Newman et al., 2010). Sorghum as a crop originated as far back as 3,000 years ago. The selection in those early times was for grain more than for forage. However, selection for forage varieties has been occurring for the last hundred years. Forage sorghums are similar to grain types but are taller and have higher forage quality (Newman et al., 2010). Forage sorghums are used primarily as silage for livestock. They are sometimes grown and harvested with soybeans to improve the protein content of the silage. Sudan grasses and sorghum-Sudan grass hybrids are grazed by livestock or fed as green chop or hay (Doggett, 1988). However, irrespective of the cultivar (Fontani et al., 2001) determined a 134 to 150 g kg\(^{-1}\) concentration of crude proteins in sorghum. However, green mass and dry matter yields and nutritional value of forage sorghum depend on the development stage at which cutting was carried out (Pospisile et al., 2009).

2.7.6.2 Importance of sorghum

All Sudan/Sorghum forages are good choices for dairy and beef cattle feed. The choice of forage will be heavily dependent on seasonal needs and intended harvest management silage, pasture, green-chop, etc. Sudan grass and Sudan grass hybrids should probably be the first choice over sorghum-Sudan hybrids for sheep pasteurize (lang, 2001). Sorghum is a drought resistant crop with a very efficient, well-branched root system containing considerable amounts of silica that prevent the plant from collapsing in dry soils.
Sorghum can also reduce its transpiration during periods of water shortage by rolling its leaves and by stomata closure; in these conditions, it can remain dormant while other crops perish, and when the rains resume it recovers rapidly. Sorghum needs at least 300-380 mm water during the growing period. It is one of a few crops that can withstand short periods of water logging; therefore it is popular on heavy clay soils (Mustafa, 2006). Forage sorghums should be harvested at the mid dough stage of development and stored as silage contains 28% Dry matter, 52 to 65% dry matter digestibility, 8 to 12% Crude protein, 2.8% Ether Extract, Fiber content 34 to 40% (Alhag, 2001).

2.7.6.3 Molasses as energy source

Using of molasses in livestock and poultry feeds dates back into the nineteenth century and has been the subject of several excellent review articles (Scott, 1953; VanNiekerk, 1980 and Waldroup, 1981).

In general, 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 (McDonaldset al., 2002).

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 (bagasse) which is burned or used as low quality roughage for animal feed. The juice is boiled to extract sugar, the 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). In addition to that it is used in fermentation of rumen and beer (Smagakki, Tag Eldin, 2009). Molasses contain 75% DM, 12.7MJ/kg ME and CP 4.1g/kgDM (MAFF, 1975). This by-product is produced from manufactory of sugar, molasses are use in rations of cattle being a good source of energy, which can be substitute for grain but molasses is a poor source of protein, and needs to be supplemented with urea as a non-protein source of nitrogen for sustaining higher levels of production. The constraint in utilizing high levels of molasses is its toxicity, experience indicates that molasses may be toxic when fed in large quantities, so the recommended
inclusion rate that does not usually exceed 15% for cattle and 8% for sheep (McDonald et al. 2010).

2.7.7 Basal protein feeds

Agro-Industrial by-products are important source of protein supply for livestock and their use as a part of feed for livestock reduces the cost of production, improve the quality of feed, ensure regular feed supply even during slump period and ultimately increase the profit margin of livestock farmers (Abrar et al., 2004).

2.8 Additives

2.8.1 Urea

It is a non-protein nitrogen compound (NPN) which contains 46% nitrogen. It is the most common source of NPN used in ruminant feeding because of its lower cost and easiness of use compared to other sources (Santonand Whitter, 2008). Attaand EL Khidir, (2007) reported that molasses and urea are good alternative to sorghum grains and oil seed cakes, as energy and protein sources respectively, as being of low production cost and non-competitive with human and poultry. Urea is the most common of non-protein nitrogen (NPN). NPN must be fed with an energy source that is readily available to the rumen (John and Hall, 2009). It should not make up more than 1% of the total diet or 3% of the concentrate. Urea is often used in lick tanks liquid protein supplements to increase the CP value of the product. If urea treated straw is fed straight away, then straw digestibility is increased by about 5 units, whereas if it is ensiled for ten days, the increase in digestibility is twice (Singh and Chandramoni, 2010). By treating rice straw with urea or calcium hydroxide or by supplementing rice straw with protein, intake, degradability and milk yield can be enhanced, compared to feeding untreated rice straw alone (Elseed, 2005; Wanapat et al., 2009).

Treatment of straw with anhydrous and aqueous ammonia, urea or other ammonia-releasing compounds has been widely investigated to improve degradability (Abou-EL-Eninet et al., 1999; Selim et al., 2002; Elseed et al., 2003). Urea treatment improves the nutritive value of cereal straws by increasing crude protein content, palatability and digestibility. This technology is considered a proven technology to improve the nutritive
value of roughages. Opinions on its utility and application in the field, however, are varied among animal nutritionists, farmers and extension workers. Not withstanding the enormous research and technology-transfer efforts, this technology, in many countries including India, has remained a ‘hardly used technology’ at farmer level. An increasing number of workers believe that this technology, in its present format, does not have a future, (FAO, 2011). To improve the nutritive value of fibrous crop residues, urea treatment of straw was developed as an alternative to caustic/corrosive sodium hydroxide treatment, for use mostly in tropical countries. A large number of on-station and on-farm trials conducted in several countries under different conditions have shown that feeding urea-treated straw vis-à-vis untreated straw increases feed intake by 10 to 15 percent, growth rate of calves by 100 to 150 g/day and milk yield by 0.5 to 1.5 liters/day. Urea-treated straw is more palatable and digestible. The dry matter (DM) digestibility increases by approximately 10 percentage units, the total digestible nutrient (TDN) value increases by 10 to 15 percentage units and the CP content increases almost three times. The feedback received from the farmers involved in on-farm trials has been largely positive. In spite of the technology appearing to be quite sound, it was almost entirely rejected by livestock farmers in the tropical region, barring some exceptional situations (Walliet al., 1988 and Schiere and Nell, 1993). The ammonization of straw with urea has proved to be a simple, economical and more viable process for its farm level application (Saadullah et al., 1992, Makkar and Singh, 1987; Schiere and Nell, 1993 and Taiwoetal., 1995).

2.8.1.1 Precautions when using urea

Urea and certain other non-protein nitrogen substances can be fed safely to ruminants to replace part of the dietary vegetable protein. Favorable results can be expected when cereal grains are also included in the ration, but performance may be less satisfactory on forage alone. Urea may cause toxicity and even death in ruminants if it is fed inadequately mixed with other feeds or in too large a dose. The toxic signs can easily be recognized. High urea supplements should be withdrawn at least one half day before and after the administration of carbon tetrachloride, if the latter is being given as treatment against liver flukes and Haemonchus contortus infestations, because a concomitant absorption of ammonia increases the risks of toxic effects resulting from the drug.
Animals should never be permitted access to urea not mixed with other feeds (Loosli, 1968).

2.8.1.2 Treated straws

Any treatment that can increase the digestibility intake and crude protein of these feeds should result in improved animal performance (Folkes and Preston, 1978). Straw, like all mature plant tissue, is relatively indigestible by the microorganisms that inhabit the digestive tract of ruminants; this is because straw cell walls are heavily lignified or silicified.

These methods may be classified as chemical, physical, and biological. The chemical methods all involve the use of alkali solutions and are the most widely tested methods at present. Among the physical treatments, only pressure cooking alters the cell wall; simple grinding does not increase digestibility. A promising method of biological treatment is the growing of lignin-digesting fungi on straw. In the Indian village context, the feeding of alkali-treated straw will usually require the simultaneous feeding of additional nitrogen, as it will be the limiting nutrient in straw for both ruminant digestion and growth and production of the animal. As feed nitrogen is extremely scarce, the use of a urea supplement is an essential adjunct to straw treatment (Wilson, 1987). (A) 1% urea, 5% molasses or 5% molasses + 0.5, 1, 1.5 or 2% urea (B) 5% molasses, 0.5% urea and 0. 10, 20, 30 or 40% fresh cattle manure (Alhag, 2001). Farmers may decide to treat straws rather than feeding it ‘as it is’ to their animals. The decision will depend on the price of feeds and the production levels of the animals. Straws, whether green, yellow or dry, can be treated in several ways to increase sweetness, greenness, intake and/or palatability. The main treatments are:

• Physical treatments – chopping, soaking, grinding, pellet-making, steaming.
• Chemical treatments – using caustic soda or ammonia compounds (especially urea).
• More complex treatments – using fungi, enzymes or other agents.

Some of these treatments are well known and practical; others are ineffective, impractical or too costly. Chopping and/or soaking methods have been used for many centuries. Chemical treatments have been used for the last fifty years. Some chemicals,
while they are likely to be impractical in field conditions, are mentioned here simply for the sake of completeness (Vink and Schiere 2015).

2.8.1.3 Treatment Time

Treatment time may vary from one to four weeks. In the intensive work undertaken in Bangladesh and Sri Lanka in the early 1980s, seven to ten days were normally used with no benefits in animal performance obtained by treating for a longer duration (Perdok et al., 1984). However, temperature and treatment time are inversely correlated and more time is required in the winter or in a colder climate. In well-compacted straw the temperature raises, the extent being subject to quantity of straw and temperature, but already by the second day it may be five Celsius degrees and on day seven as much as ten degrees above ambient temperature (Saadullah et al., 1981). The specific, practical method of treatment is best worked out locally within the guidelines outlined above. Simple tests of successful treatment are: a browning in the color of the straw, a strong smell of ammonia and absence of rotten and molded straw.

2.8.2 Trona” Atron”

In Sudan Trona “Atron” deposits were found in many locations at “Atron” oasis and other small basins around “Atron” area at 18° 10’. 12” N and 26° 36’. 54” E. it’s found at another location north of Nukheil Oasis at 19° 15’. 46” N and 26° 10’. 27” E. The deposit in all basins was found in many forms as hard beds at the middle and bottoms of the old lakes or disseminated through the sand in the upper part. Also it is found as efflorescence crust on the surface of the soil, and can be found in brine water at some basins as in Daleba and “Atron” basin. After drilling, sampling and chemical analysis, the evaluation of the deposit at different basins was made by Geological Research Authority of Sudan. According to its estimates the total reserve is about 38.5 million. The average quantity of sodium carbonate in the crude stocks is about 60%; the net expected sodium carbonate is 23.1 million (Idris and Abakar, 1996). There is a reasonable market for sodium carbonate, and Sudan import considerable quantities for use in various industries such as textile, paper, soap and detergent, carbonated beverages, leather industry and water purification.
2.8.2.1 Uses of Trona “Atron”

Trona “Atron” is used in a variety of applications used in animal feed, with the largest market being a rumen buffer for dairy cows. A proper feed program that includes Trona actually increases milk production. Addition of sodium Sesquicarbonate, a rumen buffer, to a diet with a potentially high ruminal degradability increased dry matter intake and production of milk and milk components by cows in late lactation, from rumen buffer (digestive aid) for cattle to reduction of acid gas in stack emissions for industries such as electric power generation (ESAPA, 2003). These beneficial effects might have been the result of stability of ruminal pH and fermentation and increased passage of soluble nutrients in ruminal fluid to the small intestine, which improved digestion of organic matter and increased feed intake optimal rumen function, is essential in order to maximize performance as well as allowing maximum utilization of low cost forages, (Frint, 1971). Rumen function can be impaired by feeding high cereal rations, acidic silages; short chop forage and starchy forages which in turn can lead to impaired digestion, reduced intakes and poor performance (e.g. reduced butterfat). Feeding Sodium Bicarbonate assists the saliva in its buffering capacity, thus reducing the risk of large drops in rumen pH which can lead to acidosis. Trona is responsible for the increase of pH solution above 10 because of the presence of high concentration of the carbonate, (Frint, 1971).
CHAPTER THREE
MATERIALS AND METHODS

3.1 Study area

This study was conducted at the faculty of Agricultural Sciences university of Gezira, Gezira state.

The chemical analysis was done at the laboratory of Animal Production, Faculty of Animal production, Khartoum University.

3.2 Samples collection and preparation

Four types of by–products, mainly groundnut (Arachis hypogaea L.) haulms, Pigeon pea (Cajanus cajan) "lubia adasi" residues and Sorghum (Sorghum bicolor) straw were collected from Al-karaibah market, and Sesame residues were collected from El Gadarif state. The straws were cut into small pieces (15-20 cm in length). Twenty kilograms of each sample were used, each divided into four treatments with 5 kilograms.

The samples were treated as follows:

Treatment (1): Five kg of each sample were used as a control.

Treatment (2): Five kg of each sample were treated with adding Molasses plus urea (15% molasses + 2% urea).

Treatment (3): Five kg of each sample were treated with Trona "Atron" solution as a source of sodium Sesquicarbonate, by dissolving 6.25kg Trona "Atron" into 50 ml water. 10 litter of prepared solution was used to spray 5kg (2L/kg) of each sample.

Treatment (4): Five kg of each sample were treated with Rabaa (Trianthema pentandra) ash Alkali, 8% in concentration. 2litters of prepared solution was used to spray 1kg of sample.
3.3 Chemical analysis

3.3.1 Proximate analysis

Dry matter (DM), crude Protein (CP), crude fiber (CF), ether extract (EE), ash, were determined according to AOAC (1990). All samples were analyzed in 3 replicates when the replicate value agreed within a reasonable limit an average was taken. NFE was calculated by difference method. Finally the metabolized energy (ME) was calculated according to MAFF (1975).

3.3.2 Analytical Procedures

3.3.2.1 Dry matter (DM)

To determine the DM content, 5 g of each sample were weighed into silica dish, dried in an oven for 48 h at 85°C, cooled in a desiccator and weighed.

Calculation:

\[
\text{Dry matter (DM) \%} = \frac{\text{wt. of the sample after drying}}{\text{Fresh sample wt.}} \times 100
\]

3.3.2.2 Ash

Three grams of each sample were weighed into a silica dish, ignited in a muffle furnace at a dull red heat (about 600°C) and kept for 5 h until the ash is grey or nearly white, then cooled in a desiccator and weighed.

Calculation:

\[
\text{Ash \%} = \frac{\text{wt. of the sample after ignition}}{\text{wt. of the sample on DM basis}} \times 100
\]

3.3.2.3 Ether extractive (EE)

A soxhlet extractor was fitted up with a reflux condenser and a round bottom flask (which has been previously dried in an oven and weighed). Accurately 3 g of each sample
were weighed, transferred to a fat free extraction thimble, plugged tightly with cotton wool and placed in the extractor. The extractor was filled with low boiling petrolcum ether (B. P.40-60°C) until it siphoned once. More ether was added until the extractor was half full, then the condenser was replaced, heated to boil gently and was left to siphon over for 6 h. Finally when ether was just short of siphoning over, the flask was detached and the contents of the barrel of the extractor was siphoned into the stock bottle, drained well, then the thimble was removed and dried on a watch glass, away from any flame. The condenser and the flask were replaced and distillation was continued until the flask was practically dry. The flask (which now contains all the fat) was detached from the extractor and dried in the oven to constant weight.

Calculation:

Ether extractives (EE) % = \frac{\text{wt. of oil contents}}{\text{wt. of the dry sample}} \times 100

3.3.2.4 Crude fibre (CF)

The residues from the ether extract determination were placed in a beaker fitted with a (cold finger), 180 ml of distilled water were added and boiled. Then 20 ml of 2.55 N sulphuric acid were added (giving 200 ml of 0.255 N H2SO4), heated rapidly to boil (the start point for extraction), then boiled gently for 30 min. the contents of the beaker were swirled gently (by imparting a circular motion to the beaker). Mean – while a hardened filter paper was fitted into a Hartley Buchner funnel, few boiling distilled water was poured and allowed to remain there until the funnel was hot. The water was then removed by suction and finally a shallow layer of hot water was left in the funnel, At the completion of the 30 min. boiling period, the digest was poured into the funnel and filtered by suction (the time for filtration should not exceed 10 min.). The residues were washed with boiling water until the washings were free from acid, then returned to the digestion beaker by supporting the paper on a watch glass and using a washing bottle containing a measured 180 ml of boiling distilled water, when the residues were completely transferred, the reminder of 180 ml distilled water were added, boiled and 20
ml of 3,13 N NaOH were added (giving 200 ml of 0.313 N NaOH), brought rapidly to boil and boiled gently for 30 min. then filtered through a whatman No. 4 (15 cm) filter paper, washed with boiled distilled water, then with 1% hydrochloric acid. Then washed twice with 95% alcohol, and three times with petroleum ether, using quite small quantities. The residues were allowed to dry partially, and carefully transferred (without the filter paper) to a crucible of known weight. Dried in an oven to a constant weight, ignited to burn off all organic matter, cooled and weighed (the loss on ignition is crude fibre).

**Calculation:**

Crude fibre (CF)% = Difference in crucible content wt. x 100
Sample wt on DM basis

### 3.3.2.5 Crude protein (CP)

One gram of each sample was weighed into a kjeldahl flask, plus one gram catalyst (one part copper sulphate +15 pats lithium sulphate) plus 25 ml conc. Sulphuric acid, placed on the special kjeldahl digestion rack and heated gently for 5-10 min. (it is essential that the fume extraction fan should be running, when frothing occurred the contents were swirled gently, a stronger flame may be used and the contents of the flask digested until they were clear (digested for 2 h), cooled and before absolutely cold, was diluted with 50 ml distilled water transferred to a 250 ml graduated flask. The kjeldahl flask was washed several times, all washings were added to the flask. The contents of the flask were mixed, to allow contraction caused by the mixing of sulphuric acid and water takes place. Finally the flask was completed up to the mark and mixed thoroughly.

### 3.3.2.5.1 Distillation

A micro-kjeldahl distillation apparatus was used, steamed out for 10 min. to remove the condensed water. The steam generator was placed on a heat source.
3.3.2.5.2 Blank and standard reading

For blank 5 ml of distilled water added into the body of apparatus via the small funnel aperture, plus 10 ml NaOH 40% (ww/v). While for standard readings, standard ammonium solution (NH₄)₂ SO₄ (1ml N/ml) was used instead of distilled water and digested sample solution, 5 ml of the digested sample solution was added into the body of the apparatus via the small funnel aperture. At the receiving tip of the condenser was placed a conical flask containing 25 ml of 2% (v/v) boric acid (20 g boric acid + 5 ml indicator [1g methyl red + 0.5 g bromocresol] +1.0 litre distilled water), the funnel plug was lifled carefully and 10 ml caustic soda (40% w/v) was allowed to run into the apparatus. To prevent any violent (suck back), the received flask was held just clear of the condenser tip while the caustic soda was running in, but quickly returned to its normal position as soon as possible. Distillation was continued for 2 min., at the end of which, the flask was removed away from the condenser tip and allowed for 10 sec. for drainage from the condenser to be collected, which was washed with a little distilled water.

3.3.2.5.3 Titration

The contents of the receiving flask were titrated using (0.1N) hydrochloric acid. The boric acid, while preventing loss of ammonia by formation of ammonium borate, is a very weak aid and does not affect the indicator in any way, the titration may then be thought of as being essentially between ammonium hydroxide and hydrochloric acid.

Calculation:

Crude protein (CP) % = ml HCL (sample solution) – Bl/(St-Bl) x0.0014x6.25x20x100
Sample wt. on DM basis

Where:

Bl = ml HC used for blank titration.
St = ml HC used for standard titration.
3.3.2.6 Nitrogen free extract (NFE)

The percentages of moisture, ash, ether extract, crude fibre, and crude protein were added up and subtracted the total from 100%. The difference is the percentage of nitrogen free extract.

\[
\text{NFE\%} = 100\% - (\text{moist. \% + Ash\% + EE\% + CP\% + CF\%})
\]

All results were calculated as g/kg of the feed (on dry matter basis), obtained by multiplying% concentration x 10.

3.3.3 Estimation of metabolizable energy (ME)

The metabolizable energy was estimated from the chemical analysis (CP, CF and fat content), MAFF (1975) by using the following equation.

\[
\text{ME ((M)/kg DM)} = 0.12\text{CP} + 0.03\text{EE} + 0.005\text{CF} + 0.014\text{NFE}
\]

3.3.4 In vitro Dry Matter Digestibility (IVDMD)

The In vitro Dry Matter Digestibility (IVDMD) was measured by using Tilley and Terry (1963) procedure (two-stage in vitro method).

1. First stage, 5 g of finely ground sample was incubated for 48 hrs with buffered rumen liquor (anaerobic conditions).

2. Second stage, bacteria were killed by acidifying with HCl to pH 2, then the samples were digested by incubating them with pepsin for further 48 hrs, digestibility of each nutrient was determined from insoluble residues.

\[
\text{In vitro Dry Matter Digestibility (IVDMD\%)} = \frac{\text{Sample wt.} - \text{Sample residue}}{\text{Sample wt. on DM basis}} \times 100
\]

3.4 Statistical analysis

The data was subjected to analysis of variance using statistics 0.8 program, while the least significant differences (LSD) test was used in all cases to compare the means.
CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Chemical Composition

4.1.1 Chemical Composition of groundnut haulms

Table (4.1) presents the chemical composition of groundnut haulms treated with molasses plus urea, rabaa ash alkali "Trianthema Pentandra" and trona "Atron" and untreated groundnut haulms. There were highly significant differences (P≤0.05) in all nutrients except NFE. The results showed that groundnut haulms treated with rabaa ash alkali had the highest dry matter, whereas groundnut haulms treated with Molasses plus Urea had the lowest value. This is because molasses contain less dry matter (74.4%) than dry rabaa ash and trona. Abusuwaret al. (2012) found that groundnut haulms treated with molasses plus urea had lower dry matter (88.6%) while, untreated groundnut haulms had 95.1% DM. In another study the above author reported that molasses decreased the dry matter (74.4%) whereas, untreated groundnut haulms had a dry matter 95.1%. While, Mahala and Khalifa (2007) reported that the dry matter was not significantly different (P≤ 0.05).

Groundnut haulms treated with rabaa ash alkali showed the highest Ash content (23.19%), while, groundnut haulms treated with molasses plus urea had the lowest value (10.85%) which nearly similar to untreated groundnut haulms (10.90%). The increment in ash content in groundnut haulms treated with rabaa ash alkali or trona "Atron" may be referred to that rabaa ash alkali and trona are mainly minerals in their nature. Groundnut haulms treated with trona "Atron" showed the lowest Ash content because trona "Atron" contains huge amounts of silica which have no ability to dissolve in water and hence sieved to remove it from the prepared solution. Abusuwaret al. (2012) found that Ash content (10.25%) decreased in groundnut haulms treated with urea, while untreated groundnut haulms (12.37%). Mahala and Khalifa (2007) reported that ash content generally increased due to increment of molasses, the highest ash content (9.3%) was
found in groundnut haulms treated with (15%) molasses and the lowest value (8.23%) in control.

It could be obviously observed that untreated groundnut haulms and groundnut haulms treated with trona "Atron" or molasses plus urea were slightly different in Ether Extract content (1.79, 1.80 and 1.44%, respectively), they showed significant differences (P≤0.05) when compared with groundnut haulms treated with rabaa ash alkali (2.52 %), the highest content of EE in groundnut haulms treated with rabaa ash alkali may be referred to the greasy nature of prepared rabaa ash alkali. Abusuwar et al. (2012) found urea treatment increased EE content (1.88%) in groundnut haulms, while EE content of untreated groundnut haulms was (1.23%).

Groundnut haulms treated with molasses plus urea showed the highest CF content (29.57%) while, groundnut haulms treated with rabaa ash alkali had the lowest value (20.78%). Hamed (2007) Suggested that the decrease in CF with increasing rabaa ash alkali is beneficial in modifying fibres and improving the nutritive value for ruminants. Abusuwar et al. (2012) found that groundnut haulms treated with Urea contain less CF (55.2%) compared to untreated groundnut haulms (61.1%).

Groundnut haulms treated with molasses plus urea and untreated groundnut haulms showed the highest CP content (12.87%) while, groundnut haulms treated with rabaa ash alkali had the lowest value (11.20%) which not significantly different from groundnut haulms treated with trona "Atron" (11.29%). In general groundnut haulms treated with rabaa ash alkali and trona "Atron" were significantly different (P≤0.05), from untreated groundnut haulms and groundnut haulms treated with molasses plus urea. The results of CP in this study were lower than what reported by Abusuwar et al. (2012). In this study groundnut haulms treated with molasses plus urea did not increase the crude protein content which was in contrast to the findings of Abusuwar et al. (2012) Who found that groundnut haulms treated with urea increased the CP content (16.31%), compared to untreated groundnut haulms (5.45%). In contrast, Idris (2015) reported that the groundnut haulms has (on DM basis) 9% of crude protein. Mahala and Khalifa (2007) reported that the CP content increased significantly with increased molasses levels. The highest CP value (7.88%) was obtained when molasses was (15%), while, the lower value (6.54%) was seen in the control.
Nitrogen free extract (NFE) content in groundnut haulms treated with Molasses plus Urea, rabaa ash alkali and trona "Atron" and untreated groundnut haulms were not significantly different, NFE content ranged between 37.87% - 39.88% in groundnut haulms treated with trona and rabaa, respectively. Groundnut haulms treated with Molasses plus Urea and rabaa ash alkali were slightly differed from untreated groundnut haulms and groundnut haulms treated with trona "Atron" but, not statistically different.

Also the results showed that, treated and untreated groundnut haulms were significantly different (p≤ 0.05) in ME content, ME content ranged between (8.47 - 9.73 MJ/kg DM). Groundnut haulms treated with molasses plus urea and trona "Atron" were not significantly different in ME content. It could be observed that all treatments reduced the energy content; this may be attributed to that, all treatments affected the chemical composition of Groundnut haulms. The present investigation was higher than the reported value of Chowdhury et al. (2015).

The results showed that groundnut haulms treated with rabaa ash alkali had the highest In vitro digestibility (83.33%), while, groundnut haulms treated with trona "Atron" had the lowest value (50%). It could be observed that all treatments were significantly different (p≤ 0.05) in IVDMD. Molasses plus urea and rabaa ash alkali increased IVDMD while, trona "Atron" decreased it. This may be attributed to the differences in CF and ash contents. In this study the IVDMD of groundnut haulms was 67.33% higher than that reported by VinodKumar (2013) who found the IVDMD of groundnut haulms was 55.3%.
Table (4.1): Chemical Composition (%) metabolizable energy (ME, MJ/kgDM) and digestibility (IVDMD %) of treated and untreated groundnut haulms

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DM</th>
<th>Ash</th>
<th>EE</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>ME (ME,MJ/KgDM)</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Groundnut haulms (control)</td>
<td>93.63&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.90&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.79&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28.61&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>12.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>39.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>58.67&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Groundnut haulms+Molasses+Urea</td>
<td>92.66&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10.85&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.78&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>67.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Groundnut haulms +Rabaa</td>
<td>95.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.78&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>83.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Groundnut haulms +Trona &quot;Atron&quot;</td>
<td>94.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.77&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.86&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>50.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CV%</td>
<td>0.17</td>
<td>2.63</td>
<td>17.04</td>
<td>3.88</td>
<td>4.85</td>
<td>3.06</td>
<td>6.47</td>
<td>3.41</td>
</tr>
<tr>
<td>SE±</td>
<td>0.09</td>
<td>0.23</td>
<td>0.19</td>
<td>0.60</td>
<td>0.34</td>
<td>0.68</td>
<td>0.34</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Means with different superscripts letters in the same column were significantly different (P≤ 0.05).
4.2 Pigeon pea "Lubia adasi" residues

Table (4.2) presents the chemical composition of Pigeon pea "Lubia adasi" residues treated with molasses plus urea, rabaa ash alkali and trona "Atron" and untreated Pigeon pea residues. There was a significant difference in DM content (P≤0.05) between Pigeon pea residues treated with trona (93.59%) and the residues treated with molasses plus urea, rabaa ash alkali and untreated residues. The results showed that pigeon pea residues treated with molasses plus urea, rabaa ash alkali, and untreated residues nearly had the same DM percentage (94.98, 94.99 and 95.39%, respectively); they had the highest dry matter percent.

The results showed significant differences (P≤0.05) in Ash content, the highest Ash content was seen in Pigeon pea residues treated with rabaa ash alkali (19.45%) followed by trona "Atron" treated Pigeon pea residues (11.60%) and then the untreated Pigeon pea residues (10.46%). However, Pigeon pea residues treated with molasses plus urea showed the lowest ash content (9.05%).

It could be obviously observed that Pigeon pea residues treated with molasses plus urea and trona "Atron" and untreated Pigeon pea residues were not significantly different in EE content (1.73, 1.62 and 2.14%, respectively) but significantly different (P≤0.05) from Pigeon pea residues treated with rabaa ash alkali. Rabaa ash alkali treatment significantly (P≤0.05) increased Ether Extract content (2.84%), while, Molasses plus Urea and trona "Atron" treatment decreased EE content. This may be referred to the greasy nature of the prepared rabaa ash alkali blocks.

Also the results showed significant differences (P≤0.05) between treated and untreated Pigeon pea residues in crude fiber content. Untreated Pigeon pea residues and Pigeon pea residues treated with trona "Atron" showed the highest CF content (26.29% and 26.36%, respectively), while Pigeon pea residues treated with rabaa ash alkali and Molasses plus Urea had the lowest value (22.53% and 22.24%, respectively). This may be referred to their clear effects on the chemical composition mainly CP and ash.

The crude protein (CP) content percent of Pigeon pea residues treated with molasses plus urea increased to (15.84%), compared with the untreated (8.93%). However, treatment with rabaa ash alkali and trona "Atron" increased the CP (12.43% and 12.69%, respectively), compared to the control but both had lower effect than
molasses plus urea. Mahala and Khalifa (2007) reported that Ash and CP contents in groundnut haulms were significantly (P≤0.05) increased due to increment of molasses levels in treatment. Hamed (2007), reported that rabaa alkali treatment increased CP and Ash and decreased CF in sesame residues. The decline in CF in sesame residues was more than for sorghum straw.

Also the results showed that treated and untreated Pigeon pea residues were significantly different (p≤ 0.05) in NFE content, NFE content ranged between (37.75 and 47.57%). It could be observed that all treatments decreased NFE content; this may be referred to the increment in other nutrients.

The result showed significant differences (P≤0.05) between the different treatments in metabolizable energy content (ME, MJ/kg DM). Pigeon pea residues treated with molasses plus urea showed the highest value (10.01%MJ/kg DM) followed by untreated (9.71%MJ/kg DM) then Pigeon pea residues treated with trona "Atron" (9.13%MJ/kg DM) and the least ME (8.78%MJ/kg DM) was seen in Pigeon pea residues treated with rabaa ash alkali.

The results showed that Pigeon pea residues treated with trona "Atron" showed the highest dry matter digestibility (86.67%), whereas untreated pigeon pea residues had the lowest value (58.67%). In general, all treatments improved positively the digestibility of Pigeon pea residues and they showed significant (P≤0.05) differences. Pigeon pea residues treated with molasses plus urea showed slight increase compared to untreated Pigeon pea residues. However, it was not significant difference. In another study for Hamed (2007) sesame residues treated with rabaa ash alkali had generally increased rumen degradation and the effect was highest for the highest alkali level.
Table (4.2): Chemical composition (%) metabolizable energy (ME, MJ/kg DM) and digestibility (IVDMD %) of treated and untreated pigeon pea residues

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DM</th>
<th>Ash</th>
<th>EE</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>ME (MJ/kg DM)</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Pigeon pea residue control</td>
<td>95.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.46&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.93&lt;sup&gt;c&lt;/sup&gt;</td>
<td>47.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>58.67&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pigeon pea residue + Molasses+Urea</td>
<td>94.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.33&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pigeon pea residue+ Rabaa ash alkali</td>
<td>94.99&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>22.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.75&lt;sup&gt;d&lt;/sup&gt;</td>
<td>8.78&lt;sup&gt;d&lt;/sup&gt;</td>
<td>70.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pigeon pea residue+Trona &quot;Atron&quot;</td>
<td>93.59&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.69&lt;sup&gt;b&lt;/sup&gt;</td>
<td>41.32&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>86.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CV%</td>
<td>0.28</td>
<td>2.40</td>
<td>16.25</td>
<td>0.98</td>
<td>4.38</td>
<td>1.55</td>
<td>0.90</td>
<td>4.05</td>
</tr>
<tr>
<td>SE±</td>
<td>0.15</td>
<td>0.18</td>
<td>0.20</td>
<td>0.14</td>
<td>0.32</td>
<td>0.39</td>
<td>0.05</td>
<td>1.63</td>
</tr>
</tbody>
</table>

Means with different superscripts letters in the same column were significantly different (P≤0.05).
4.3 Sorghum Straw

Table (4.3) presents the chemical composition of sorghum straw treated with molasses plus urea, rabaa "Trianthema Pentandra" ash alkali and trona "Atron" and untreated sorghum straw. There were significant differences ($P \leq 0.05$) in all components. The results showed that untreated sorghum straw and sorghum straw treated with rabaa ash alkali and trona "Atron" had the highest dry matters (95.12, 95.59% and 95.03%, respectively), they were not significantly different. While, sorghum straw treated with molasses plus urea had the lowest value (94%).

Ash content in Sorghum straw treated with molasses plus urea and trona "Atron" were nearly similar to ash content in untreated Sorghum straw (9.80, 10.02, and 10.26%, respectively). Their content differed significantly ($P \leq 0.05$) from Sorghum straw treated with rabaa ash alkali (20.51%). It could be observed that molasses plus urea treatment decreased ash content; this result was in contrast with Abakar (2007) who reported that using molasses had increased ash percentages in two types of sorghum.

Untreated Sorghum straw, sorghum straw treated with molasses plus urea and trona "Atron" were slightly differed in EE content, but significantly different ($P \leq 0.05$) from sorghum straw treated with rabaa ash alkali which showed the highest EE content (2.62%). The increment of EE associated with rabaa ash alkali may be referred to its greasy natures.

Sorghum straw treated with molasses plus urea showed the highest CF content (32.13%) which slightly differed from untreated sorghum straw (31.9%) While, Sorghum straw treated with rabaa ash alkali had the lowest value (25.31%), this may be referred to the highest increment in ash content which affect the level of other components. These results were in line with the findings of Georgis, E. H. W. (2017) who reported that chemical composition (potential nutritive value) of sorghum and millet was improved with urea treatment by increasing the CP and ME but at the same time reducing the values of the NDF and ADF. On the other hand, Yagoup (2010) found that the Urea treatment significantly increased CP content in sorghum.
It could be obviously observed that there were significant \( P \leq 0.05 \) differences in CP content between treated and untreated sorghum straw. Sorghum straw treated with molasses plus urea showed the highest value (9.92%), while, sorghum straw treated with rabaa ash alkali and untreated sorghum straw were slightly different, and they had the lowest values (7.62 % and 7.35%, respectively). Hamed (2007) reported that molasses and urea supplementation separately or together had improved the chemical composition of sorghum straw by increasing CP, EE and NFE.

On the other hand, the results showed that treated and untreated sorghum straw were significantly different \( P \leq 0.05 \) in NFE content. NFE content ranged between 38.94% in sorghum straw treated with rabaa ash alkali and 45.22% in sorghum straw treated with trona "Atron". Untreated sorghum straw, sorghum straw treated with molasses plus urea and sorghum straw treated with trona "Atron" were slightly differed in NFE content, but they significantly differed \( P \leq 0.05 \) from sorghum straw treated with rabaa ash alkali. Hamed (2007) reported that rabaa ash alkali treatment decreased CF and NFE and also decreased dry matter in sorghum straw.

Untreated sorghum straw, sorghum straw treated with molasses plus urea and sorghum straw treated with trona "Atron" were slightly differed in metabolizable energy value, but they were significantly differed \( P \leq 0.05 \) from sorghum straw treated with rabaa ash alkali. In general, all treatments decreased ME content; this may be due to the changes occurred in the chemical composition of sorghum straw.

Molasses plus urea, rabaa ash alkali and trona "Atron" treatments improved the \textit{in vitro} digestibility of sorghum straw. Untreated sorghum straw, sorghum straw treated with molasses plus urea were not significantly different, but they showed significant differences \( P \leq 0.05 \) from sorghum straw treated with rabaa ash alkali and trona "Atron". Hamed (2007) reported that rabaa ash alkali treatment was generally more effective in upgrading sorghum straw by improving its chemical composition and apparent digestibility.
Table (4.3): Chemical composition (%) metabolizable energy (ME, MJ/Kg DM) and digestibility (IVDMD %) of treated and untreated sorghum straw

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DM</th>
<th>Ash</th>
<th>EE</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>ME (MJ/kgDM)</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Sorghum straw control</td>
<td>95.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.35&lt;sup&gt;c&lt;/sup&gt;</td>
<td>43.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>44.00&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sorghum straw + Molasses + Urea</td>
<td>94.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46.67&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sorghum straw + Rabaa ash alkali</td>
<td>95.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.90&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.62&lt;sup&gt;c&lt;/sup&gt;</td>
<td>38.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>77.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sorghum straw + Trona &quot;Atron&quot;</td>
<td>95.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.83&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>66.67&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>25.39</td>
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<td>3.77</td>
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<td>0.18</td>
<td>0.29</td>
<td>0.38</td>
<td>0.18</td>
<td>0.71</td>
<td>0.05</td>
<td>1.28</td>
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</tbody>
</table>

Means with different superscripts letters in the same column were significantly different (P≤ 0.05).
4.4 Sesame residues

Table (4.4) presents the chemical composition of sesame residues treated with molasses plus urea, rabaa *Trianthema Pentandra* ash alkali and trona*Atron* and untreated sesame residues. There were significant differences (P≤0.05) in all components except ME. Dry matter content was generally very high in all treatments and they were significantly different (P≤0.05). The results showed that sesame residues treated with trona *Atron* had the highest dry matter (96.32%), while, sesame residues treated with molasses plus urea had the lowest value (93.35%).

The results showed significant differences (P≤0.05) between treated and untreated sesame residues in ash content. sesame residues treated with rabaa ash alkali had the highest value in ash content (15.75%), followed by trona *Atron* and molasses plus urea (9.82 and 7.22, respectively), while, untreated sesame residues had the lowest value in ash (6.18%). molasses plus urea treatment increased ash content slightly, but not significantly different from untreated sesame residues.

Also the results showed significant differences (P≤0.05) between treated and untreated sesame residues in EE content. Sesame residues treated with rabaa ash alkali and trona *Atron* were nearly similar in EE content (1.37% and 1.49%, respectively). In general, all treatments decreased EE content in Sesame residues.

There were significant differences (P≤0.05) between treated Sesame residues and untreated one in CF content. Sesame residues treated with molasses plus urea and sesame residues treated with rabaa ash alkali had the lowest CF content (33.93% and 33.27%, respectively) followed by Sesame residues treated with trona *Atron*’ (36.65%), the untreated sesame residues had the higher CF content (40.84%). Shoryabi (2014) reported that use of supplementation with molasses and urea resulted in significant differences in DM and CP content and there were no significant effects on the other chemical composition. Hamed (2007) reported that rabaa alkali treatment increased CP and Ash and decreased CF in sesame residues. The decrease in CF in sesame residues was more than in sorghum straw. In another study for Hamed(2007) sesame residues treated with rabaa ash alkali had generally increased rumen degradation and the effect was highest for the highest alkali level.
It could be obviously observed that Sesame residues treated with rabaa ash alkali and that untreated residues were not significantly different in CP content (8.29% and 8.67%, respectively) but significantly different (P≤0.05) from Sesame residues treated molasses plus urea and trona "Atron". Rabaa ash alkali, molasses plus urea and trona "Atron" treatments decreased CP content. Hamed (2007) reported that rabaa alkali treatment increased CP and Ash and decreased CF in sesame residues.

Also the results showed significant differences (P≤0.05) between treated and untreated sesame residues in NFE content. sesame residues treated with molasses plus urea showed the highest value (42.89%), followed by Sesame residues treated with trona "Atron" (40.57%), rabaa ash alkali (37.13) and untreated sesame residues (36.53%). No significant difference was observed between sesame residues treated with rabaa ash alkali and untreated one.

The results showed that, there were significant differences between different treatments in metabolizable energy content (ME, MJ/kg DM). Sesame residues treated with molasses plus urea showed the highest value (9.27%), followed by sesame residues treated with trona "Atron" (8.91 - 8.28%) and then untreated sesame residues which showed the lowest value in ME content (7.52%). In general all treatments increased the energetic value of sesame residues.

The results revealed that, all treatments improved crop residues digestibility (IVDMD) they showed significant differences (P≤0.05). Sesame residues treated with trona "Atron" had the highest digestibility value (86.00%), while, untreated sesame residues had the lowest value (41.33%).
Table (4.4): Chemical composition (%) metabolizable energy (ME, MJ/KgDM) and digestibility (IVDMD %) of treated and untreated Sesame residues

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DM</th>
<th>Ash</th>
<th>EE</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>ME (MJ/kg DM)</th>
<th>IVDMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Sesame residues control</td>
<td>94.83&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.18&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.53&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.33&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sesame residues + Molasses + Urea</td>
<td>93.35&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.22&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.22&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>33.93&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>45.33&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sesame residues + Rabaa ash alkali</td>
<td>95.81&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.13&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.28&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sesame residues + Trona &quot;Atron&quot;</td>
<td>96.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.82&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.79&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>40.57&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>86.00&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CV%</td>
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<td>22.99</td>
<td>1.49</td>
<td>6.10</td>
<td>0.92</td>
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<td>SE±</td>
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<td>0.31</td>
<td>0.28</td>
<td>0.21</td>
<td>0.68</td>
<td>0.33</td>
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</table>

Means with different superscripts letters in the same column were significantly different (P≤ 0.05).
Table (4.5) presents the chemical composition of treated and untreated groundnut haulms, pigeon pea residues, sorghum straw and sesame residues, the results showed significant differences (P≤0.05) between treatments in all components. It could be observed that all treatments affected dry mater content in crop residues, the range of the effect depended on the level of moisture content of the ingredients used in treatment and the condition of drying period. Rabaa ash alkali and trona "Atron" increased ash content in all treatments, Rabaa ash alkali showed the highest values in all cases, figure 1.

![Graph showing total minerals (%) in some crop residues treated with molasses plus urea, Rabaa ash alkali or trona "Atron".]

**Figure (1): Total minerals (%) in some crop residues treated with molasses plus urea, Rabaa ash alkali or trona "Atron"**

Although the change in Ether Extract content is very narrow, but they showed significant differences (P≤0.05). In general, Rabaa ash alkali treatment had the highest value in all cases, this attributed to the nature of Rabaa ash alkali blocks.

All treatments decreased CF content in all crop residues except an unexplainable slight increment that observed in groundnut haulms and sorghum straw treated with molasses plus urea and Pigeon pea residues treated with trona "Atron", figure 2.
Figure (2): Crude fiber (%) in some crop residues treated with molasses plus urea, tabaa ash alkali or trona "Atron"

The treatments improved crude protein in Pigeon pea residues and sorghum straw, the best improvement observed in Pigeon pea residues, figure 3.

Figure (3): Crude protein (%) in some crop residues treated with molasses plus urea, rabaa ash alkali or trona "Atron"
Also the treatment showed positive effects in metabolizable energy (ME) content of sesame residues only, figure 4.

![Metabolizable energy chart](chart.png)

**Figure (4): Metabolizable (MJ/Kg DM) in some crop residues treated with molasses plus urea, rabaa ash alkali or trona "Atron"**

The *in vitro* digestibility (IVDMD) was improved in all treatments, rabaa ash alkali showed the best improvement in groundnut haulms and sorghum straw digestibilities, while; trona "Atron" showed the best improvement in Pigeon pea residues and sesame residues, figure 5.
Figure (5): *In vitro* digestibility (%) in some crop residues treated with molasses plus urea, rabaa ash alkali or trona "Atron"

Table 4.5 and figure 6 present the effect of molasses plus urea, rabaa *Trianthema Pentandra* ash alkali and trona"Atron" on the chemical composition of groundnut haulms, pigeon pea residues, sorghum straw and sesame residues.
Table (5): Effects of molasses plus urea, rabaa ash alkali and trona "Atron" Treatments on some crop residues.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>DM</th>
<th>Ash</th>
<th>EE</th>
<th>CF</th>
<th>CP</th>
<th>NFE</th>
<th>ME (MJ/kg DM)</th>
<th>IVDMD</th>
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Figure (6): Effects of molasses plus urea, rabaa ash alkali and trona "Atron" Treatments on some crop residues.
CHAPTER FIVE
CONCLUSION AND RECOMMENDTIONS

5.1 Conclusions

1) All treatments decreased CF content in all crop residues.
2) Rabaa ash alkali and trona "Atron" increased ash content.
3) Molasses plus Urea treatment showed the best improvement in CP content in pigeon pea residues and Sorghum straw while, in groundnut haulms the CP content remained as its the treatment showed negative effect on.
4) The treatment decreased NFE content in Pigeon pea residues, Sorghum straw and Sesame residues except Sorghum straw treated with trona "Atron", and also increased NFE content in all treated Sesame residues.
5) Metabolizable energy decreased in all treated groundnut haulms, Pigeon pea residues treated with rabaa ash alkali and trona "Atron", and Sorghum straw treated with trona "Atron".
6) Rabaa ash alkali treatment showed the highest improvement in IVDMD of groundnut haulms and Sorghum straw.
7) Trona "Atron" treatment showed the highest improvement in IVDMD of Pigeon pea residues and Sesame residues.
5.2 Recommendations

1. Further studies are recommended to improve the efficiency of these treatments.
2. More research are needed to study the effect of these treatments on animal performance.
3. It is recommended to use rabaa ash alkali and trona "Atron" to upgrade the nutritive value of poor quality roughages.
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