كلية الدراسات العليا Sudan University of Science and Technology

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# Effect of Some Physical and Chemical Treatments of Millet Straw on Nutritive Value

# أثر بعض المعالجات الفيزيائية والكيميائية لسيقان الدخن علي قيمتها الغذائية

**Thesis Submitted in Fulfillment of the Degree**

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# ABSTRACT

Limited use of cereal straws in livestock feeding is due to their low voluntary intake, low protein contents and low digestibility. Nutritional value of these roughages can be improved through chemical, physical or biological methods. Efficacy of treating straw with urea for improving its nutritive value is considered equivalent to anhydrous or aqueous ammonia. However, the adoption rate of urea treatment by farmers is low, maybe due to relatively tedious technology and higher requirement of labor. There is need to simplify urea treatment methods. The study was carried out at North Darfur State, Sudan. The mean, minimum and maximum temperatures are 17.7C$^{o}$ and 34.7C$^{o}$ respectively(Elfasher Metrological Station, 2014).The state lies between latitudes 12° 30" and 21° 55" *N* and longitudes 24° 00" and 27° 30" *E* within the arid and semi-arid zones. The state can be divided into two main geographical zones based on average amount of annual rainfall and soil types. These are the desert and semi-desert zones; the two together cover an area of about 296,400 km$^2$; about 60% of it is rangelands. There are three distinct seasons in the area, the hot rainy season or autumn (Khareef) from June to September, the cool season or winter from November to February and the hot dry season or summer from March to May. The average annual rainfall for the last ten years was 218.09 mm. The main objective of the study was to investigate, ways to improve the nutritive value of millet straw for use as feed during the dry season when there is acute shortage of fodder from rangelands both on quantity and quality. In the present study an effort has been made to simplify the existing urea treatment method so that farmers could easily adopt this technique.

The present method involves weighing the required amount of urea (4% of weight of straw), giving 30% moisture by adding 50liter water, putting this mixture in a plastic bag, piling the straw covered and keep it air-tight, three weeks at room temperature. In this method three steps including preparation of urea solution, sprinkling of solution on straw and pressing the straw during treatment process, have been eliminated which resulted in saving labor by 55%. (the three steps included: prepared by chopped and grinded millet straw, sprayed and mixed with urea solution, stored straw treated in plastic bags and sealed, kept air-tight and left for three weeks at room temperature). Taking into account the straw processor to sunlight display before it is submitted to the animal to get rid of the excess concentration of urea. The results obtained showed that treatment with urea resulted in increased CP% both in the ground and chopped form (14.58 and 14.61% respectively) compared with untreated straw (7.8 and 11.9% respectively). Neutral detergent fiber was also lower in urea treated straw compared with untreated straw both in the ground and chopped form (62.50 and 66.0% respectively) compared with untreated straw (65.50 and 72.50% respectively).Neutral detergent fiber (NDF), and Acid detergent lignin (ADL) were decreased consistently, while the content of ether extract (EE) increased. Urea treatment had a positive influence on  millet straw digestibility. Dry matter digestibility of millet straw treated with urea was higher both when the straw was ground and chopped (64.1 and 65.0%) compared with that of untreated straw(56.5 and 52.4%).The improvement in digestibility could be attributed to an enhancement of rumen microbial activity as a result of increased nitrogen. Ground untreated millet straw had a higher digestibility than untreated straw in the chopped form, however the difference was not significant ($P>0.05$).

Effect of treatments on dry matter intake of millet straw by Sheep revealed no significant differences between treatments as regards intake of dry matter, despite the decline in dry matter intake by sheep there are noticeable increases in the animal weight. However, voluntary intake of millet straw may be limited by physical factors causing low rates of passage. Grinding usually breaks the lignin bonds of the cell wall and exposes a larger surface area to rumen microbial action, resulting in faster removal of digesta from the rumen.

# الخلاصة

يعزي الإستخدام المحدود لمخلفات محاصيل الحبوب في تغذية الماشية إلي إنخفاض الكمية المتناولة طوعا بواسطة الحيوان، وذلك بسبب إنخفاض محتواها من البروتين ووجود اللجنين في جدران الخلايا مما يشكل عازلا بين ميكروبات الكرش والمكونات القابلة للهضم. ويمكن تحسين القيمة الغذائية لهذه المخلفات بإستخدام بعض الطرق الفيزيائية والكيميائية البسيطة والتي يسهل علي المزارع تطبيقها. وفي هذه الدراسة تم إستخدام اليوريا بنسبة (4%) لمعالجة مخلفات الدخن وتعتبر فعالية علاج قش الدخن باليوريا لتحسين قيمتها الغذائية مقاربة لإستخدام الأمونيا المائية واللامائية. ومع ذلك فإن معدل تبني المزارعين لعلاج هذه المخلفات باليوريا منخفضة ربما بسبب أنها تحتاج إلي بعض التقنيات الدقيقة نسبيا وإلي عدد كبير من الأيدي العاملة، لذا كانت الحاجة لطرق تبسط المعالجة باليوريا .

وقد أجريت هذه الدراسة في ولاية شمال دارفور بغرب السودان حيث متوسط الحد الأدنى والحد الأقصى لدرجات الحرارة ( 17,7مْ و34,7مْ على التوالي ) محطة الارصاد الجوية الفاشر،2014. وتقع الولاية بين خطي عرضْ12 30" وْ21 55" شمالآ وخطي طول ْ24 55" وْ27 30" شرقآ في المنطقة الصحراوية وشبه الصحراوية, ويمكن تقسيم الولاية إلي منطقتين جغرافيتين علي اساس متوسط كمية المطر السنوي وأنواع التربة, حيث تحتل المراعي الطبيعية حوالي 60% من هذه المساحة. وتتميز المنطقة بوجود ثلاثة فصول,حيث موسم الأمطار الساخن (الخريف) ويمتد من شهر يونيو إلي سبتمبر, وموسم بارد (فصل الشتاء) من نوفمبر إلي فبراير, والموسم الحار الجاف (فصل الصيف) من مارس حتي مايو. وقد كان متوسط هطول الأمطار السنوي علي مدي السنوات العشر الماضية حوالي 218,09ملم.هدفت هذه الدراسة إلي تبسيط فكرة علاج مخلفات المحاصيل باليوريا بحيث يمكن للمزارعين تبني أوإعتماد هذه التقنية وتحسين القيمة الغذائية لقش الدخن للإستخدام كعلف خلال موسم الجفاف عندما يكون هنالك نقص حاد في الأعلاف من المراعي الطبيعية كمآ ونوعآ. تتضمن هذه الطريقة التي إستخدمناها وزن أربعة كيلوجرام من اليوريا لكل مائة كيلوجرام من القش المطحون ومائة كيلوجرام أخري من القش المقطع وجعلها تحتوي على30% رطوبة وذلك بإضافة 50 لتر ماء ثم اضافة 1%ملح طعام ووضع الخليط في كيس من البلاستيك مع مراعاة الإغلاق المحكم لمنع دخول الهواء, يحفظ الخليط لمدة ثلاثة أسابيع علي درجة حرارة الغرفة وتقل هذه المدة صيفا. وفي هذه الطريقة ثلاث خطوات تشمل إعداد محلول اليوريا ورش المحلول علي القش خلال عملية المعالجة والتخزين. هذه الطريقة توفر العمالة بنسبة 55% وكفاءتها أعلي بنحو 33% من طرق المعالجة التقليدية،

مع مراعاة عرض القش المعالج لأشعة الشمس قبل تقديمه للحيوان للتخلص من التركيز الزائد لليوريا. وقد خلصت الدراسة إلي أن المعالجة باليوريا أدت إلي زيادة نسبة البروتين الخام في القش المعالج (المطحون والمقطع) حيث بلغت (14,58% و14,61% علي التوالي) مقارنة مع القش غير المعالج (المطحون والمقطع) حيث كانت النسبة (7,8% و11,9% علي التوالي). كذلك إنخفضت نسبة الألياف الخام في القش المعالج باليوريا (المطحون والمقطع ) حيث صارت (62,50% و66,00% علي التوالي) مقارنة مع القش غير المعالج (المطحون والمقطع) (65,50% و72,50% علي التوالي) كذلك إنخفض محتوى اللجنين في حين إرتفع محتوي مستخلص الإيثر .

وقد أظهرت المعالجة باليوريا تأثيرا إيجابيا علي معامل هضم قش الدخن وذلك من خلال هضم المادة الجافة لقش الدخن المعالج (المطحون والمقطع) التي بلغت ( 64,1% و65,0% ) مقارنة مع القش غير المعالج ( المطحون والمقطع) (56,5% و52,4% ) ويعزي التحسن في هضم قش الدخن بسبب تعزيز النشاط الميكروبي في كرش الحيوان نتيجة لزيادة النيتروجين وكذلك تكسير روابط اللجنين مما يسهل وصول ميكروبات الكرش الى المكونات التي يمكن هضمها. كما نجد أن تأثير المعالجة باليوريا علي الكمية المتناولة (المادة الجافة ) من قبل الأغنام لم يظهر فرقا معنويا رغم أن هنالك زيادة ملحوظة في وزن الأغنام. ومن المعروف أن تناول القش طوعيا من الحيوان يزيد نتيجة للطحن بسبب بعض العوامل مثل مرور كميات كبيرة من القش المطحون بسرعة عبر القناة الهضمية, كذلك طول فترة بقائها في الكرش لحاجتها لوقت أطول لكسر روابط اللجنين بجدار الخلية .

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Maha

# *Dedication*

*To our great prophet Mohammed (peace and prayers be upon him)*

*To those who gave me ----Name and taught me how life could be*

*My affectionate mother---*

*My grandmother ---*

*My dear father---*

*To those who led me through life ----My brothers, sisters and friends*

*For all those I dedication this humble work*

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# Chapter One

# Introduction

## 1.1 General

Agricultural straws in the Arab world is about 164 million tons, in addition to18 million tons of manufactured agricultural residues, totaling to almost182million tons (AOAD, 1994).Wheat, sorghum, maize and millet contribute144million tons of straws, or about 79% of the straws in the Arab world. Sudan and Egypt are the most productive of the Arab countries, amounting to about 45%. Sudan has a vast area for production of crop straws and green fodder, where the natural pasture area is about (187million acres).Contribution of natural pasture is about 76% of dry matter, compared to 4% from irrigated feeds and 22 % of agricultural and industrial residues and1% of concentrates(Abusuwar,2004).Despite the fact that Sudanese productivity of all crops is less than global production ,but the large cultivated areas in Sudan provides huge amounts of crop residue that can be exploited in animal production and solve the problems of feed in the summer period. The types of agricultural residues in Sudan include sorghum, millet, peanut hulls and agro-processing residues such as molasses, bagasse and others.These provide a great deal of agricultural and industrial residues that can be used in animal feed, but only 4% is used (AOAD,2011). In the Gezira Scheme, for example, there is a gap in feed supply during the dry period of up to nearly 7 % of the total needed. Feed quality is also poor with (5.3% protein ) which reduces palatability as the animal do not consume large quantities because of longest retention time in the rumen high fiber crop residues with low digestibility

(AOAD,2011).The estimated livestock number in Sudan is about 103 million head, equivalent to 42 million Tropical Livestock Units (Ministry of Animal Resources and Fisheries, 2010). This significant wealth needs more efforts to provide the required amount of feed necessary to the animal herd.There is increasing interest in the whole world to maximize the benefits from agricultural residues and improving their nutritional value through various treatments, whether mechanical grinding and cutting, or chemical treatments such as addition of ammonia, urea or caustic soda (Gotlib et al, 1977) or other vital transactions using some fungi. The objective of these transactions is to raise the nutritional value of these residues leading to improved quality thus reducing pressure on rangeland.

In developing countries, livestock is usually fed high fibrous crop residues (wheat straw, rice straw, millet straw, stovers, etc.) characterized by high indigestible fiber due to increased lignifications of cell wall. Fermentable energy and protein deficiencies in crop residues coupled with their low digestibility impair intake, ruminal functions, and thus animal productivity. The situation strongly demands the improvement of the nutritive value of high fibrous crop residues through various treatments, for the efficient utilization of existing feed resources. Efforts were made in the past to improve the digestibility and protein through chemical treatment. In this connection sodium hydroxide was used (Dass and Kundu, 1994) which resulted in improving the digestibility, but its use remained limited due to a high cost of chemicals and environmental pollution. The other compound used was anhydrous ammonia (Gotlib *et al.*, 1977) which improved the digestibility and increased the nitrogen contents of the treated straw(Yadav and Yadav, 1989),but non-availability of ammonia gas in the common market and its transportation through specialized containers limited its use. Lately fertilizer grade urea has been used for this purpose (Ali et al, 1992; Sarwar et al, 2006).

Urea is cheaper, easily available and assumed to be equivalent to anhydrous or aqueous ammonia for upgrading cereal straws in the warmer regions of the world.

## 1.2 Research problem and justification

North Darfur state is affected by droughts, fluctuation of rainfall, wars, environmental degradation and overgrazing in many of its regions. Due to the large number of herds and the fragility of the semi-desert ecosystem the study area is one of the areas that are exposed to grazing intensively, particularly by sheep,camels and goats in addition to seasonal movements of cattle. In addition to intensive grazing there are seasonal fires and excessive cutting of trees and shrubs for use as firewood, coal and agricultural land. The study area is characterized by large quantities of cereal crops, especially millet. So when treated the nutritional value will be enhanced providing copious amounts of feed and for animals in the summer season when there is lack of green fodder. Therefore, the study focused on some of the physical and chemical methods that can be used to enhance the quality of millet straw as animal feed.

## 1-3 Main objective of the study

The main objective of the study was to investigate, ways to improve the nutritive value of millet straw for use as feed during the dry season when there is acute shortage of fodder from rangelands both in quantity and quality.

### 1-3-1 Specific objectives were to:

1. Improve the nutritional value of millet straw through physical and chemical treatment.

2. Measure the impact of the use of treated millet straw on digestibility and dry matter intake

3. Estimate the types and quantities of millet straw in study area (North Darfur).

4. Study the social and economic aspects of millet production, storage and utilization in study area.

# Chapter Two

# Literature Review

## 2-1 Obstacles of feed production

Expansion of the production of green fodder and agricultural crop residues in Sudan is constrained by many factors manifested in:

- Technical problems related to the nature and abundance of straws and the extent of knowledge of their benefits.
- Institutional problems associated with bodies and organizations that deal with agricultural residues and green fodder production, ways of using these and responsibilities.
- Environmental problems related to the extent of the negative impact on the environment when no benefit is made from agricultural residues and their disposal contaminates the environment.
- Economic obstacles such as the difficulty of collection and high cost of transportation.
-Social problems dealing with relations between the beneficiary populations using agricultural residues resulting in disputes that arise between livestock herders and farmers as a result of damage caused by animals to crop residues. The importance of agricultural crop residues in animal feed is becoming increasingly clear in Darfur. There are now simple appropriate technologies that can result in substantial improvements in the utilization of crop residues. They reduce bulk, extend the season of feed availability, improve nutritive value and reduce harmful impact on the environment through failure to dispose of these residues (Abu suwar, 2004).

## 2-2 The history of straw treatments

Protein is a specific component required to feed ruminants. It is usually known to be costly.When plants rich in protein, such as legumes, are not grown on farm resort was made to non-protein nitrogen sources to replace part of the protein.Studies suggest the possibility of the use of urea and ammonia chemical compounds in ruminant feed. Ruminant animals are characterized by their ability to take advantage of non-protein nitrogen compounds and turn them into protein. It was therefore suggested that non-protein nitrogen replace a portion of the protein in the diet of ruminants. Scientific studies suggest that urea is the most commonly used source of non-protein nitrogen in the diets of ruminants. In the United States, recent reports suggest that the amount of urea used in the diets of ruminant animals reached about 725,000 tons and this amount is growing at a rate of 15% per year. This amount is equivalent to about 4,500, 000 tons of soybean straw, the most widely used in the United States (FAO, 1994).The proportion of continuous improvement in the way to take advantage of urea in the diets of ruminants accelerated the transfer of this technology to animal breeders for use of urea treated diets to feed their animals, due to the low price of urea compared to other protein sources. All these factors led to a continued increase in the use of urea as a source of nitrogen out of non-protein in the diets of ruminant animals. In a study at the University of Alexandria where animals were fed on four types of rice straw diets containing urea at the rates of 32% 33% 66% 100% of the protein diet, it was found that the amount of food consumed increased with increasing urea level in the diet to 66% but decreases again when urea was increased to replace all protein in the diet. Also the increase of urea in the diet was found to increase the digestion of cellulose (FAO, 2006).

As for the advantage of the protein diet to different species of animals, the species differ in the degree of benefit. While goats and sheep take advantage of lower levels of urea it was found that at the level of 66% of the protein diet buffalo and cows show the highest benefit and the buffalo benefited more than cows at that level. The findings suggest that large animals such as cattle and buffalo benefit more from urea than small ruminants. (FAO,2006). In studies also conducted on sheep by (Nour, 2006) to assess the peel of peanuts as a diet using three levels of grinding and non-grinding and with addition of urea at a rate of 1.1%, the results of the experiment also showed that percentage of intake increased significantly when grinding peels, the addition of urea also achieved an increase in intake equivalent to12% compared to untreated peel.

## 2-2-1 Physical Treatments

Grinding, pelleting, chopping, and soaking in water and steam are all considered physical delignification treatments for straw. Some physical treatments, like grinding, increase accessibility of chemical and biological treatments to straw, but do not reduce lignin content. Many physical treatments have been used successfully as pre-treatments or in combination with chemical (Montane et al,1998) and biological treatments (Zhanga et al, 2008).

### 2-2-1-1 Steam

Steam explosion pretreatments have been used independently or in combination with chemical and biological delignification methods. Generally, during a steam explosion process, straw is contained in a high pressure container at pressures from 0.5 to 2.7 MPa (Van Soest, 2006).

In the container, steam is used to heat. During steam explosion straw is heated for short periods, usually for just a few minutes (Indacoechea, 2006).Steam explosion effectively causes lignin to be separated from polysaccharides (Kitani and Hal, 1989). Through steam explosion alone, cellulose, hemicellulose, and lignin contents in corn straw can be decreased by 8.47%, 50.45% and 36.65%, respectively (Chang et al., 2011). Viola (2008) found that steam explosion increased digestibility of wheat, barley, and oat straw by 25%. When steam explosion was combined with alkaline washing, digestibility was increased by an additional 9%. The average relative percent increase in digestibility for rice straw was calculated from data of eight different steam pressure studies (Van Soest, 2006). The average relative percent change in digestibility from the eight studies was14%.

### 2-2-2 Chemical Treatments

Chemical methods for increasing the nutritional quality of straw have been studied for more than 100 years (Kamstra et al., 1958) to improve feed digestibility. Chemicals most widely studied and used for treatment of straw, to improve digestibility, are sodium hydroxide, ammonia, and urea. These chemicals break lignin-cellulose structure by raising straw pH above 8.

#### 2-2-2-1 Ammonia

The average relative percent increase in digestibility for rice straw was calculated from data of 25different ammonia treatment studies (Van Soest, 2006).The average relative percent change in digestibility from the 25 studies was 31%. Knapp (1987) treated six wheat cultivars with 3% ammonia by weight. Straws were allowed to incubate for 21days at 25 ºC. The cellulase-reducing sugar method was used to determine the digestibility of treated versus non-treated straws. Ammonia treatments increased the digestibility of the non-treated straws. Ammonia treatment increased the digestibility of wheat straws by17 to 48 %, when compared to the untreated straws. Significant differences, in digestibility, were also found between wheat cultivars. Treatment of straw with anhydrous ammonia has been researched and has been proven, consistently, to be effective in improving straw feed quality. Therefore, much information is available on this technique. The Universities of Idaho, Minnesota and Washington State all provided information on anhydrous ammoniation of straw (Brownson, 2000). The University of California-Davis (Toenje et al,1986), North Dakota (Lardy and Bauer, 2008) and Oklahoma State University (Lalman, et al., 2012) have published their own ammoniation recommendations using anhydrous ammonia. Each of these publications give beef producer instructions for the ammoniation of baled straw with appropriate precautions regarding chemical safety and toxicity.During ammoniation straws are required to have moisture contents of approximately15%. Ammonia treated straws are also put into sealed gas tight containers during treatment time periods.All recommendations emphasize that straw be treated with 3% to 5% anhydrous ammonia by weight.

### 2-2-2-2 Urea

The average relative percent increase in digestibility of rice straw was calculated from data of 33 different urea treatment studies (Van Soest, 2006).The average relative percent change in digestibility from the 33 studies was 23%.Where anhydrous ammonia is not available in many parts of the world, urea is perfect for small or undeveloped feed operations. Instructions on urea ammoniation are published by the Food and Agriculture Organization of the United Nations (FAO, 1994). Treating straw with urea is a way of indirectly ammoniating straw. Two processes must occur for urea to effectively increase the digestibility of straw. First, urea must undergo ureolysis or the change of urea to ammonia. The reaction requires adequate moisture, 30 %,(Sahnounea et al, 1991) and addition of urease depending on the type of straw.

Second, ammonia must degrade straw cell walls (Chenost,1995). Aitchison (1988) reported that the digestibility of “very poor” quality straw can be increased by as much as 30% with urea treatment .

**How to feed urea:**

- Urea is provided for animals in small quantities and when it is necessary to give doses to control the feed rate so that it is not allowed by administration of large amounts in a short time and thus can prevent the occurrence of poisoning.

- The better nutrition urea system is a system that allows analysis of urea without straining, (Chenost,1995) found that this method increases the utilization of urea nitrogen significantly.

## 2-2-2-3 Sodium Hydroxide

McAnally (1942) soaked wheat straw in 1.5 % sodium hydroxide for 24 hours. The treated straw was then washed with cold water. Five gram portions of treated and untreated straw were placed in silk bags and suspended in sheep rumen for 1 week. It was found that treated wheat straw was 28% more digestible than untreated wheat straw. Straw treated with sodium hydroxide has greater digestibility and promotes better animal performance than ammonia (Males, 1987). Nevertheless, there are fewer official recommendations for sodium hydroxide or non-nitrogen alkali straw treatments than there are for ammonia straw treatments. This may be due to concerns over high sodium content in straws treated with sodium hydroxide. Ammoniation of straws may also be recommended more because ammoniated straws require less nitrogen supplementation (Males, 1987). Sodium hydroxide treatment of straw is recommended by FAO(2012) through its Technologies and Practices for Small Agricultural Producers platform(TECA).To aid producers in treating straw with sodium hydroxide the TECA recommends the Beckmann method. The Beckmann method is similar to the method used by McAnally (1942) which was described previously. The Beckmann method requires straw to be soaked in a 1.5% sodium hydroxide solution for 18 to 20 hours, then rinsed with fresh water and fed. The Beckmann method is simple and sodium hydroxide is available worldwide, ideal for use in developing countries (FAO, 2012).The Beckmann Method can increase straw digestibility from about 40% to 70% (Jackson, 1977).

## 2-2-3 Biological Treatments

Enzymes are at the core of biological treatments used to reduce lignin or liberate carbohydrates in straw. (Beauchemin, 2002) identified the use of exogenous cell wall degrading enzymes as a promising technology with the potential to improve feed utilization in ruminant animals. Enzymes can be applied to straw in their pure form or through inoculation with appropriate cell wall degrading microbes. There are many bacterial sources of enzymes. However, in general, Bacillus subtilis, Lactobacillus acidophilus, L. Plantarum, and Streptococcus faecium, spp. are the source of bacterial enzymes (McAllister et al, 2001). Straw can be directly treated with enzymes or indirectly through inoculation of straw with fungi or bacteria. Enzymes may be used alone (Dai, 2007) or in combination with physical and/or chemical treatments (Pedersen et al, 2010).There have been many in vitro biological delignification studies using straw and fewer in vivo studies.

### 2-2-3-1 Combined Enzyme and Chemical Treatment

(Wang, 2004) found that an alkali pre-treatment of 5% sodium hydroxide by weight on wheat straw improved the efficacy of exogenous fibrolytic enzymes. As explained previously; alkali increases straw pH causing lignin-carbohydrate complexes to disassociate.

Oncethelignin-carbohydrate complexes are disassociated fibrolytic enzymes are able to acton the disassociated carbohydrate remnants creating monosaccharide's or other shorter chain carbohydrates

(Wiedmeier, 2012). Efficacy of fibrolytic enzymes is increased through alkali pre-treatments. (Wang, 2004) treated wheat straw with ammonia, 3% by weight on a dry matter basis, four months prior to feeding. Enzymes were applied to the straw just before feeding to 32 cows. Total nitrogen as well as dry and organic matter digestibilities were significantly ($P<0.05$) increased by applying enzymes to ammoniated straw before feeding. (Morgavi, 2001) had determined that exogenous enzymes are more stable in the rumen than expected, especially if applied prior to ingestion. (Nagaraja, 2012) suggested that applying enzymes just prior to feeding allows enzymes to bind to substrate feed protecting them against proteolysis and increases enzyme residence time in the rumen environment. (Wang, 2004) presumed that enzyme efficacy was increased by breaking esterified bonds and the release of phenolic compounds or by enhancing the enzyme penetration. (Eun, 2006) determined that ammonia pre-treatments are more effective than in vitro degradation of rice straw with exogenous enzymes alone. The study demonstrated that there is a synergistic effect between ammoniated pre-treatment and the action of exogenous enzymes in the degradation of rice straw. Using ammonia pre-treatments with exogenous enzymes improves ruminal digestibility of rice straw.

**2-2-3-2 Enzyme treatment alone**

(Beauchemin, 1995) treated alfalfa hay, timothy hay, and barley silage with levels of xylanase and cellulose and fed the treated feeds to 72 steers weighing 289 kg on average. The enzyme treated alfalfa and timothy hay increased weight gains in the steers by 30 and 36% respectively. However, there was no response to enzyme treatment from the barley silage. Beauchemin concluded that xylanase and cellulase increased weight gain in beef cattle and that ideal enzyme levels depended on forage type.

### 2-2-3-3 Fungal Treatments

White rot fungi (Basidiomycetes) produce extracellular phenoloxidases as well as hemicellulases, and celluloses. Lignocellulolytic enzyme production make white rot fungi very attractive as a biological treatment of straw for animal feed (Sharma and Arora, 2010). (Jafari et al, 2007) found that the in vitro digestibility of rice straw, inoculated with four Pleurotus species, was increased significantly. In degrading straw, of the four Pleurotus species studied, Sajor-caju fungus exhibited the greatest in vitro dry matter digestibility and in vitro organic matter digestibility with 80.10 and 82.18%, respectively.

(Fazaeli, 2008) treated wheat straw with Pleurotus florida (oyster mushroom). Results showed that fungus treated straw had significantly ($P<0.05$) greater crude protein and in vitro digestibility and a decrease in organic matter and cell wall components compared to research to provide solutions to the straw–lignin problem. Most research into physical and chemical treatments used to degrade straw into a usable form was carried out prior to 2000.Currently; biological treatments seem to be the direction of straw research. Based on the trend of present scientific literature it seems that discovery, selection, and manipulation of ligninocelluloic enzymes will be the future emphasis of feed straw research. Research into the discovery, selection, and use of whole lignin degrading organisms, such as white rot fungi, is in its infancy and will probably continue to expand in the future. As world demand increases for fossil fuels and grain supplies the economics and practicality of converting straw to more usable forms will become more crucial.

### 2-3 STRAW Definition

Straw is the dried, above ground, remains of physiologically mature plants from which seeds have been harvested (Leighty, 1924). As plants become physiologically mature, nutrient rich concentrates such as fat, starch, and protein are accumulated in the seeds. Accordingly, less valuable nutrients like cellulose, hemicellulose, and lignin remain in the straw. Generally, straw is comprised of plant stem and leaf fractions. However, because of non-selective processing inherent in modern harvesting equipment, straw can contain other plant parts.

### 2-3-1 Straw Composition

Straw has several botanical fractions (Plate 1). Leaves are typically thin flat plant organs which specialize in photosynthesis.Stems are above ground plant structures that support leaves and flowers. Nodes are the part of the stem where leaves are attached and internodes are areas between nodes on a stem (Antongiovanni and Sargentini, 1991). Ratios of botanical fractions vary with species, variety, and growing environment.

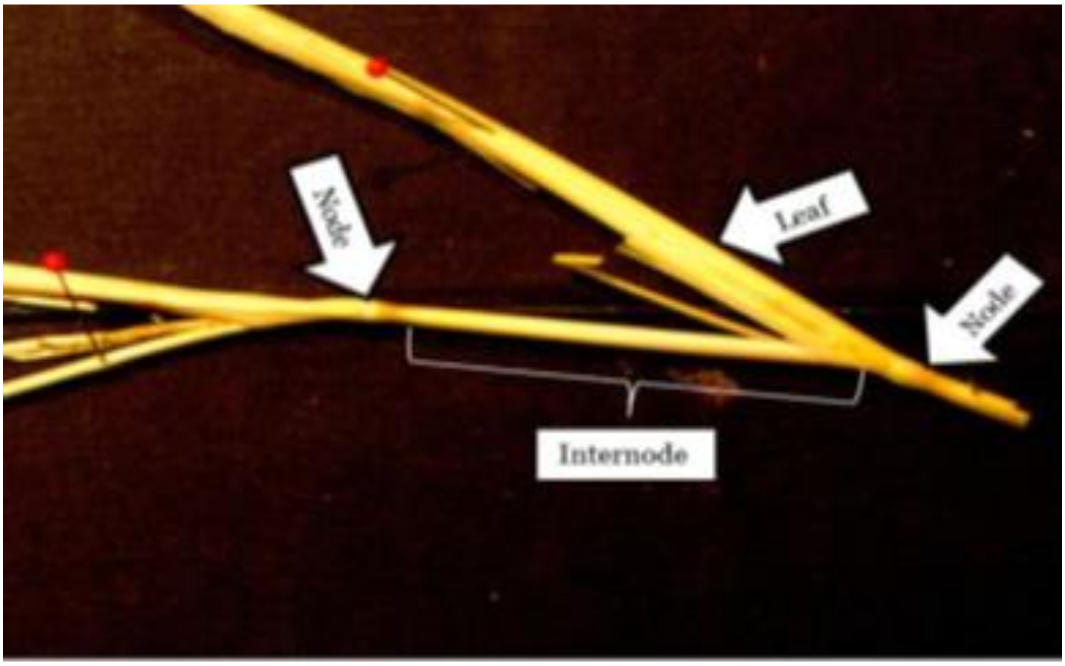



**Plate (2-1) Botanical fractions of straw (Source: J.severe, 2012)**

In addition to function and structure, botanical fractions vary in chemical composition such as protein, cellulose, hemicelluloses and lignin. Among botanical fractions, internodes are highest in lignin while leaves and nodes have the greatest protein content.

Hemicelluloses are highest in nodes and cellulose is highest in internodes (Antongiovanni and Sargentini, 1991).

**2-3-2 Plant cell wall development**

Plant cell walls are laid down in layers from the outside of the cell inward (Esau, 1977). The first cell wall layer is laid down during cell division. The Golgi apparatus provides vesicles of non-cellulosic Polysaccharides which migrate and form a cell plate between the two daughter cells. The vesicles dump their contents along the cell equator.

Vesicle membranes become the new cell membrane and vesicle contents form the new cell wall. Initially, vesicles contain mostly pectic polysaccharides. Asplant cell growth proceeds, pectic polysaccharides continue to be deposited and so the first layer of cell wall thickens. This first layer of the cell wall is called the middle lamella (Saupe, 2011).

**2-3-3 Cellulose**

Cellulose synthase is produced at the rough endoplasmic reticulum. Cellulose synthase is packaged into vesicles, and then deposited at the membrane of the plant cell. Once deposited in the membrane cellulose synthase begins producing cellulose to be laid down as the primary cell wall. Cell wall proteins are also laid down in the same way. It is not fully understood how plant cell wall components are joined. Two methods are assumed. Either the components undergo self-assembly or undergo enzymatic assembly (Saupe, 2011). After plant cells stop enlarging, the secondary cell wall is laid down in the same way the primary wall was produced. The secondary cell wall is made mostly of cellulose and smaller portions of hemicellulose and lignin (Zhong and Ye, 2009).

Lignin is deposited primarily in the secondary cell wall. How lignin deposition is carried out and directed to specific sites within the cell wall is not fully understood (Li and Chapple, 2010). A helpful visual summation of plant structure is given by (Yarris, 2012).

**2-3-4 Hemicelluloses**

Hemicelluloses are a group of heterogeneous polysaccharides which are formed through biosynthetic routes different from that of cellulose (Corredor, 2008). Hemicelluloses are polysaccharides in plant cell walls that have β-1,4-linked backbones with an equatorial configuration with the function to strengthening the cell wall by interaction with cellulose and, in some walls, with lignin (Scheller and Ulvskov, 2010). Unlike cellulose, hemicelluloses is composed of combinations of C5 and C6 sugars such as pentoses (Xylose and Arabinose) and/or hexoses (mannose galactose, and glucose), and it is frequently acetylated and has side chain groups such as uronic acid and the 4-O-methyl ester (Hu and Ragauskas, 2012). In general, the dominant component of hemicellulase from hardwoods and agricultural plants, such as grasses and straws, is xylan, while glucomannan is prevalent for softwoods (Hu and Ragauskas, 2012; Pu et al., 2008). In contrast to cellulose, which is crystalline and strong, hemicellulases have a random, amorphous, and branched structure with little resistance to hydrolysis, and they are more easily hydrolysed by acids to their monomer components (Taherzadeh and Karimi, 2008).

**2-3-5 Lignin**

Lignin offers the plant mechanical strength and resistance to microbial degradation (Vanholme, et al., 2010). Phenolic compounds in lignin act as physical barriers to rumen microbes and have anti-nutritive actions (Antongiovanni and Sargentini, 1991). Lignin content in cereal straws is a major barrier in the use of straw in diets of ruminants (Flachowskya et al., 1999). Lignin is the most significant factor limiting the digestibility of cell wall materials in ruminants and other anaerobic digestion systems (Van Soest, 1994).Rice straw is unique, where silica and lignin are both major barriers to straw utilization by ruminants (Van Soest, 2006).

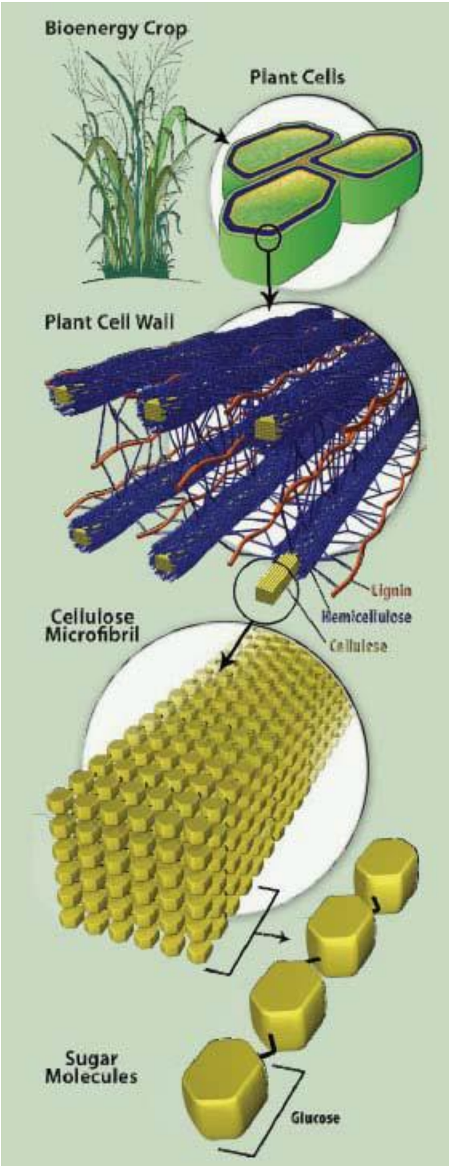



**Plate (2-2) Lignocellulose is made up of three components: cellulose, hemicellulose and lignin, which give the cell wall strength and structure (Yarris, 2012).**

## 2-4 Pearl millet in the Sudan

Pearl millet, *Pennisetum glaucum (L.)*,locally known as "Dukhun", is one of the important cereal crops of the Sudan, ranking as the second most-important cereal crop, after sorghum , both in terms of area and total production. It is the preferred staple food crop for the majority of the inhabitants of western Sudan (Kordofan and Darfur States).The average total area annually planted in the country is about 6 million feddans (2.5 million ha). About 95% of this area is found in Western Sudan (Abuelgasim, et al, 1992). The grain is consumed as human food mainly in the form of porridge, called "aseeda" or in the form of a thin pancake called "kisra". The stalks can be used as feed for animals but they are also used as building material or fuel.

### 2-4-1 Pearl millet production in the Sudan

Since pearl millet is a drought and heat tolerant crop capable of producing grain in regions of low soil fertility and limited moisture, where other summer cereals like sorghum and maize, may fail, it occupies the marginal low-rainfall areas of western Sudan(Abuelgasim,et al,1989) . This is mainly due to its extensive and more efficient root system, as well as its high ability to produce tillers. Although the crop is grown in areas where rainfall ranges between 200 mm to more than 1000 mm, most of it occurs in areas receiving 250-700 mm. In Western Sudan, most of the pearl millet production is centered in the extensive sandy soils “Goz” occupying the northern parts of the region. These are marginal areas with less than 400mm rainfall. In these areas, pearl millet is the most extensively grown crop, and therefore, a millet-based farming system prevails. However, the cultivation of the crop extends further south into the clay soils where rainfall goes upto700 mm. Within these southern areas, usually locations of lighter and sandier soils are assigned to pearl millet. The average total pearl millet area annually planted in the Sudan ranges from 5 to 7 million feddans (2.1 to 2.9 million ha). The crop is almost exclusively grown under rain-fed conditions, with about 98% of it being produced under traditional farming practices, mostly using local varieties (Abuelgasim, et al, 1997). Being an indigenous crop that has been growing for centuries in Western Sudan area, pearl millet has a wide diversity of local types. This diversity has been encouraged by the fact that pearl millet is a highly cross-pollinated crop (with 80% or more cross -pollination). Farmers continued to grow local varieties that are usually heterogeneous populations with broadly based genetic composition. Within the same farmer's field, usually many different plant types can be seen. In spite of this within population variability, a number of local varieties or landraces could be identified and named by farmers in Western Sudan.

The most widely known varieties include the following:

**1- Dembi**: This is the most popular and widely grown local variety in Kordofan. It has a light brown to yellowish brown seed color. It is comparatively late in maturity (around 120 days) with a medium or tall plant height.

**2- Aish Bernu**: Characterized by a slate grey seed color and a very compact head type that gives it some resistance to the attack of the head worm "Naffasha" (Heliocheilus albipunctella). The plant is usually tall and late in maturity. This variety is most probably a long time introduction from West Africa.

**3- Hammer**: Characterized by having deep yellow seeds with a reddish tinge. Its head is comparatively thick. Porridge 'Aseeda' made out of it is yellow in color and is described as having a strong smell characteristic to millet. The variety was mostly in Hammer area (El Nuhud), but it is disappearing and now is mostly confined to El Magrur- El Odeya area in West Kordofan.

**4- Sharoba**: Has a creamy white seed color. It is widely grown in the western part of West Kordofan extending from El Nuhud to El Odeya and up to El Deaain in Darfur. It has similarity to the variety "Bauda" of Darfur States.

**5- Bauda**: This is the most popular local variety in Darfur States .It is characterized by having a cream colored grain. It has heads of medium size and it is of medium to late maturity.

**6- Abu Soof** or **Abu Shara**: Refers to strains with bristled heads. They are usually mixed with other non-bristled strains.

**2-4-2 Crop improvement efforts**

The crop improvement efforts on pearl millet in the Sudan, were summarized by(Abuelgasim,1989), (Abuelgasim, 1992)and (Abuelgasim, 1997). In spite of the importance of the pearl millet crop in the Sudan, it did not receive much attention to improve it prior to 1974 when a plant breeder was appointed for starting a pearl millet improvement program in Western Sudan. The breeder was stationed at Elobeid in North Kordofan Province, with the idea of initiating research station there. He started a pearl millet breeding program by collection of the local millet germplasm from different millet growing areas in Kordofan and some parts of Darfur. The crop improvement program was initiated with the objectives of producing adapted improved varieties with high grain yield, early maturity, resistance to prevailing pests and diseases, in addition to having acceptable grain quality and taste. Improvement of the cultural practices was also taken in consideration .The millet improvement program was strengthened in 1977, by imitation of a joint cooperative improvement program with the International Crop Research Institute for Semi-Arid Tropics (ICRISTAT), in India .A plant breeder from ICRISAT was stationed at Elobied to supervise ICRISAT millet breeding program.

This joint program resulted in the release of the first improved millet variety, in January, 1981, under the name of 'Ugandi'. This was an improved composite variety that was early maturing, with bristled heads and grey seeds color. The millet improvement program in the Sudan, also received help from the International Sorghum and Millet Improvement program (INTSORMIL) of USA. The second improved millet variety, named 'Ashana', was released in the year 2000. It is an introduction, (SDMV 93032), from ICRISAT Millet program in Zimbabwi (SADIC program) .The variety 'Ashana' is characterized by early maturity, resistance to downy mildew disease, and has grey grain color. Presently, the millet improvement program is continuing at three main research stations, namely, Wad Medani, Elobied and Sennar stations. It has the same objectives as before, and it depends mainly on local funding of research activities.

**2-5 Digestibility of the straws**

Dry matter digestibility (DMD), is related to nutrient composition. The digestibility of cellulose and cell walls decreased as the lignin to cellulose or lignin to acid detergent fiber ratio increased (Robbins and Moir, 1975). The ammonia treatment was the most effective producing an increase of +10 points for organic matter and +12.5 for cell walls , followed by the free treatment with urea and soya beans , which gave an increase of +8.7 points for organic matter and +10.7 for cell walls (Dulphy et al.,1992 ) .

**2-6 Regulation of voluntary feed intake**

Control of feed intake and regulation of energy balance in ruminants were extensively reviewed at the Third International Ruminant Symposium (Arnold, 1970a, Baumgardt, 1970, Campling, 1970) and thereafter by (Baile and Forbes, 1974). In a review by Baile (1975), several intake-controlling mechanisms were discussed such as humoral factors, neural transmitters, and chemical and hormonal mechanisms, as well as digestibility, reticulo-rumen fill, and rate of passage. The effect of oral and abomasal infusions of volatile fatty acids on feed intake was studied by Papas and Hatfield (1978). Effect of particle size of hay on digestion and retention time in sheep was studied by Fadlalla et al., (1987) who found a decrease in mean retention time and digestibility of hay in the rumen as well as the whole digestive tract with the decrease in particle size. The bulky, fibrous nature of most range ruminant diets, and their relatively low content of digestible energy, point to the importance of the physical effect of gut fill in limiting voluntary intake. Considerable evidence is available showing, with predominantly roughage diets, voluntary intake is limited by capacity of the reticulo-rumen and by rate of disappearance of digesta from this organ (Balch and Campling 1962, Ellis,1978). Rate of disappearance depends on rate of passage and rate of absorption. Voluntary food intake is limited by physical conditions within the gut and particularly by amount of digesta in the reticulorumen. Studies concerning effects on voluntary intake of intraruminal additions or removals of food and other materials, relationship between rumen-fill and voluntary intake, and relationship between rate of disappearance of digesta and voluntary intake, support the previous statement and were reviewed by (Campling, 1970). Feed intake by the animal is a key component in diets development and feeding strategies for optimizing the animal production (Pereira et al, 2003).

# Chapter Three

# Materials and methods

## 3-1The study area:

The study was carried out at North Darfur State, Sudan (Map 1).The state lies between latitudes 12° 30"and 21° 55" *N* and longitudes 24° 00" and 27° 30" *E* within the arid and semi-arid zones.The state can be divided into two main geographical zones based on average amount of annual rainfall and soil types. These are the desert and semi-desert zones; the two together cover an area of about 296,400 $km^2$; about 60% of it is rangelands. The state includes 13 localities; Elfasher, Kutum, Milliet, Dar elslam, Tawella, Elsirief beni husien, Umkaddada, Eltiwesha, Elaiyd, Kabkabia, Sarf oumra, Karnoy and Eltinna (Map 2).

### 3-1-1Population

The total population of North Darfur State is estimated at 2.1 million. The rural, urban and nomadic population constitutes 64%, 16.8% and 19.2% respectively (Adam, 2013). The majority of the rural populations are small farmers who cultivate crops and raise a small number of livestock. Animal production is contributes significantly to the economy of the State which is considered among the leading regions of Sudan in terms of animal resources that are estimated at 6,916,641 heads of sheep, 4,953,979 goats, 1,331,486 camels and 400,594 cattle (Animal Statistic and Planning, Admin, 2009).

### 3-1-2 Climate

There are three distinct seasons in the area, the hot rainy season or autumn (Khareef) from June to September, the cool season or winter from November to February and the hot dry season or summer from March to May. The average annual rainfall for the last ten years was 218.09 mm. The mean, minimum and maximum temperatures are 17.7C$^{o}$ and 34.7C$^{o}$ respectively (Elfasher Metrological Station, 2014).

The major geological formations in Darfur according to hunting technical Services (HTS) (1976) are:

(a) Basement complex rocks covering more than 45% of the area. These do not bear ground water aquifers and water availability is confined to some localized fractures.

(b) Naga formations which are rarely found as outcrop on the surface. These are composed of fine grain and are poor in terms of carrying groundwater.

(c) Nubian sandstone that covers more than 30% of Darfur. This formation bears rich water aquifers.

(d) Tertiary volcanic which is formed after volcanic eruptions and is mainly found in Jabal Marra area.

(e) Um Ruawaba formation lies over the Nubian Sandstone.

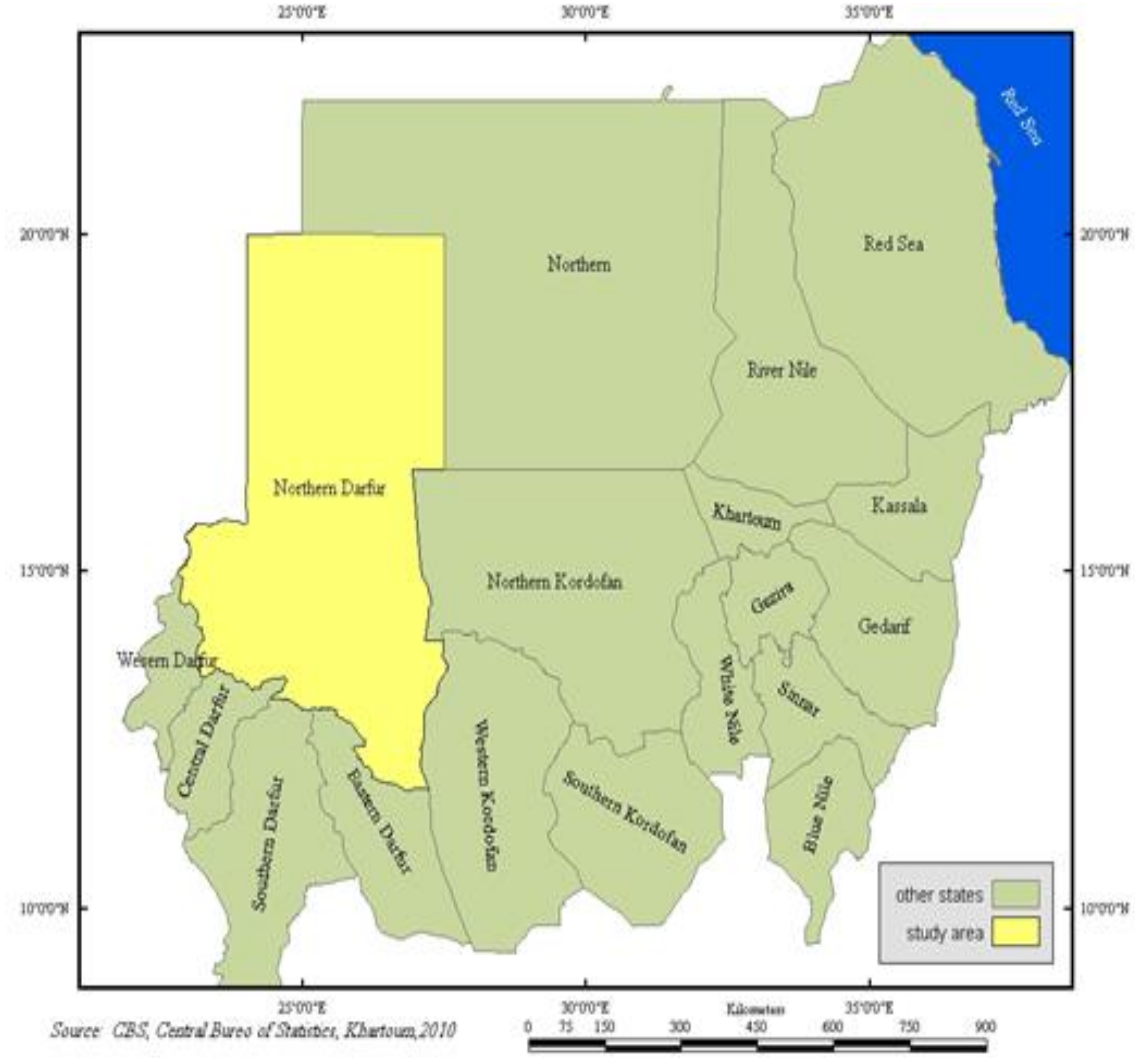
### 3-1-3 Vegetation

Vegetation type is closely associated with rainfall. As the amount of rainfall increases, so do the height and density of vegetation. The vegetation composition will contain more preferable and palatable types as the rainfall increases. Using Harrison and Jackson zonation of the Sudan vegetation (1958), classified the area as semi-desert vegetation.

This zone is characterized by sparse and patchy vegetation cover, mainly formed of thorny scrub trees. The dominant tree species are *Acacia Senegal* (Hashab), *Acacia mellifera* (Kitter), *Boscia senegalensis* (Mukhait), *Acacia tortilis* (Seyal), *Acacia nubica* (Laot), *Faidherbia albida* (Haraz), *Maerua crassifolia* (Sereh), and *Balanites aegyptiaca* (Heglig). Annual grass cover composed mainly of *Cenchrus sp.* (Haskanit), Aristida *sp.* (GAW), *Echinocloa colonum* (Difra), *Eragrostis sp.* (Banu), and *Dactyloctenium aegyptium* (Abuasabi).

**3-1-4 Millet Production**

Summarizes the production statistics of millet (*dukhn*) for the last ten years in Sudan. The area under millet is about 5 million feddans (about 2.1 million ha), located mostly in the lighter soils of western Sudan. Millet production in season (2000/2001) was estimated at 479 thousand tons, averaging 92 kg /feddan. Around 93% of the millet crop is produced by the traditional rainfed sector, of which 66 % and 24 % come from Darfur and Kordofan respectively.These sandy areas of Darfur and Kordofan are classified as marginal lands where rainfall is about 400mm/annum, creating an environment unsuitable and unfavourable for the cultivation of other crops (Abuelgasim, 1997).

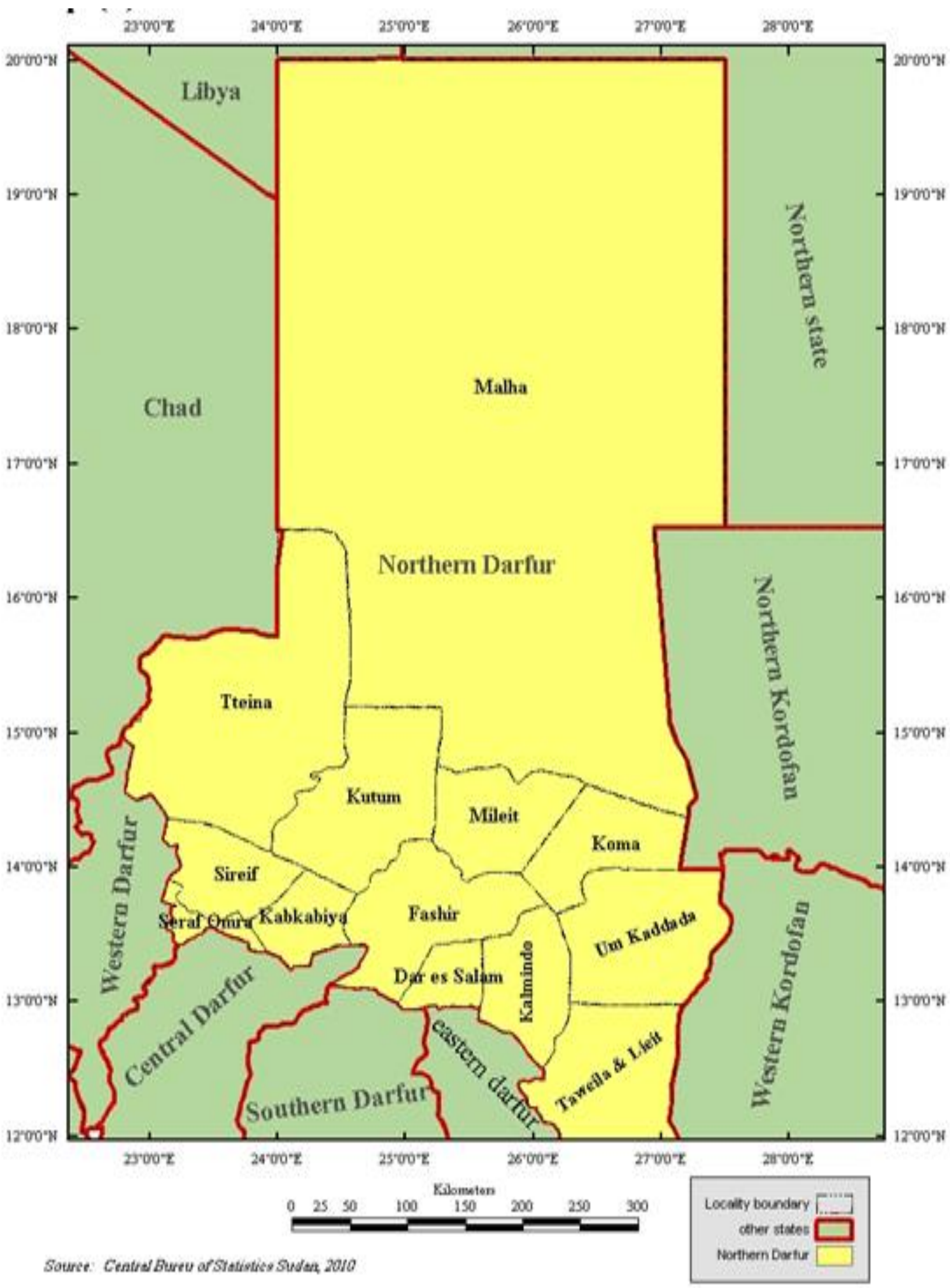



**Map (1) Location of Northern Darfur within the Sudan**

## Table (3-1) Millet Production in North Darfur

| Year | Plantd area (Fedan) | Harvested area (Fedan) | Total grain production (Ton) | Total straw production (Ton) |
|---|---|---|---|---|
| 1992 | 5207661 | 3071479 | - | - |
| 1993 | 6114378 | 1392820 | - | - |
| 1994 | 3407502 | 2320015 | - | - |
| 1995 | 2081997 | 682412 | 123700 | 82134 |
| 1996 | 1720256 | 527667 | 284123 | 652341 |
| 1997 | 435209 | 235681 | 1412150 | 125875 |
| 1998 | 2211415 | 1861019 | 3120461 | 812409 |
| 1999 | 424298 | 283570 | 166076 | 580380 |
| 2000 | 234657 | 231465 | 87969 | 439845 |
| 2001 | 2120813 | 922822 | 60943 | 304715 |
| 2002 | 2181887 | 1794091 | 96197 | 480985 |
| 2003 | 2607477 | 2308793 | 74163 | 370815 |
| 2004 | 1349666 | 387298 | 23305 | 116525 |
| 2005 | 1405956 | 503591 | 311005 | 15550 |
| 2006 | 1138959 | 591364 | 52741 | 2737705 |
| 2007 | 1784307 | 571198 | 54415 | 272075 |
| 2008 | 1391443 | 1074356 | 106678 | 533390 |
| 2009 | 309356 | 228353 | 18809.1 | 9404505 |
| 2010 | 1613667 | 1224246 | 79914 | 399570 |
| 2011 | 1412734 | 1161285 | 119879 | 5993980 |
| 2012 | 1567436 | 1440764 | 172234 | 8611670 |
| 2013 | 1636809 | 1505487 | 164116 | 8208580 |
| 2014 | 1820538 | 1209879 | 1702453 | 9852349 |

Source: Planning and Agriculture Administration, Elfasher (2014)




**Map (2) Northern Darfur Location and localities**

**Table (3-2): Average maximum and minimum temperature ($^{0}C$) and relative humidity (%) at Elfasher town**

| Month | Maximum Temp | Minimum Temp | Relative Humidity |
|---|---|---|---|
| January | 29.4 | 9.9 | 25 |
| February | 31.8 | 11.9 | 21 |
| March | 35.2 | 15.9 | 17 |
| April | 37.9 | 19 | 18 |
| May | 38.9 | 22.1 | 25 |
| June | 38.5 | 23.3 | 32 |
| July | 35.8 | 22.9 | 51 |
| August | 34.6 | 22.3 | 58 |
| September | 35.8 | 21.8 | 45 |
| October | 36 | 19.5 | 31 |
| November | 32.7 | 13.7 | 26 |
| December | 29.8 | 10.5 | 25 |
| Average | 34.7° | 17.7° | 31% |

Source: Elfasher Metrological Station, 2014

**Table (3-3) Annual rainfall at Elfasher Town from 2000 to 2014**

| Season | Apr | May | June | July | Aug | Sep | Oct | Total |
|---|---|---|---|---|---|---|---|---|
| **2000** | NR* | 21.7 | 21.1 | 100.4 | 76.2 | 27 | 21.6 | **268** |
| **2001** | NR* | 1.4 | 43.6 | 68 | 33.3 | 18.9 | NR* | **165.2** |
| **2002** | NR* | 3.3 | 21.1 | 58 | 55.6 | 27.4 | 1.3 | **166.7** |
| **2003** | NR* | 3.8 | 16.3 | 69.5 | 97.8 | 4.8 | 2.1 | **194.3** |
| **2004** | NR* | 0.6 | 28.4 | 42.2 | 36.6 | 8.7 | NR* | **116.5** |
| **2005** | NR* | 23.3 | 4.5 | 58.9 | 188.5 | 42 | NR* | **317.2** |
| **2006** | NR* | 1.2 | 8.7 | 78.3 | 107.9 | 52.1 | NR* | **248.2** |
| **2007** | NR* | 8.7 | 3.9 | 42.9 | 205.3 | 20.2 | NR* | **281** |
| **2008** | 6.1 | 1.5 | 5.4 | 37.9 | 83.4 | 24.8 | NR* | **159.1** |
| **2009** | NR* | NR* | NR* | 70.7 | 37.9 | 9.5 | 13.4 | **131.5** |
| **2010** | NR* | NR* | 8.9 | 108.4 | 69.4 | 37.4 | 15.9 | **240** |
| **2011** | NR* | 42.1 | 7.9 | 18.6 | 50.6 | 28 | NR* | **147.2** |
| **2012** | NR* | 19.2 | 18.7 | 59.5 | 166.9 | 23.4 | NR* | **287.7** |
| **2013** | NR* | 0.9 | 20 | 139 | 67.5 | 25.1 | NR* | **252.5** |
| **2014** | NR* | 20.5 | 26 | 96.5 | 145 | 37.3 | 15 | **340.3** |
| **Mean** | 0.4 | 8.7 | 15.6 | 69.9 | 94.8 | 25.8 | 4.62 | **208.1** |

Source: Elfasher Metrological Station, 2014 (NR*= not recorded)

### 3-2 Experimental dietary treatments

A100kg of millet straw was ground in a hammer mill, mixed thoroughly, and sprayed with a solution of 4 kg of urea and 1% salt dissolved in 50 liters of water. The treated straw was put in a plastic bag after thorough mixing, pressed to exclude air and then stored. A similar amount of chopped millet was treated as above and stored in plastic bags. The bags were sealed, kept air-tight and left for three weeks at room temperature. Controls made of a 100kg each of ground and chopped millet straw sprayed with a solution of 1% salt dissolved in in 50 liters of water were also put into plastic bags, pressed to exclude air, sealed and stored at room temperature for three weeks. All straws were then dried in the sun before fed to animals. A total of 800 kg of millet was prepared.

**Table (3-4) straw was then offered to rams in a 4x4 Latin square design**

| A | B | C | D |
|---|---|---|---|
| 1 | 4 | 2 | 3 |
| 3 | 1 | 4 | 2 |
| 4 | 2 | 3 | 1 |
| 2 | 3 | 1 | 4 |

A = Ground, treated straw      B= Ground, untreated straw

C = Chopped, treated straw     D = Chopped, untreated straw

1,2,3,4 = Animal numbers

### 3-3 Experiment animals

Experimental animals were four desert rams about one year of age, with average weight of 23.5kg. The rams were bought from the surrounding markets and treated with Ivomec against internal and external parasites. They were also dipped in diluted cypermethrin and were also provided with salt lick plus vitamins. The rams were given the experimental diets for an adaptation period of three weeks during which the diets were offered adlibitum to fix the amount to be given during the experimental period. At the end of the adaptation period the animals were given the experimental diets for ten days during which feed offered, refusals and feces excreted were weighed and dried for determination of in vivo digestibility and dry matter intake.

### 3-4 Physical treatment

**3-4-1Chopping** by machines with knives or flails cuts the blades of straw into relatively long sections (from 1 to 10 cm) (Plate 1).

**3-4-2Grinding** with a hammer mill produces straw particles which are less than a centimeter in length (abut 2-5 mm) (Plate 3-1).The particles resulting from mechanically treated straw are usually agglomerated so as to reduce their volume and ease handling.

### 3-5 Chemical treatment

It is this category of treatment techniques which has attracted the most attention both from a research and development point of view. These treatments are in fact very efficient and indeed some of them, as will be emphasised below, extremely easy to put into practice.

**Urea** was cheaper, easily available and assumed to be equivalent to anhydrous or aqueous ammonia for upgrading cereal straws in the warmer regions of the world, and simple practical and the material to be used in the treatment is available on the farm. Experiment was used 16kg urea proportion 4% per 400 kg millet straw. (Plate 3-2).

**Plate (3-1): Physical treatment**

**Plate (3-2): Chemical treatment**

### 3-6 Dry matter intake and digestibility

Dry matter intake and digestibility were determined as:

- DM straw offered – DM straw refused =DM intake
- DM intake – DM feces excreted = DM feed digested
- Digestibility% = {(DM feed digested /DM feed consumed) X100}

**Plate (3-3) The Sheep intake**

### 3-7 Chemical analysis

Samples of the experimental feedstuffs were analyzed for dry matter, ash, crude protein, ether extract, crude fiber, nitrogen free extract and ADL at the Central Animal Production Research Laboratory at Kuku, Khartoum North. Chemical composition was done according to AOAC (1980).

### 3-8 Socioeconomic Study

A socio-economic study was carried out to explore the various uses of millet straw by farmer households in North Darfur. For that purpose a questionnaire was designed and distributed to 50 respondents from 5 Villages around Elfasher, the capital of North Darfur State.

### 3-9 Statistical analysis

Data were analyzed using one- way ANOVA using SAS software.

(Stiststix 9 was used for treatment data analysis)

Data of socioeconomic were analyzed on a personal computer using statistical package for social science (SPSS) software.

# Chapter Four

# Results and Discussion

This chapter reports on and discusses the effects of feeding millet straw in the chopped or ground form with or without urea treatment to sheep on chemical composition, digestibility, and voluntary feed intake. It also addresses some socio-economic aspects of millet straw production and consumption.

**4-1Chemical composition of treated and untreated millet straw**

Table (4-1) shows the chemical composition of millet straw under different treatment. Treatment with urea resulted in increased CP% both in the ground and chopped form (14.58% and 14.61respectively) compared with untreated straw (7.8and11.9%respectively).Neutral detergent fiber was also lower in urea treated straw compared with untreated both in the ground and chopped form(62.50 and 66.0% respectively) compared with untreated straw(65.50and72.50% respectively) The crude protein values of millet straw in this study were comparable with values reported by Fall et al. (2005) and Redden (2012), However the value were higher than would be expected of natural grass in Botswana (4.4% in natural grass harvested at full maturity (APRU, 1975). Content of CP of pearl millet straw in the present study was higher than that of pearl millet straw in studies by Elnazeir and Suaad (2013), Ramana (1990) and Mattoni et al (2007). The variation among studies maybe due to environmental factors, location, climate, soil fertility and soil type. The mean CP in the present study (9.8%) was higher than that obtained for grain sorghum stover tested by Youngquist et al (1990) in Botswana. It was also higher than the mean of 6.2% for grain sorghum residue reported by Snyman and Joubert (1995) in South Africa. Kamalamma Krishnamoorthy et al. (1996) also recorded lower amounts of CP% for finger millet straw than was observed in the present study.

**Table (4-1) Chemical composition of treated and untreated millet straw**

| Treatments | DM% | ASH% | CP% | EE% | CF% | NDF% | ADL% |
|---|---|---|---|---|---|---|---|
| Ground+ urea (A) | 94.90 | 28.98 | 14.58 | 0.40 | 31.20 | 62.50 | 28.50 |
| Ground (B) | 94.80 | 17.50 | 7.8 | 2.40 | 29.40 | 65.5 | 28.00 |
| Chopped +urea (C) | 94.00 | 13.62 | 14.61 | 1.60 | 34.80 | 66.50 | 27.50 |
| Chopped (D) | 92.20 | 13.91 | 11.9 | 1.20 | 30.20 | 72.50 | 28.50 |

DM = Dry matter E.E =Ether Extract CP = Crude protein

CF = Crude fiber NDF =Neutral detergent fiber ADL = Acid detergent lignin

## 4-2 In vivo digestibility

Urea treatment had a positive influence on millet straw digestibility Table (4-2). Dry matter digestibility of urea treated millet Straw was higher both when ground or chopped (64.1 and 65.0%) compared with that of untreated straw (56.5 and 52.4%). The improvement in digestibility could be attributed to an enhancement of rumen microbial activity as a result of increased nitrogen.Ground untreated millet straw had ahigher digestibility than untreated straw in the chopped form, however the difference was not significant($P>0.05$).Grinding usually avails a larger surface area for microbial action. It also breaks the lignin bonds of straw exposing cellulose and hemicelluloses for microbial degradation.

## Table (4-2) Effect of treatments on dry matter digestibility of millet straw in sheep

| Sheep No | Diet physical form | | | |
|---|---|---|---|---|
| | Ground+ urea (A) | Ground (B) | Chopped+ urea (C ) | Chopped (D) |
| 11 | 62.0(1) | 50.0(2) | 66.0(4) | 54.5(3) |
| 22 | 65.5(4) | 54.0(3) | 67.0(1) | 46.0(2) |
| 33 | 61.0(2) | 61.0(4) | 60.0(3) | 54.0(1) |
| 44 | 68.0(3) | 61.0(1) | 67.0(2) | 55.0(4) |
| Mean | $64.1^{a}$ | $56.5^{b}$ | $65.0^{a}$ | $52.4^{b}$ |
| Lsd | At P = 0.05 0.01<br>2.53 3.83 | | | |

a,b =Means in the same row with similar superscript are not significantly different

## 4-3 variation in different treatments of digestibility

| **Treatments** | **Significance of difference** |
|---|---|
| • Ground+ urea (A) v Ground(B) | * |
| • Ground +urea (A) v Chopped+ urea (C) | Ns |
| • Ground +urea (A) v Chopped (D) | ** |
| • Ground (B) v Chopped + urea (C) | * |
| • Ground (B) v Chopped (D) | Ns |
| • Chopped +urea (C) v chopped (D) | ** |

**Ns not significant    * Significant at P>0.05    **significant at P<0. 01**

**Table (4-3) Body weight of experimental sheep**

| Parameter | Period 1 | Period 2 | Period 3 | Period 4 |
|---|---|---|---|---|
| Number of sheep | 4 | 4 | 4 | 4 |
| Mean body weight (kg) | 26.5±2.25 | 25.0±2.02 | 28.2±2.39 | 22.0±1.83 |
| Mean body weight w $^{0.75}$ | 72.48 | 72.07 | 69.56 | 80.99 |

## 4-4 The effect of treatments on dry matter intake

Effect of treatments on dry matter intake of millet straw by sheep is presented in Table (4-4). No significant difference was found between treatments as regards intake of dry matter. A similar result was found by Shehata and Nour (1986) where addition of urea or urea and molasses to millet straw and rice straw in complete chopped or ground diets did not increase feed intake. Data by other authors supported this finding (Abdullah and Wanyoike (1987); and Pond et al (1995). However, voluntary intake of millet straw may be limited by physical factors causing low rates of passage. Grinding usually breaks the lignin bonds of the cell wall and exposes a larger surface area to rumen microbial action, resulting in faster removal of digest from the rumen. This fast removal of residues from the rumen allows more feed intake from ground feeds. However in some cases very fine grinding may limit intake due to dust. In the present study dry matter intake by sheep feed urea treated millet straw was slightly higher than those given millet straw without addition of urea but differences were not significant. Despite the decline in dry matter intake by sheep there is a noticeable increase in the animal weight.

**Table (4-4) Mean voluntary dry matter intake (DMI) and sheep body weight**

| Parameter/ diet | Ground +Urea A | Ground B | Chopped +Urea C | Chopped D |
|---|---|---|---|---|
| Number of sheep | 4 | 4 | 4 | 4 |
| DMI (g / day) | 848 | 807.3 | 848.6 | 834.3 |
| DMI(g / w $^{0.75\ kg}$) | 72.48 | 72.07 | 69.56 | 80.99 |
| DMI(Kg / 100kg BW) | 2.25 | 2.02 | 2.39 | 1.83 |

Significant At P>0.05

## 4-5 Socioeconomic Study

A socio-economic study was carried out to explore the various uses of millet straw by farmer households in North Darfur. For that purpose a questionnaire was designed and distributed to 50 respondents from 5 villages around Elfasher the capital of North Darfur State.

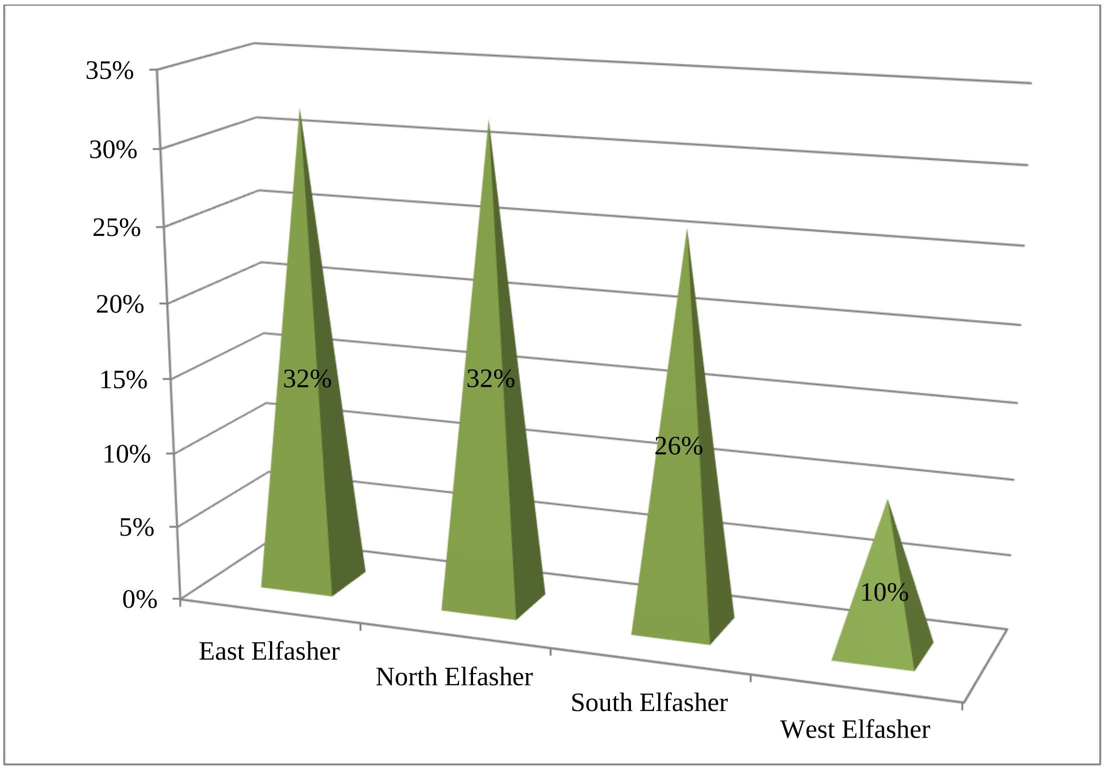



**Plate (4-1) Villages survey according to location from Elfasher Town**

Table (4-5) shows the size of villages, Most of the villages (84%) are composed of more than 100 households with 40% of the villages having more than 250 households reflecting a relatively high population density encompassing mostly pastoralists and farmers. So the provision of agricultural extension services for farmer and pastoral communities will help upgrade the capacities of these communities for increased production and food security.

**Table (4-5) Number of households in the community**

| Number of households | Frequency | Percent |
|---|---|---|
| 25-49 | 1 | 2 |
| 50-99 | 7 | 14 |
| 100-249 | 22 | 44 |
| More than 250 | 20 | 40 |
| Total | **50** | **100** |

Agriculture and grazing is the most important sources of income in the study area, including grain, vegetable fruit and forest products. There are also vast pastoral areas utilized by livestock of various kinds, but there are a lot of problems that face the development such as security problems and problems between pastoralists and farmers themselves, Fluctuation of rainfall in some seasons is a major constraint. Sources of income of communities are shown in Table (4-6). The main source of income is derived from traditional and or shifting agriculture as reported by 84 % of respondents. Horticulture contributed 10% while pastures contributed 6%.Other sources of income are obtained through working with NGOs in the area, gold mining and remittances from household members working in other parts of Sudan and abroad. All these reasons have contributed directly or indirectly to the stability of these communities.

**Table (4-6) Main source of income in the community**

| | Frequency | Percent |
|---|---|---|
| Traditional and / or shifting agriculture | 42 | 84 |
| Horticulture | 5 | 10 |
| Pastures | 3 | 6 |
| Total | **50** | **100** |

Water sources vary in these areas, such as wells and the excavation and Shallow water, but far away from the population, which requires much effort and time to connect to it. Water sources include Hafeers, hand pumps and others. Most villages depend on more than one source of water Table (4-7). However water is not clean and contains some pollutants, which negatively affected the health of the population. Water prices were high reaching more than two pounds per 50-liter.

**Table (4-7) Source of water for the community**

| | Frequency | Percent |
|---|---|---|
| Multiple | 34 | 68 |
| Hafeer | 10 | 20 |
| Hand pumps | 5 | 10 |
| Others | 1 | 2 |
| Total | **50** | **100** |

Difficult access to big markets in cities forces people to sell their agricultural products locally in village market or in neighboring villages at very low prices which reflect negatively on household income and production in the next season Table (4-8).

**Table (4-8) Community access to market**

| | Frequency | Percent |
|---|---|---|
| Village market | 19 | 38 |
| Nearby village market | 14 | 28 |
| Town market | 10 | 20 |
| All the above | 7 | 14 |
| Total | **50** | **100** |

Impact of conflict was reflected in deterioration of natural resources Table( 4-9).Conflict displaced communities to more secure areas where crowdedness led to the misuse of resources on those areas causing damage to forests and pastures, due to use in construction and fuel, as well as overgrazing. About 66%of respondents reported presence of overgrazing while 64% reported forest burning.

**Table (4-9) Overgrazing and Forest burning problems**

| | **Overgrazing** | | **Forest burning** | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| Yes | 33 | 66 | 32 | 64 |
| No | 17 | 34 | 18 | 36 |
| Total | **50** | **100** | **50** | **100** |

In table (4-10) some of the proposals to improve and develop the local environment were provided by communities. Improving the environment means maintaining of resources and through rational ways. Availability of water sources directly and indirectly contribute to the improvement of the environment and sustenance of the various resources, because availability of natural resource in any community means stability. About 68% of respondents suggested that improving forests and pastures would improve environmental conditions.

**Table (4-10) the main actions that could be taken to improve the environmental conditions in the community**

| | Frequency | Percent |
|---|---|---|
| Improving forest and Pastures | 34 | 68 |
| Use of agricultural machinery and ending war | 12 | 24 |
| Improving water service | 4 | 8 |
| Total | 50 | 100 |

Use of agricultural machinery showed major development even in smallholder agriculture, leading to an increase in the production and productivity of most crops the residues of which can be very useful and used to feed ruminants in dry period (objective of this study) .The main activities practiced by communities according to respondents are presented in Table (4-11). Traditional small holder farming and pastoralism was 60% of community activities while traditional small holder farming and horticulture constituted 28%.

**Table (4-11) the main agricultural or livestock activities undertaken by the community**

| | Frequency | Percent |
|---|---|---|
| Traditional small holder farming and Pastoral | 30 | 60 |
| Traditional small holder farming and Horticulture | 14 | 28 |
| Mechanized small holder farming | 2 | 4 |
| Horticulture | 2 | 4 |
| Traditional small holder farming | 1 | 2 |
| Pastoral | 1 | 2 |
| Total | **50** | **100** |

As can be seen from Table (4-12) about 90% of the communities reported a devastating effect of war on community welfare.

**Table (4-12) Impact of war on production and marketing of millet**

| | Frequency | Percent |
|---|---|---|
| Yes | 45 | 90 |
| No | 5 | 10 |
| Total | 50 | 100 |

Millet is a major crop in North Darfur, It is usually grown in mixed stands with other crops by all communities (Plate 4-2). It is a staple crop that is the main food of most population. It also provides feed for livestock as crop residues. Data about millet production was presented in Chapter 3.

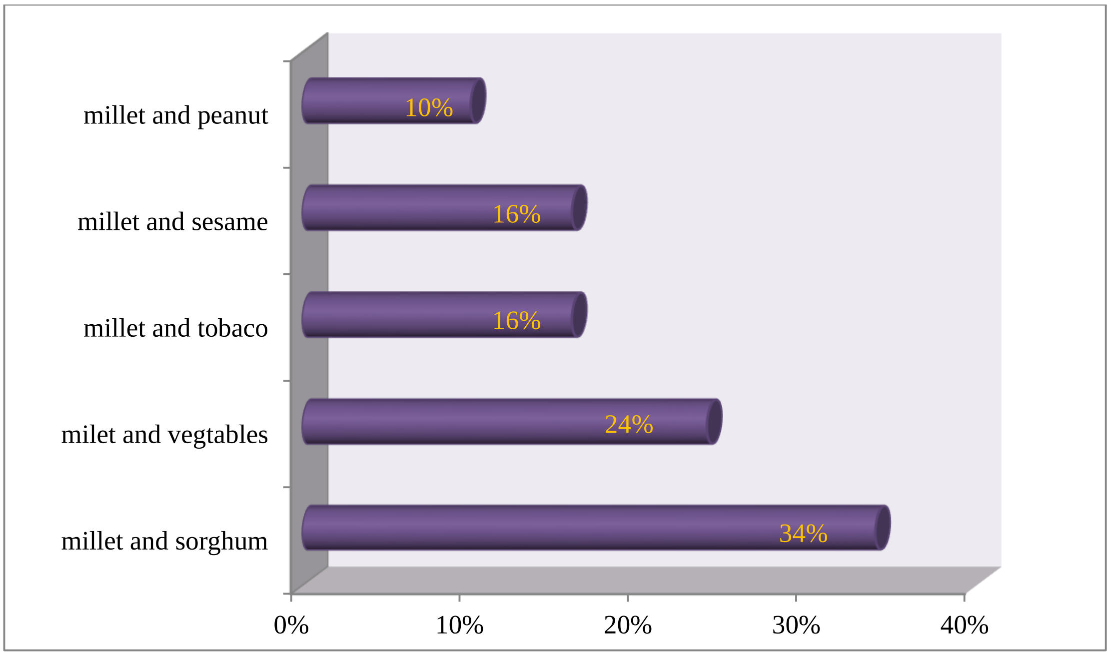



**Plate (4-2) Main crops grown by communities in study area**

Millet is considered by 94% of the communities as the most important staple food crop. About 4% considered it important as building material while 2% use it as animal feed. Since use of stalks for building looked limited there is scope to promote millet stalks as animal feed. This is in line with the objectives of this study which tries to explore ways to enhance the quality of millet straw as animal feed.

**Table (4-13) Uses of millet crop**

| | Frequency | Percent |
|---|---|---|
| The most important food crop in the region | 47 | 94 |
| It is instrumental in building | 2 | 4 |
| Use for animal fodder | 1 | 2 |
| Total | **50** | **100** |

Millet varieties most grown in study area are Dembi and White millet Table(4-14). Dembi is the commonly grown variety (80%) of respondents grow it and is characterized by dark yellow color of the grain that varies from one region to another according to the soil type, It is resistant to agricultural pests to some extent. The white millet is grown in Alsiref, Elfasher, Kabkabiya, Saraf Omra and Klaimindo. It is very sensitive Alnavashh, White millet is used in the manufacture of certain types of food that cannot be made from Dembi.

**Table (4-14) Variety type of millet in study area**

| | Frequency | Percent |
|---|---|---|
| Dembi | 40 | 80 |
| White millet | 10 | 20 |
| Total | **50** | **100** |

When respondents were asked whether they have farms about 96% reported that they do have farms Table (4-15). Farm size ranged between medium and small. Large numbers of animals were also kept, but they lack agricultural extension and some necessary services to help them manage their farms correctly.

**Table (4-15) Respondents land ownership**

| | Frequency | Percent |
|---|---|---|
| Yes | 48 | 96 |
| No | 2 | 4 |
| Total | **50** | **100** |

Average grain production from millet is shown in Table (4-16). Millet is an open pollinated crop which is very sensitive to agricultural pests which have a negative impact on the crop. So selection of appropriate seeds to ensure the quality of production and productivity is needed. The average production per hectare was11sacks of 60 kg capacity.

**Table (16) Average production of millet grain by smallholder farmers**

| Yield (Sacks) | Frequency | Percent |
|---|---|---|
| 2-7 | 36 | 72 |
| 16 | 12 | 24 |
| More than 16 | 2 | 4 |
| Total | **50** | **100** |

Millet stalks are produced in large quantities even in the case of grain production failure, thus providing large amounts of roughage fodder, with an average production per hectare more than 7 tons Plate (4-3).

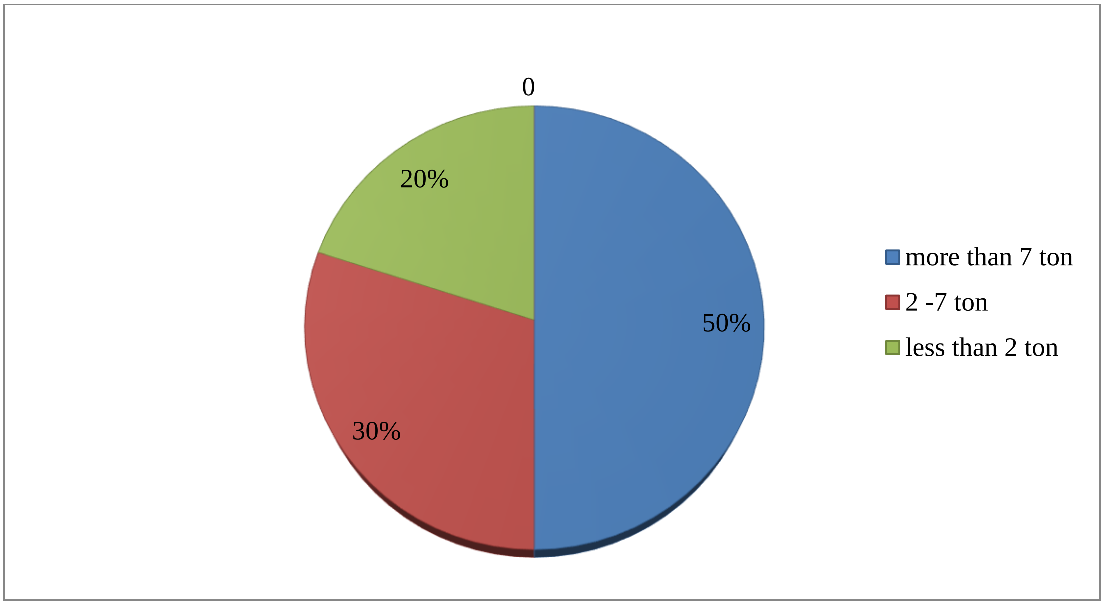



**Plate (4-3) Production of millet stalks (T/Ha)**

Millet stalks contribute to increasing farmers' income when they are sold, because 75% of population uses them to build houses, so are stored in different places, even sell them with building materials. Most millet straw produced was stored on farm and at home Table (4-17).

**Table (4-17) Storage of millet straw**

| Place of storage | Frequency | Percent |
|---|---|---|
| On farm and house | 26 | 52 |
| On farm | 7 | 14 |
| In a house | 6 | 12 |
| Others | 6 | 12 |
| On farm and other | 5 | 10 |
| Total | **50** | **100** |

Agricultural pests are a major limitation to millet production in the region, especially the desert locust and birds which together accounted for 90% of the losses. Striga and Nafasha (Raghuva Heliochellus) had relatively limited impact. Pest attack result in reduction in production and productivity. Table (4-18).So the farmer must choose varieties of good genetic traits and improved seeds to resist these pests.

**Table (4-18) Pests affecting millet**

| Pest Name | Frequency | Percent |
|---|---|---|
| Locusts | 28 | 56 |
| Birds | 17 | 34 |
| Striga (Bouda) | 3 | 6 |
| Alnavasha | 1 | 2 |
| Nothing | 1 | 2 |
| Total | **50** | **100** |

The negative effects of pests on the production of millet in the region, especially in the last ten years, resulted in the increased grain prices forcing communities to search for alternative food sources. About 94% of the respondents stated that pests had a devastating effect on millet production Table (4-19).

**Table (4-19) Impact of pests on the production of millet**

| | Frequency | Percent |
|---|---|---|
| Yes | 47 | 94 |
| No | 3 | 6 |
| Total | **50** | **100** |

About 70% of the respondents' rate millet straw as a valuable animal feed Table (4-20). Since straw is fed without any processing extension is needed to enhance nutritive value. The vagaries of weather and climate require the provision of alternative fodder in the dry season to maintain the stability of animal production.

**Table (4-20) Value of millet straw as animal feed according to respondents**

| Response | Frequency | Percent |
|---|---|---|
| Yes | 35 | 70 |
| No | 15 | 30 |
| Total | **50** | **100** |

Most of the population believed that sorghum and millet straws are good feeds though sorghum stalks were preferred by a slightly larger number of respondents Table (4-21).

**Table (4-21) Ranking cereal straws as animal feed in terms of nutritional value and palatability**

| | Frequency | Percent |
|---|---|---|
| Sorghum straw | 23 | 46 |
| Millet straw | 20 | 40 |
| Straw of other crops | 7 | 14 |
| Total | **50** | **100** |

The plants parts of millet straw preferred by animals are shown in Plate (4-4). Leaves are the most preferred plant parts followed by the whole plant Stalks and husks are less preferred.

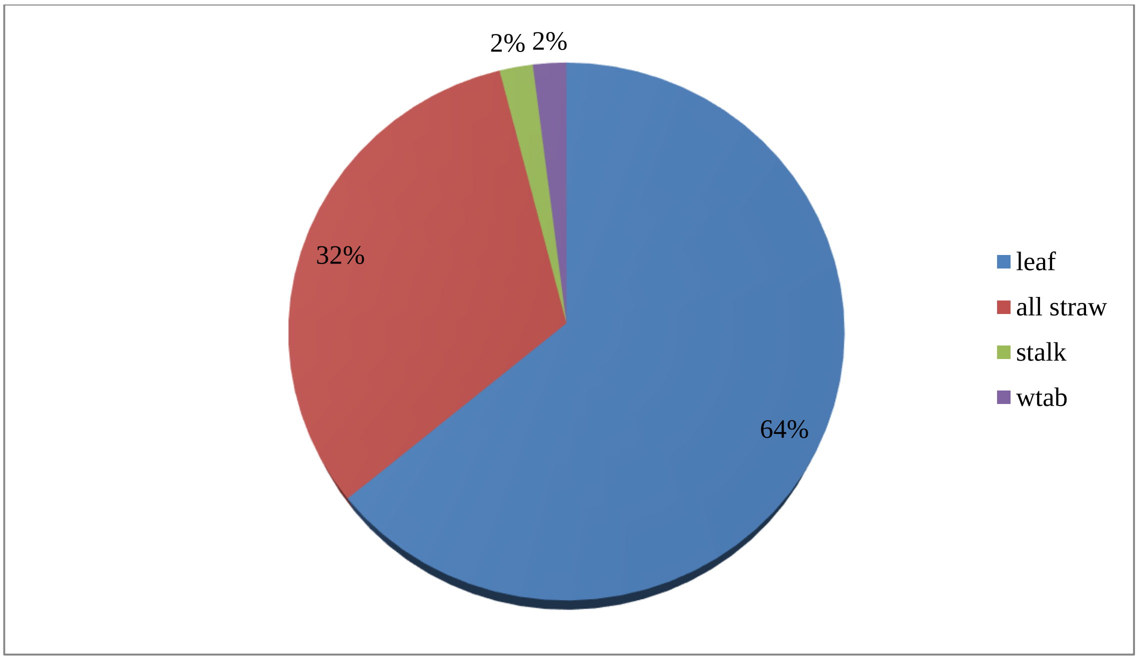



**Plate (4-4) Millet straw parts most preferred by animals**

Millet straw is usually offered to animals during late and mid-summer when green fodder is scarce and animal numbers increase due to the movement of nomads from one place to another Table (4-22).

**Table (4-22) Time of feeding millet straw**

| Time | Frequency | Percent |
|---|---|---|
| Late summer | 28 | 56 |
| Midsummer | 17 | 34 |
| Immediately after harvest | 5 | 10 |
| Total | **50** | **100** |

Sale of millet straw is an important source of income for farmers when not fed to household animals. The average price of a bundle weighing 5 kg worth more than 3 Sudanese pounds Table (4-23).

**Table (4-23) Price of millet straw (Bundle of 5 kg)**

| | Frequency | Percent |
|---|---|---|
| 1-3 pound | 25 | 46 |
| More than3 pound | 16 | 32 |
| Less than 7 pound | 9 | 16 |
| Total | **50** | **100** |

Millet straw is mainly fed in the long form (84%) while 10% is offered in the chopped form and only 6% was presented to animals in the ground form Plate (4-5).

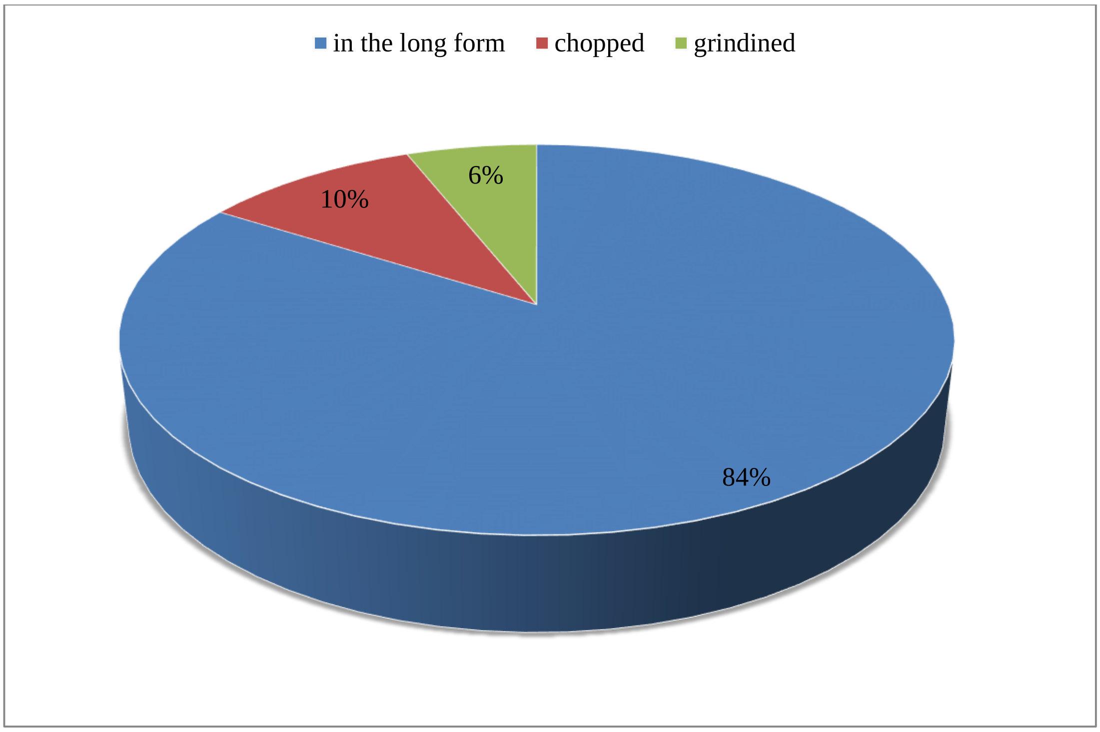



**Plate (4-5) Physical form in which people use millet straw to feed animals**

When asked whether they use any treatment to improve millet straw quality about 92% of the respondents answered yes Table (4-24). About 75% reported treating straw by chopping or grinding and then mixing with salt or atroon Table (4-25). Grinding and mixing with cake was also practiced by 25% of the respondents.

**Table (4-24) Have you tried to improve the palatability or nutritional value of millet straw by any treatment?**

| | Frequency | Percent |
|---|---|---|
| Yes | 46 | 92 |
| No | 4 | 8 |
| Total | **50** | **100** |

**Table (4-25) Millet straw treatment by farmers**

| | Frequency | Percent |
|---|---|---|
| By chopping or grinding and then adding salt or aatron | 35 | 75 |
| Grinding and mixing with cake | 15 | 25 |
| Total | **50** | **100** |

Most of the respondents (82%) have stated that they will adopt treatment of millet straw to provide a good feed in the dry season Table (4-26). It is therefore important that extension services come into play and these must be supported by the appropriate inputs such as choppers, grinders, urea and cakes.

**Table (4-26) Do you agree to use some simple ways to make millet straw more palatable for feeding at summer when there is feed shortage ?**

| | Frequency | Percent |
|---|---|---|
| Agree | 41 | 82 |
| Disagree | 9 | 18 |
| Total | **50** | **100** |

# Chapter five

# Conclusions and Recommendations

## 5-1 Conclusions

The study concluded the following:

The Treatment with urea resulted in increased crude protein both in the ground and chopped form compared with untreated straw, neutral detergent fiber was also lower in urea treated straw compared with untreated both in the ground and chopped form. Urea treatment had a positive influence on the digestibility of millet straw. Dry matter digestibility of urea treated millet straw was higher both when the straw was ground or chopped compared with that of untreated straw. Ground untreated millet straw also had a higher digestibility than untreated straw in the chopped form. Grinding usually avails a larger surface area for microbial action. It also breaks the lignin bonds of straw exposing cellulose and hemicelluloses for microbial degradation. No significant differences were found between treatments as regards feed intake. Dry matter intake by sheep feed the urea treated millet straw was slightly higher than those given millet straw without addition of urea but differences were not significant. Despite the decline in dry matter intake by sheep there are noticeable increases in the animal weight. The present method of treatment of millet straw with urea is simple and requires less labor. However, for binding of nitrogen it is 30% less efficient than the other urea treatment methods.

## 5-2 Recommendations

The study recommended that:

Encouraging farmers to adopt urea treatment of millet straw as it improves its nutritional value. It increases crude protein, lowers neutral detergent fiber and enhances dry matter digestibility.

Future research should address enhancing physical and chemical treatment on farmer's field and biological treatment in the laboratory.

Millet straw is widely recognized as an underutilized and potentially large feed resource. Urea treatment is one of the solutions to offer.

As world demand increases for fossil fuels and grain supplies the economics and practicality of converting straw to more usable forms will become more crucial.

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# Appendixes

## Appendix (1)

بسم الله الرحمن الرحيم

Sudan University of science and technology

College of forestry and Range Science

Department of Range Science

Questionnaire

**1. COMMUNITY IDENTIFICATION**

1.1. Name of Locality
1.2. Name of Rural Administrative Unit
1.3. Name of Village
1.4. Geographic Coordinates:
1.5. Survey date

**2. COMMUNITY CHARACTERISTICS**

2.1 How many households are in this community?

| | | |
|---|---|---|
| Fewer than 25 | [ ] | 1 |
| Between 25 and 49 | [ ] | 2 |
| Between 50 and 99 | [ ] | 3 |
| Between 100 and 249 | [ ] | 4 |
| More than 250 | [ ] | 5 |

2.2 What is the main source of income in this community?

| | | |
|---|---|---|
| Traditional and/or Shifting Agriculture | [ ] | 1 |
| Small holder Mechanized Agriculture | [ ] | 2 |
| Horticulture | [ ] | 3 |
| Pastoralism | [ ] | 4 |
| Off-Farm | [ ] | 5 |

In the last three years, the overall quality of life of the people living in this community has: (*consider job availability, safety and security, environment, housing, etc.*)

| | | |
|---|---|---|
| Improved | [ ] | 1 |
| Worsened | [ ] | 2 |
| Remained the same | [ ] | 3 |

On the average, the level of living of this community may be characterized as: (*enquire first on community perception of poor and less poor households then aggregate*)

| | | |
|---|---|---|
| Above Average | [ ] | 1 |
| Average | [ ] | 2 |
| Poor | [ ] | 3 |

## 3. PRINCIPAL SERVICES

***Drinking Water***

3.1 What is the source of water for the community?

| | | |
|---|---|---|
| Hand pumps | [ ] | 1 |
| Shallow Wells | [ ] | 2 |
| Deep Wells | [ ] | 3 |
| Hafir | [ ] | 4 |
| Other | [ ] | 5 |

3.2 Currently, the potable water service is:

| | | |
|---|---|---|
| Good | [ ] | 1 |
| Average | [ ] | 2 |
| Poor | [ ] | 3 |

3.3 In the last three years, potable water service has:

| | | |
|---|---|---|
| Improved | [ ] | 1 |
| Worsened | [ ] | 2 |
| Remained the same | [ ] | 3 |

3.4 What are the main problems with the potable water service?

(a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

*Public Market*

3.5 Community access to market?

| | | |
|---|---|---|
| Village Market | [ ] | 1 |
| Near by village | [ ] | 2 |
| Town Market | [ ] | 3 |

What are the types of transportation used by the community to go to neighboring communities and markets? (List the two most important ones).

| (a) | (b) |
|---|---|
| | |

1 Walking
2 Bicycle
3 Animals (Horse/Donkey)
4 Lorry
5 Cart

Since 2001, has the village settlement moved?

| | | |
|---|---|---|
| Yes | [ ] | 1 |
| No | [ ] | 2 |

## LABOR MIGRATION

4.1 Are there members of this community who go to other places to work during certain periods of the year?

| | | |
|---|---|---|
| Yes | [ ] | 1 |
| No | [ ] | 2 (go to question 4.6) |

4.2 Do more women than men leave to work? Do more men than women leave to work? Or equal numbers of women and men?

| | | |
|---|---|---|
| More women than men | [ ] | 1 |
| More men than women | [ ] | 2 |
| Equal numbers | [ ] | 3 |
| No women migration | [ ] | 4 |

4.3 Where do they go to work primarily?

| | | |
|---|---|---|
| To a city in Greater Elfasher | [ ] | 1 |
| To a rural area in Greater Elfasher | [ ] | 2 |
| Elsewhere in Sudan | [ ] | 3 |
| To places of mining | | |
| [ ] | | 4 |

4.4 What are the two principal jobs women leave for?

(a) ______________________________

(b) ______________________________

4.5 What are the two principal jobs men leave for?

(a) ______________________________

(b) ______________________________

4.6 Are there people from other communities who come to work in this community?

Yes [ ] 1
No [ ] 2 (go to section 5)

4.7 What are the two principal jobs they come for?

(a) ______________________________

(b) ______________________________

. **EDUCATION**

***Preschool***

5.1 Does this community have a public preschool *(Khalwa, Raoud)*?

Khalwa Yes [ ] 1
No [ ] 2

Rawda Yes [ ] 1
No [ ] 2

***Primary School***

5.2 Does this community have a public primary school?

Yes [ ] 1
No Is there an adult literacy campaign or program for the community?

Yes [ ] 1
No [ ] 2

5.3 Are there job training programs for this community?

Yes [ ] 1
No [ ] 2

**HEALTH**

6.1Does this community have a health clinic or hospital?
Yes [ ] 1
No [ ] 2

6.2 Does the health clinic or hospital regularly have sufficient:

| | Sufficient | Insufficient | None |
|---|---|---|---|
| a. Basic medicines | [ ] 1 | [ ] 2 | [ ] 3 |
| b. Equipment/instruments | [ ] 1 | [ ] 2 | [ ] 3 |
| c. Patient beds | [ ] 1 | [ ] 2 | [ ] 3 |
| d. Ambulances | [ ] 1 | [ ] 2 | [ ] 3 |
| e. Physicians | [ ] 1 | [ ] 2 | [ ] 3 |
| f. Nurses | [ ] 1 | [ ] 2 | [ ] 3 |
| g. Trained Midwives | [ ] 1 | [ ] 2 | [ ] 3 |

**ENVIRONMENTAL ISSUES**

7.Does the community suffer from one of the following environmental problems:

| | | |
|---|---|---|
| a. Standing water or stagnant pools | [ ] 1 | [ ] 2 |
| b. Clear cutting | [ ] 1 | [ ] 2 |
| c. forest burns | [ ] 1 | [ ] 2 |
| d. overgrazing | [ ] 1 | [ ] 2 |

What are the two main actions that could be taken to improve the environmental conditions in this community?

(a) ______________________________ [ ] 1

(b) ______________________________ [ ] 2

**8. AGRICULTURE**

8.1 What are the two principal agricultural or livestock activities undertaken in this community?

| a | b |
|---|---|
| | |

1 Traditional small holder farming
2 Mechanized small holder farming
3 Horticulture
4 Pastoral

8.2 What are the two main crops:

(a) ______________________________

(b) ______________________________

8.3 Where do the inhabitants of this community generally sell their livestock and produce? (*List up to two venues by order of importance.*)

| a | b |
|---|---|
| | |

1 Community market
2 Market in neighboring areas
3 Market in nearest town
4 Domestic middlemen
5 Exporters
6 Public institutions
7 Cooperatives
8 Local stores and shops
9 Other (specify)

8.4 Is the war impact on the production and marketing?

| | |
|---|---|
| | |

What are the two main persons or institutions that provide credit or loans to agricultural producers in this community?

| a | b |
|---|---|
| | |

| | |
|---|---|
| banks | 1 |
| Private banks | 2 |
| Agricultural credit unions | 3 |
| or cooperatives | 4 |
| Private individuals | 5 |
| organizations | 6 |
| Packing businesses | 7 |
| Producer associations | 8 |
| Warehouses or middlemen | 9 |

8.5 What percentage of the agricultural producers in this community use loans or credits to support their activities?

(a) Most producers [ ] 1
(b) About Half the Producers [ ] 2
(c) Less than Half [ ] 3
(d) Very Few or None [ ] 4

ماذا تعرف عن نبات الدخن ؟

ماهي الأصناف السائدة بمنطقتكم؟ هل لديك مزرعة ؟ نعم ( ) لا ( )

ماهو متوسط الإنتاج السنوي من الحبوب بالجوال ؟

كم هو انتاج السيقان من الفدان ؟

أين تحفظ المخلفات ؟

1. في الحقل
2. في المنزل
3. أخري

هل تعانون من الآفات ؟ نعم ( ) لا ( )

ماهي الآفات المؤثرة علي الدخن ؟

1.
2.
3.

ما مدي الضرر وهل أثر ذلك علي الإنتاج ؟

ماهي أنواع الحيوانات التي تربيها ؟

1. أبقار
2. ماعز
3. أغنام
4. أخري

ماهو افضل انواع الترب لإنجاح نمو الدخن بمنطقتكم ؟

ماهي اهم إستخداماتكم لمخلفات الدخن ؟ وماهي نسبة المخلفات التي تذهب لكل؟

| | الإستخدامات | %80 | %50 | %30 | %20 |
|---|---|---|---|---|---|
| 1. علف | ( ) | ( ) | ( ) | ( ) | ( ) |
| 2. بناء | ( ) | ( ) | ( ) | ( ) | ( ) |
| 3. طبخ | ( ) | ( ) | ( ) | ( ) | ( ) |
| 4. أخري | ( ) | ( ) | ( ) | ( ) | ( ) |

هل تعتقد أن مخلفات الدخن مفيدة للحيوان ؟ نعم ( ) لا ( )

لماذا ؟

من خلال تجربتكم ايهما افضل للحيوان من ناحية القيمة الغذائية والإستساغة ؟ مخلفات الدخن ام الذرة أخري.

.1

.2

.3

لماذا ؟

هل هنالك حيوانات تفضل مخلفات الدخن دون الحيوانات الأخري ؟

| | تفضل |
|---|---|
| 1.أبقار | ( ) |
| 2. ماعز | ( ) |
| 3.أغنام | ( ) |
| 4أخري | ( ) |

ماهو الوقت الذي تطعم فيه مخلفات الدخن ؟ بعد الحصاد مباشرة ، منتصف الصيف ، نهاية الصيف . -----------------------------------------------

هل تبيع هذه المخلفات ؟ متي ؟ وماهو متوسط سعر الحزمة ؟

-------------------------------------------------------------------------------

ماهي الطريقة التي تقدم بها مخلفات الدخن للحيوان ؟

1. مقطع ( )
2. مطحون ( )
3. أخري ( )

ماهي اكثر الأجزاء التي يفضلها الحيوان؟

| ساق | أوراق | وتاب | أخري |
| --- | --- | --- | --- |
| ( ) | ( ) | ( ) | ( ) |

هل حاولت تحسين الإستساغة او القيمة الغذائية لمخلفات الدخن بأي من المعاملات ؟ وماهي

ماهو رأيك في أن نستخدم بعض الطرق البسيطة لجعل مخلفات الدخن أكثرإستساغة وبالتالي إستخدامها في وقت الندرة ( الصيف ) او عند تدهور المراعي الطبيعية؟

أوافق لا أوافق أتحفظ

# Appendix (2)

## statistical analysis

Digestibility

| period | Sheep | | | | Sum |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | |
| 1 | (A)62.0 | (C)67.0 | (D)54.0 | (B)61.0 | **244.0** |
| 2 | (B)50.0 | (D)46.0 | (A)61.0 | (C)67.0 | **224.0** |
| 3 | (D)54.5 | (B)54.0 | (C)60.0 | (A)68.0 | **236.5** |
| 4 | (C)66.0 | (A)65.5 | (B)61.0 | (D)55.0 | **247.5** |
| sum | **232.5** | **232.5** | **236.0** | **251.0** | **952.0** |

**Summary of treatments**

| | A | B | C | D |
|---|---|---|---|---|
| sum | 256.5 | 226 | 260 | 209.5 |
| mean | 64.12 | 56.5 | 65 | 52.4 |

1-C.F = 56644

2-ss. Total =654.5

3-ss.Treatments =445.62

4- ss. Periods = 81.125

5- ss. Sheep =58.375

6- Error =69.38

| Source of variation | D.F. | S.S. | M.S. | F. Obs. | F. Table 0.05 |
|---|---|---|---|---|---|
| Total | 15 | 654.5 | - | - | |
| Treatments | 3 | 445.62 | 148.54 | 12.85* | 9.28 |
| Periods | 3 | 81.125 | 27.04 | 2.34 | |
| Sheep | 3 | 58.375 | 19.46 | 1.68 | |
| Error | 6 | 69.38 | 11.56 | - | |

# Appendix (3)

## Statistical analysis of intake

### Intake

| | sheep | | | | Sum |
|---|---|---|---|---|---|
| period | 1 | 2 | 3 | 4 | |
| 1 | (A)518 | ( C)537 | (D)572 | (B)502 | 2129 |
| 2 | (B)945 | (D)730 | (A)902.5 | (C)1008 | 3585.5 |
| 3 | (D)860 | (B)846 | (C)944 | (A)993 | 3643 |
| 4 | ( C)1069 | (A)1116 | (B)976 | (D)834 | 3995 |
| sum | 3392 | 3229 | 3394.5 | 3337 | 13352.5 |

### Summary of treatments

| | A | B | C | D |
|---|---|---|---|---|
| sum | 3529.5 | 3269 | 3558 | 2996 |
| mean | 882.4 | 817.3 | 889.5 | 749 |

**C.F.** = 1170764.14

**SS. Total** = 177118492.11

**SS.treatments** = 13188854.67

**SS. period** =10484217.2

**SS.Sheep** =35902736.9

**Residual** =117542663.34

| **Source of variation** | **D.F.** | **S.S.** | **M.S.** | **F.obs.** |
|---|---|---|---|---|
| Total | 15 | 177118492.11 | - | - |
| Treatments | 3 | 13188854.67 | 4396284.89 | 0.112 |
| Period | 3 | 10484217.2 | 3494739 | 0.089 |
| Sheep | 3 | 35902736.9 | 11967578.9 | 0.305 |
| Residual | 3 | 117542683.34 | 39180894.4 | |