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EFFECTS OF LOCAL BREWERY BYPRODUCT, NOUG SEED CAKE (Guizotia abyssinica), AND THEIR MIXTURES OF SUPPLEMENTATION ON FEED INTAKE, DIGESTIBILITY, WEIGHT GAIN AND ECONOMIC FEASIBILITY OF WASHERA LAMBS

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MSc. Thesis

By

Eneyew Kassa Gared

July 2020

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MSc. Thesis

By

Eneyew Kassa

Submitted to the graduate program in partial fulfillment of the requirements for the degree of Master of Science (MSc.) in "Animal Production"

July 2020

Bahir Dar, Ethiopia

THESIS APPROVAL SHEET

As a member of the Board of Examiners of the Master of Sciences (MSc.) thesis open defense examination, we have read and evaluated this thesis prepared by Mr. Eneyew kassa entitled.**"Effects of local brewery by product, noug seed (*Guizotia abyssinica*) cake and their mixtures supplementation on feed intake, Digestibility, weight gain and economic feasibility of Washera lambs."** We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of sciences (MSc.) in Animal Production.

Board of Examiners

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DECLARATION

This is to certify that this entitled **"Effects of local brewery byproduct, noug seed cake (*Guizotia abyssinica*) and their mixtures supplementation on feed intake, digestibility , weight gain and economic feasibility of Washera lamb**s''is submitted in partial fulfill- ment of the requirements for the award of the Degree of Master of Science in Animal Production to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by **Mr. Eneyew Kassa (BDU 1018232PR)** is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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ACRONYMS/NOMENCLATURE

ADF	Acid Detergent Fiber
ADFDC	Acid Detergent Fiber Digestibility Coefficient
ADFI	Acid Detergent Fiber Intake
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
BDG	Brewery Dried Grain
BW	Body Weight
BWC	Body weight change
CAES	College of Agriculture and Environmental Sciences
CP	Crude Protein
CPDC	Crude Protein Digestibility Coefficient
CPI	Crude Protein Intake
CSA	Central Statistical Agency
DA	Dried Atella
DCP	Digestible Crude Protein
DM	Dry Matter
DMDC	Dry Matter Digestibility Coefficient
DMI	Dry Matter Intake
FAO	Food and Agricultural Organization of the United Nations
FCE	Feed Conversion Efficiency
GLM	General Linear Model
HDM	Hay Dry Matter
ILRI	International Livestock Research Institute
m.a.s. l	Meter Above Sea Level
ME	Metabolizable Energy
MJ	Mega Joule
MRR	Marginal Rate of Return
NDF	Neutral Detergent Fiber

NDFDC	Neutral Detergent Fiber Digestibility Coefficient
NDFI	Neutral Detergent Fiber Intake
NI	Net income
NPH	Natural Pasture Hay
NRC	National Research Council
NSC	Noug Seed Cake
OM	Organic Matter
OMDC	Organic Matter Digestibility Coefficient
OMDC	Organic Matter Digestibility Coefficient
OMI	Organic Matter Intake
RCBD	Randomized Complete Block Design
SDM	Supplement Dry Matter
TR	Total Return
TVC	Total Variable Cost

Effects of local brewery byproduct, noug seedcake (*Guizotia abyssinica*) and their mixtures Supplementation on feed intake, digestibility, weight gain and economic feasibility of Washera lambs fed natural pasture hay

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ABSTRACT

The experiment was conducted to investigate the response of the replacement value of dried atella to noug seed (Guizotia abyssinica) cake on feed intake, digestibility, Body weight change, feed conversion efficiency, and economic feasibility of Washera lambs.For the experiment, twenty- five washera lambs with an average initial body weight (BW) of 20.08 ± 1.14 kg (mean ± SD) were used. Randomized complete block design (RCBD) was used for the experiment. The experimental animals were grouped into five blocks based on their initial BW, and each animal within each block were randomly assigned to the five dietary treatments. The treatments were T1 (100% DA), T2 (75% DA +25% NSC), T3(50 % DA + 50% NSC), T4 (25% DA + 75% NSC), and T5 (100% NSC). The supplements were offered at the rate of 300 g/day/head on dry matter basis, which was offered twice per day at morning and afternoon in equal portions. Common salt and water were easily available at all times. The digestibility trial was for 7 days after 90 days of experimental period. The natural pasture hay had 6.06% CP, 64.5% NDF, 42.4% ADF, and 9.2% ADL on DM basis. The lowest dry matter intake (735.2 g/d/h) was observed on experimental animals supplemented with the sole dried atella feeding group than noug seed cake (941.8 g/d/h). The apparent CP digestibility cefficient (0.84) was higher (P<0.001) for treatments which had higher noug seed cake supplementation of treatments(T5) than the dried atella supplemented in (T1). The Washera lambs fed supplemention of dried atella had low Body (58g/d/h),while the supplemented of sole noug seed cake sheep gained higher Body weigh t (82g/d/h). The highest (P<0.001) FCE was observed in the noug seed cake supplement ed treatments than the dried atella supplemented, but no significant differences (P<0.001) were recorded among the final Body weight. The sheep fed dried atella with noug seed cake in (T2) had the highest net return was observed in (658.8 ETB) and highest MRR in ratio (1.6). The sheep supplemented with NSC alone in (T5) had the lowest net return(592. 6 ETB) as compared to the other supplemented treatments. Thus, it is recommended that *supplementation of natural pasture hay with 300g/day head concentrate mixture at dried atella : NSC proportion is biologically efficient and potentially profitable in the feeding of washera sheep. Thus, T2(75% DA: 25% NSC) was the most profitable treatment in this experiment.*

***Keywords**: digestibility, brewery atella, economic values, natural pasture hay, nougseed cake, supplementation, Washera sheep*

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Chapter 1. INTRODUCTION

1.1 Background and Justifications

Ethiopia has the largest livestock population in Africa with an estimated number of 59.5 million cattle, 30.70 million sheep, 30.20 million goats, 2.16 million horses, 0.41 million mules, 8.44 million donkeys, 1.21 million camels in the sedentary areas of the country, and 56.53 million poultry that have a considerable contribution to the national economy and the livelihood of the people (CSA, 2017). Among livestock species, sheep and goats are highly adaptable to a broad range of environments and are closely linked to the social and cultural life of resource-poor farmers, serve as a living bank for many farmers, and provide security in bad years of cropping (Solomon Gizaw *et al*., 2010). The short generation interval, ability to give multiple births and their small size make sheep adaptable to smallholder mixed crop-livestock production systems where they contribute up to 22 to 63% to the net cash income (FAO, 2009). The small size of sheep and goats has distinct economic, managerial, and biological advantages. Although livestock production plays an important role in the farming system, productivity has remained sub-optimal due to feed, disease, genetics, services, and market constraints.

Shortage of feed has emerged as the major constraint for livestock production in the highlands of Ethiopia (Z. Desta and G. Oba, 2004) and crop residues have become a major source of feed as grazing lands diminish. Feed shortage particularly during the dry season; limit the animal output in most of Ethiopia. The available feed resources cannot meet the nutritional requirements of animals throughout the year in many parts of the country either due to inadequate supply or due to the quality of the feed. Livestock feed resources in Ethiopia are mainly natural grazing and crop residues, which are low in energy and protein leading to a significant limitation in the productivity of sheep. Such feed deficiencies cause losses of weight gains made during more favorable periods, while fodder conservation to help eliminate seasonal feed supply fluctuations is rarely practiced (Adugna Tolera, 2008). The nutritive value of crop residues is generally poor with low organic matter digestibility (less than 50%), high fiber (NDF >70%) and low crude protein contents (mostly 3- 5%) (Gizachew Lemma and G. Smit 2005).

The digestion of cellulose/hemicelluloses, the major sources of energy in forage-based ruminant diets, depends on the activities of the microflora (Annison *et al*., 2002). Hence, the maintenance of a healthy rumen ecosystem is a prerequisite of ruminant nutrition. Active microbial protein synthesis can only occur if adequate amounts of rumen degradable protein and readily available energy are simultaneously present in the feed (McDonald *et al*., 2010). Depression in feed intake is apparent mainly due to low nitrogen and high neutral detergent fiber (NDF) content (Forbes, 2007).

Currently, protein supplements are unavailable in the vicinity of smallholder farmers and if available, it is non-affordable. Therefore, it is of utmost important to look for alternative protein supplements. Moreover, there is a distinct seasonality in the availability of feeds in the highlands, reaching peak levels towards the end of the rainy season and critically low levels towards the end of the long dry period when green forage is scarce (Solomon Gizaw *et al.,* 2012; Feyissa Fekede *et al*.,2014). This latter part of the year is also the time when the quality of available feed is at its minimum, mainly composed of the above mentioned low- quality crop residues (Abegaz Assefa, *et al.,* 2007).

The combined effect of feed scarcity and poor feed quality during the dry period presents a serious challenge to livestock owners to meet the energy and nutrient demands of their Animals (Yayneshet Tesfaye *et al*., 2008). As a result, the livestock population often experiences cyclic loss of body condition following seasonal feed production patterns (Bezabih M. *et al*., 2014), which influences the supply and price of livestock products in the local market (Tsedeke Kocho. *et al.,* 2011). For instance, the price of fattened Sheep commonly reaches peak levels during major holiday markets occurring during the long dry period (ELMIS, 2015).

Improving the nutritive value of low-quality feed resources is a major part of feeding management practice. Supplementation with palatable feed resources, mainly agro-industrial by-products has been used in many developed countries for improving locally available nutrients of feed resources (Xianjun *et al*., 2012). Supplementing protein source concentrates and/or agro-industrial byproducts to low-quality tropical grass hay is known to improve the intake and digestibility of roughages (Ajebu Nurfeta, 2010). However, the use of such protein source supplements is limited under smallholder livestock production systems due to the availability and high cost. Consequently, there is limited prospect for using an agro-industrial by-product protein source supplements such as oilseed cakes as a livestock feed by smallholder farmers. Non-conventional industrial by-products such as traditional brewery/liquor residues (locally called *Atella*) are widely used by smallholder livestock farmers in Ethiopia, mainly due to their low cost and availability in most household localities.

1.2 Objectives

1.2.1 General Objective

The objective of this research was to evaluate the effect of local brewery by-product, noug seed cake and their mixtures supplementation on dry matter and nutrient intake, digestibility, weight gain, and economic feasibility of Washera lambs fed a basal feed of natural pasture hay.

1.2.2 Specific Objectives

- To assess the effect of supplementation of local brewery byproducts, noug seed cake and their mixtures on dry matter intake, nutrient intake, digestibility, body weight change, average daily body weight gain, and feed conversion efficiency of Washera lambs fed natural pasture hay as basal diet.
- To assess the economic feasibility of supplementing local brewery byproducts, noug seed cake and their mixtures of Washera lambs fed natural pasture hay as basal diet in northwestern Ethiopian.

Chapter 2. LITERATURE REVIEW

2.1 Status of Sheep Production in Ethiopia

In Ethiopia, sheep are reared mainly by smallholder farmers and grazed in small flocks on Communal open natural pasture. Ethiopia's sheep population is estimated at 30.70 million (CSA, 2017). According to FAO (2009), the total annual meat production comes from cattle (63%), sheep (25%), and goats (12%). At the national level, sheep and goat account for about 90% of the live animal/meat and 92% of skin and hide (FAO, 2009) export trade value. In the lowlands, Sheep with other livestock are the mainstay of the pastoral livelihoods. Sheep and Goats provide about 12% of the value of livestock products consumed and 48% of the cash income generated at farm level, 25% of the domestic meat consumption, and 46% of the value of national meat production. Sheep and Goats, respectively, contribute 20.9% and 16.8% of the total ruminant livestock meat output or about 13.9% and 11.2% of the total domestic meat production, with a live animal and chilled meat export surpluses. Per capita consumption of sheep and goat meat (kg/person per year) in Ethiopia is 8 kg while the global average is 38kg (104g/day) (Ameha Sebsibe, 2008). They are the major suppliers of meat for rural communities, especially during periods of public festivals (Tsedeke Kocho, 2007).

Sheep production is used as sources of cash income, mutton, manure, skins and coarse wool, security-risk mitigation, monetary saving (live bank) and investment, and social and cultural functions. The total annual mutton production in Ethiopia is estimated to be about 78000 MT. Sheep provide 15% of the domestic meat consumption and in a mixed farming system, sheep provide 19-23% of the food subsistence value derived from livestock (FAO, 2009). This could mainly be attributed to the high population size rather than productivity per head. The annual off take rate for sheep is estimated to be 25% with an average carcass weight of about 10 kg which is the second-lowest amongst sub-Saharan African countries, such as Sudan, Somalia, Djibouti and Kenya, which respectively produce 13, 13, 12, and 13 kg/head (CSA , 2006).

The current levels of contributions of the livestock sector in Ethiopia, at either the macro or microeconomic level is below potential. The levels of foreign exchange earnings from livestock and livestock products are much lower than would be expected, given the size of the livestock population (Berhanu Gebremedhin *et al*., 2007).

2.2 Washera Sheep Breed

In Amhara National Regional State Dangla (Washera) Sheep is one of the common sheep found in West and East Gojjam Zone extending to the south of Lake Tana. Washera Sheep weigh about 2.69 and 12.42 kg at birth and weaning; respectively (Mengistie Taye *et al.,* 2010). Washera breed is desribed as short fat-tailed, shorthaired, large body sized, predominantly coat colors brown, red white and both males and females polled. The breed is distributed in West Gojam, East Gojjam, and Awi zones of the Amhara Regional State, and in Dangur, Mandura and Alefa Takusa districts reared by the Amhara and Agew communities (Solomon Gizaw *et al*., 2010). The breed inhabits the northwestern highlands of Ethiopia mainly the wet, warmer and mid-highlands (1600-2000 m.a.s.l.) of the Amhara and Benishangul-Gumz Regional States (Solomon Gizaw *et al*., 2010). The growth rate after weaning is better than most of the indigenous breeds and it is comparable to some of the breeds like Horro and Bonga, which are recognized as large-sized sheep breeds in Ethiopia. The literature mentions the good potential of this breed for commercial mutton production for the local and export markets (Solomon Gizaw *et al*., 2010).

Washera sheep is also known for its relatively high twinning rate (Solomon Gizaw *et al.,* 2010). The same source reported that Washera sheep is fast growing with a mature body weight of 32.8 kg. A comparison of the growth performance of Washera sheep with other indigenous breeds such as the Menz and Horro sheep showed that they have much better growth performance under improved feeding systems (Chipman, 2003). It was also reported by Sheno Agricultural Research Center (SARC, 2003) that the potential response of yearling Washera Sheep to concentrate supplementation was found to be higher than that of Menz and Horro breeds. The Washera sheep breed is one of the most productive Ethiopian sheep breeds in terms of growth and overall performance (Chipman, 2003). Feedlot and on-farm performance of Washera sheep were quite high, with average daily weight gains of up to 126 g, with 500 g per 20 day concentrate supplementation. Washera sheep average hot carcass weights recorded from different experiments ranged between 6 and 16 kg (Tesfaye Getachew *et al.,* 2011).

2.3 Livestock Feed Resources

In Ethiopia, livestock obtain feed from on natural grassland, crop residues, agro-industrial byproducts and cultivated pasture and forage-crop species. In the commonly found mixed crop-livestock farming system as in the highlands of Ethiopia, the feed resources available depend on the type and manner of crop production. In such areas, the major available feed resources are natural pasture, crop residues and crop aftermaths (Solomon Bogale *et al*., 2008a, 2008b). To some extent, agro-industrial by-products and cultivated improved forage crops are also used.

The major livestock feed resources (both natural pasture and crop residues do not fulfill the nutritional requirement of animals, due to poor management and inherent low productivity (Alemayhu Mengistu, 2016). The crop residues, which are the major livestock feeds, particularly in the dry seasons, provide 40 to 50% of the total annual livestock feed (CSA, 2017). The major feed sources for livestock in Amhara National Regional State is green fodder, crop residues, improved frage, hay, by product and other which make up of 35.51, 41.77, 0.22, 14.14, 1.03 and 7.31%, of the total livestock feed, respectively(CSA, 2017). The same source reveals that hay and agro-industrial by-products are also used as feed for animals in the Region and account for 13.1 and 1.3% of the total livestock feed, respectively. Because of high population pressure and other reasons, grazing lands are being changed to croplands in most parts of the Region. Major crops produced in Amhara Region are teff, sorghum, finger millet, maize, barley, oats, wheat, and rice (CSA, 2015). Except rice, all mentioned cereal crops are the major crops produced in the study area. Among the major crops produced, finger millet is an important crop next to maize, whose straw makes the major feed source for livestock, especially during the dry season, and noug seed is the first among oil crops and commonly produced in the area from which 2,290.4 tons of noug seed by-products are produced annually in the study area (CSA, 2015).

In Amhara Regional State showed that feeds obtained from grazing land were inadequate for livestock in the region both in quantity and quality during wet and dry seasons of the year (Fentie Bishaw and Solomon Melaku, 2008). Therefore, the feed available was inadequate to support the maintenance requirement of the livestock population in the region.

2.3.1 Natural Pasture

Pasture in the tropics and subtropics grow rapidly during periods of heavy rainfall and high temperature (Van Soest, 1994) leading to mature pasture plants containing high levels of cell wall constituents (Yihalem Denekew *et al*., 2006; Solomon Bogale *et al.,* 2008a, 2008b). Pastures are young and green for only short periods. The nutritive values of pasture decrease with maturity increases. During the dry seasons, available feed is of low digestibility and low in nitrogen content. When used strategically, feed grown on land set aside from cropping can provide special grazing for animals currently producing or being prepared to produce outputs of high value.

The major factor that limits animal production and the causes of poor performance of animals fed on low-quality hay are due to their failure to support maximum microbial activity in the rumen because of which digestibility of cell wall fiber becomes low and hence the animals lose weight in the dry season due to the nutritional imbalances in the feed available. Natural pastures in the highlands of Ethiopia are rich in species composition, particularly indigenous grasses, and legumes. Among grass species commonly growing belongs to the genera Andropogon, Digitaria, Panicum, Pennisetum, and Trifolium (Yihalem Denekew *et al*., 2006).

In mixed farming mid-altitude areas, better soil is used for cropping and the main permanent natural pasturelands are found on the upper slopes of hills and seasonally waterlogged areas. Considering the country as a whole, grazing land contributes 54.59% (CSA, 2017) of the total land area. Even though the size of the grazing area seems to be large, the yield and quality of the pasture is very low due to poor management and overstocking. Moreover, most of this, native pastures are generally confined to degraded, shallow upland soils, fallow cropland, and to soil that cannot be successfully cropped because of physical constraints such as flooding and waterlogging. According to the reports of some recent assessments (Endale Yadess, 2015); natural pasture remains as a major component in livestock feed supplies in different parts of the country where mixed crop-livestock production is a predominant agricultural activity. CSA (2017) recent estimation has shown that green fodders that are obtained through grazing from natural pasture are contributing about 54.59% of the total annual feed supplies in sedentary areas of the country. However, the contribution of natural pasture reaches this peak during a certain season of the year. Moreover, better quality forages were obtained from this source particularly during the wet season of the year. The availability and quality aspect of forages from native pasture is governed by different factors that directly and indirectly influence species composition, i.e. climate (rainfall and temperature), altitude, soil, and farming intensity (Malede Birhan and Takele Adugna, 2014).

2.3.2. Natural Pasture Hay

Hay is forage harvested during the growing period and preserved by drying (Assefu Gizachew, 2012). Haymaking aims to reduce the moisture contents of green crops to 15-20% to inhibit the action of plant and microbial enzymes (Banerjee, 1998). Hay in central highland of Ethiopia is usually harvested after the crude protein (CP) of the pasture passed peak production and the protein content of hay on DM basis was usually less than 5%, which is below the level of maintenance required for ruminants (Solomon Bogale *et al.*, 2008a). This level of CP content reduces feed intake and affects digestibility (Kidane, 1993). According to FAO (1997), annual and perennial grass from natural pasture consumed during the dry season and often at the late stage of maturity together with the straw and stalk from cereal crops constitutes low-quality forages, with high-lignified cell wall and poor nitrogen. The quality of hay prepared varies with grass-legume proportion, leaf to stem ratio, and physiological development of the forage upon harvest (Assefu Gizachew, 2012). Mature grass, especially those that are weather leached or bleached are low in digestible energy and protein, as well as insoluble carbohydrate, carotene, and some of the minerals (Ensminger *et al.*, 1990).

The natural pasture hay had low CP (5.5%) and high NDF (76.3%), ADF (39.7%) and ADL (7.8%) contents (Firisa Woyessa *et al.*, 2013). The high fiber content and low CP content of the natural pasture hay could be explained by different factors affecting the nutritive value of natural pasture hay such as varietal differences, location or climate, the fertility of the land, stage of maturity at harvest, morphological fractions (e.g. leaf to steam ratio), harvesting and transporting practices, length and condition of storage time (Firisa Woyessa *et al.*, 2013). The CP content falls below the minimum threshold level (7%CP) for optimal rumen microbial activity, which necessitates supplementation with feeds having high protein content.

2.3.3 Improved forage production

In many parts of the country, animals are kept on poor quality natural pasture that commonly occur on permanent grasslands, roadsides, pathways and spaces between cropped plots. Moreover, the main livestock feed resources accessible in Ethiopia are natural pastures, crop residues and aftermath grazing (Adugna Tolera, 2008) and (Getnet Assefa, 2012). However, these feed resources are very low in quality having high fibre, with low to moderate digestibility and low levels of nitrogen which might be linked with a low voluntary intake, thus resulting in inadequate nutrient supply, low productivity and even weight loss. Livestock feed is greatly in short supply particularly latter in the dry season and of poor in quality. On the other hand, avoiding the feed resources from the fields results in decreasing organic matter content found in the soil which in turn degrades soil structure and increases erosion (Alemayehu Mengistu *et al*., 2016). It contribute much to supplement low quality feed resources such as crop residues and pasture roughages there by overcoming the dry season constraints affecting livestock production. Forages have much potential within the farming systems of Ethiopia. Moreover, a high quality animal feed is being produced. This increase in animal nutrition results in increased manure production from the animals, which in turn adds nutrients to the soil. Several researches have been conducted regarding to improved forage production, adoption and utilizations in different areas of the country (Muluye Fekade, 2019).

Ethiopia has cultivated various improved forage species such as Sesbania, Leucaena, and Calliandra and Tree Lucerne, for supplementary feeding of livestock and soil improvemen t. The same authors stated that understanding farmers' perception about the feeding and other alternative role of fodder trees at the farmland and constraints to adoption and growing of multipurpose fodder trees will contribute to better understanding of how and which innovations should be introduced (Muluye Fekade, 2019).

The main improved forage species widely produced in different areas of Ethiopia are not uniformly distributed as a result of a numbers of factors. The major improved forages in Libokekem district were elephant grass, vetch, oat, Rhodes grass,and sesbania.densho grass and leucaena with their decreasing order of availability(Workye Melesse *et al*., 2018).

The most important contribution of improved forages is their direct effect on livestock production. It had good feeding value related to nutrient contents and digestibility. Better animal performance can be obtained from high protein and energy because milk and other products increase their nutrients flourish for the neonate and human nutrition (Alemayehu Mengistu, 2012) and (Endalew Assefa *et al*. 2016). While grazing depletes the fertility of the land, forage growing improves soil health. For instance, intercropping species like maize and Lablab or coffee and Desmodium is more advantageous than growing one crop alone (Etsubdink Tarekegn , 2012).

Natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products are the main livestock feed resources in Ethiopia. Grazing lands have been degrading due to the demand for high pressure on land resources from increasing populations and greater cropping intensity. Although crop residues serve as a feed resource for livestock, it is poor in quality which could not provide the nutritional requirements of the animal. Removing them from the fields also reduce organic matter content in the soil which degrades soil structure and increases the erodibility of cropped land (Muluye Fekade, 2019).

2.3.4 Agro-industrial by-products and chemical cmpositions

Agro-industrial by-products have special value in feeding livestock mainly in urban and peri urban livestock production system, as well as in situations where the productive potential of the animals is relatively high and require high nutrient supply. Agro-industrial byproducts produced in Ethiopia include by-products from flour milling, sugar factory, abattoir and brewery by products (Alemayehu Mengistu *et al*., 2017). These byproducts are mainly used for dairy and fattening animals. Agro-industrial byproducts are rich in energy and/or protein contents or both. They have low fiber content, high digestibility and energy values compared with the other class of feeds. Alemu yami *et al.,* (1991) have also reported more than 35% CP and 50- 70% *in vitro* organic matter digestibility (IVOMD) for oil seed cakes and 18-20% CP and more than 80% IVOMD for flour milling by-products.

Noug seed cakes are used as commonly a protein supplement in the diet of farm animals in

Ethiopia. Annually about 84,802.34 tons of noug seed are produced in Ethiopia and oil extraction is done almost entirely by mechanical press with predominantly old machines used in the milling industry (CSA, 2015). The amount of noug seed cake produced is about 50% of the noug seed processed. Hence, the amount of noug seed cake produced per annum would be about 42, 401.17 tons. Most of the noug seed is produced in the western parts of the country, particularly western Oromia (West and South West Shewa, East Wallaga, Horro Guduru) and western Amhara (Gojjam and Gondar) regions (Adugna Tolera *et al,* 2012).

The crude protein (CP) content of noug seed cake varies from 28 to 38% with most values lying between 30 and 35%. The fat content varies from 2.1 to 12.6% with an average of 8.4% and an energy value of 2.37 Mcal ME/kg DM (Adugna Tolera *et al.*, 2012). It has high fiber (34.4% NDF and 8.4% lignin) content and relatively low digestibility (61.7% in vitro DM digestibility) compared to most other oilseed cakes (Adugna Tolera *et al.*, 2012). Noug seed cake can be highly lignified if the seed is not dehulled before extraction. Because of its high crude protein content, noug seedcake can be used a protein supplement in the diet of farm animals. When added to energy source feeds, it can improve feed intake, digestibility, and animal performance. The crude protein and fat content of noug seed cake varies depending upon the method and efficiency of oil extraction from the noug seeds. Lemma Fita *et al*. (2003) reported that the chemical composition of noug seed cake is 93.1% DM, 35.5% CP, 28.2% ADF and 11.1% ash. The CP content of noug seed cake was found to be 31.1-34.9% and the NDF content ranged from 35.8-37.5% (Alemu Yami, 1981).

In general, the chemical composition of noug seed cake are ranges from 26.1 to 35.7% CP, 92.2 to 93.15% DM, 90.2 to 92.5% OM and 9.3 MJ ME/kg DM reported by (Seyoum Bediye and Zinash Sileshi, 1989; Tesfaye Tsegaye, 2009; adugna tolera *et al*., 2012; Diriba Geleti *et al*., 2013; Girma Hailu *et al.*, 2014; Worknesh Seid, 2014; Dereje Worku, 2015).

2.3.4 Local Brewery By-Products and Chemical Compositions

Non-conventional feed resources do play a significant role in the tropics and sub-tropical Regions. Among this atella are the most widely used protein sources of local brewery by-products. The non-conventional feeds could be broadly be grouped into hulls of pulses and other crops, traditional brewery and alcohol residues, poultry wastes, vegetable and fruit wastes (Yoseph mekasha,1999). These feed types are cheap and have a far-reaching impact in complementing the daily dietary needs of animals in peri-urban dairy farms. Non-conventional feed types are mainly utilized as a supplement for dairy farms. They are unexploited, cheap, and less competitive feed resources. Traditional brewery and liquor residues and pulse hulls particularly are available throughout the year.

Therefore, to develop pertinent and economical feeding systems that would boost the performance of animals the potential of these feed resources and their limitation in supporting the performance of animals need to be well documented. The by-products have moderately high crude protein and metabolizable energy contents and digestibility. Tella atella and areqe atella, byproducts of home-brewed and home-distilled local alcoholic beverages, respectively, constitute the major ingredients of fattening rations in backyard small scale fattening operations practiced in some parts of the country (Adugna Tolera et al., 2012). As the report of Almaz Ayenew *et al.* (2012), the chemical compositions of dried *atella* 93.8% DM, 96.4%OM, 21.2% CP, and 34.6%NDF. According to Adugna Tolera *et al*. (2012), the chemical compositions of atella were 95.7%OM, 20.2% CP, and 52.8%NDF. Atella can be used as a protein supplement in sheep diets during the dry season (Yenesew Abebe *et al*., 2013). The protein and energy contents of atella are high enough to greatly increase the intake, digestibility, N retention, and performance of growing sheep fed diets based on low quality. Supplementing diets with 25-50% (DM) atella ensures that the dietary protein can support an acceptable rumen microbial activity, meeting the maintenance protein requirement (Ajebu Nurfeta, 2010; Ajebu Nurfeta *et al.,* 2013). Supplementation of wheat straw with atella resulted in weight gains similar to those observed in sheep supplemented with concentrates (Ajebu Nurfeta, 2010). Supplementation of low protein hay (crude protein 5.5% DM) with atella improved total intake, without affecting the intake of the basal forage, and greatly improved protein and energy intake (Yoseph Mekasha *et al.,* 2002). However, this result depended on the protein content of the basal forage. With a hay containing 4.1% DM protein, a significant substitution between atella and hay was observed (Ajebu Nurfeta *et al*., 2013).

2.4 Feed Intake, Digestibility and Body Weight Change of Washera Sheep

2.4.1 Feed Intake

Dry matter intake is regulated by different factors of which animal factor, environmental condition, and feed characteristics are of paramount importance (McDonald *et al.*, 2010). Feed intake is the first parameter that determines animal production (Savadogo *et al*., 2000), which is likely to be influenced by the animal, characteristics of the feed, and other environmental factors. The dry matter intake is dependent upon many factors like the density of energy in the diet, digestibility, succulence, amount of crude fiber, and the physical nature of the feed (Rehrahie Mesfin., 2003). Feed intake in ruminants consuming fibrous forages is primarily determined by the level of rumen fill, which in turn is directly related to the rate of digestion and passage of fibrous particles from the rumen (McDonald *et al*., 2010). One of the most important factors that influence the productivity of small ruminants is feed intake. Productivity of sheep can be greatly increased by supplementing their rations while they are on grazing and by managing them in a feedlot. The higher the quality of the feed offered to the animal, the higher would be the intake and performance of sheep on the diet. The nutrient requirement of sheep varies with differences in age, body weight, and stage of production. Although several factors affect feed intake in animals, it is generally expected that animals consume to meet their physiological energy demand. The amount of energy to meet the requirement of an animal is influenced by the level of voluntary dry matter intake. The dry matter intake, on the other hand, is regulated or modified by many different factors of which the animal factor, climatic condition, feedstuff, and feedstuff components are of paramount importance. Feedstuff character and components that regulate dry matter intake include the physical form of the feed, digestible energy content, bulkiness, protein, and amino acid balance of the feed. Generally, sheep and goats will consume 2 to 4 % of their body weight on a dry matter basis (Susan Schoenian, 2003).

Feeds that are digested rapidly are also of high digestibility and promote high intake. The author also noted that the faster the rate of digestion, the more rapidly is the digestive tract is emptied and the more space is made available for the next meal. There is a positive correlation between the digestible fraction of the feed and DM intake. Feed intake is negatively impacted by the quantity of indigestible fractions (such as lignin) or fractions with low digestibility like NDF and ADF content due to the need for more retention time in the rumen for further fermentation (Bruinenberg *et al.,* 2003). Obviously, the high NDF and ADF contents in the diet are expected to increase resistance to physical breakdown and contribute to more ruminal fill resulting in a lower voluntary intake. Feed that is low in protein and high in fiber content results in low digestibility and voluntary feed intake (Adugna Tolera *et al.*, 2012). Supplementation of concentrate to poor quality roughages stimulated microorganism function in the rumen, reduced retention time, and thus increased the intake of poor-quality feeds (DoThi, 2001). Concentrate supplies more easily degradable components to fibro lytic microorganisms that improve fiber degradation (Liu and Lee, 2005). The highest roughage DM intake comes synchronously with the highest ruminal fibrinolytic activities. If ruminants are offered un-supplemented low-quality roughage, there will be a loss in body weight because of the inability to meet both energy and protein requirements. In a feeding system where straws and grass hay are the basic diet of ruminants, the low intake of these roughages requires supplementation to meet the requirements for production. The addition of crude protein supplement may stimulate efficient rumen fermentation, more passage rate, and intake. Among the supplemented treatments, sheep fed the medium (250 g) and high level (350 g) of wheat bran supplement had significantly higher total DM intake which was 883.8 and 963.74 g/day/head, respectively compared to those fed low level (150 g) of supplementation which consumed 826.38 g/day (Awet Estifanos, 2007).

The exact percentage of dry matter intake varies according to the size (weight) of the animal, with smaller animals consuming a higher percentage dry matter to maintain their weight. Voluntary intakes of feeds account for 50-75% of the variation in ruminant performance (Waldo and Jorgensen, 1981). Voluntary intake of straws is very limited. Depression in the voluntary intake of straws is observed mainly due to poor palatability low nitrogen and high NDF content (Van Soest, 1982). In feeding systems where grass hay and straws are the basic diets for ruminants, the low intake of these roughages requires supplementation to meet the requirements for production. The provision of dietary by-pass protein to ruminant feeds increases also, the low-quality roughage feed intake. Part of the response in growing animals maybe that by-pass proteins provide amino acids in which microbial protein is deficient, thus increasing growth rate, which in turn will increase feed intake (Cheeke, 1991). For satisfactory digestion of poor roughages, adequate supplementation is needed. The addition of a small amount of high concentrate will generally increase rumen digestion and thereby increase the intake greatly through furnishing needed nutrients to rumen microorganisms.

The daily dry matter and nutrient intake of sheep fed natural pasture and *desho* grass hay with concentrate supplementation are range from 650 to 728g/day/head as a DM basis (Bimirew Asmare, 2016). The proportional of supplement increase in the total basal DM intake of sheep also increase. The total DM intake as percent of body weight of the experimental sheep was 3% while intake per metabolic body weight of experimental sheep varied from 61 to 64 % although the results were not statistically significant (Bimirew Asmare, 2016). The daily nutrient intakes of experimental sheep followed the same trend as that of total DM intake. The total DM intake of sheep in the current study was comparable to results of (Awoke, 2015) for the same breed of sheep fed hay as a basal diet and supplemented with F.sycomorous leaf, fruit and their mixtures.

2.4.2 Digestibility

Digestibility of feeds refers to the percentage of the complete feed or any single nutrient in the feed, which is not excreted and thus assumed available to animals for absorption from the gastrointestinal tract. The digestibility of a feed is determined largely by the chemical composition of NDF and ADF in the feeds. For instance, the digestibility of one feed is believed to be different from that of a similar feed because each feed may contain different chemical entities some of these constituents diminish the opportunity for the digestive enzymes to be exposed to their respective substrates (Khan *et al*., 2003). The primary chemical composition of feeds that determines the rate of digestion is neutral detergent fiber (NDF), which is itself a measure of cell-wall content; thus, there is a negative relationship between the NDF content of feeds and the rate at which they are digested (McDonald *et al*., 2010). Indeed, low NDF content 20-30% has been shown to result in high digestibility, while lignification of the plant cell wall decreases the digestibility of plant material in the rumen. Hence, information on the NDF, ADF, lignin, and tannin content of tree foliage is essential for the assessment of their digestibility (Sanon, 2007). Mentioned that consumption of low-quality diets would be determined by the digestibility of their components. Digestibility of a feed is influenced not only by its composition, but also by the composition of others feeds consumed with it. For the ruminant to express their full genetic potential for growth, the apparent digestibility should exceed 70% on a dry weight basis. When apparent digestibility is 60%, performance will be intermediate and the minimum range of apparent digestibility to assure body maintenance needs is 42-45%, whereas at lower digestibility of feeds animals lose weight (McDowell, 1988).

2.4.3 Body weight Change of Sheep

Body growth commonly refers to an increase in the size or weight of animals (Warriss, 2000). It is crude because the change in body weight of intestinal contents, which in ruminants may often account for 20% of body weight gain (McDonald *et al.,* 2010) affects the bodyweight of the animal. Nutrition is perhaps the most important consideration in livestock management as it has much influence on growth rate and body composition. Nutrition level largely determines the growth rate in lambs and kids (Sayed, 2009). Animal performance is a function of feed intake and the relative digestibility of the diet that leads to nutrient availability. The type of management of animals and stage of growth (Takele Kumsa *et al.,* 2006) influences the rate of weight gain of sheep. Larbi and Olaloku (2005) suggested that with increasing level of crude protein in the diets of small ruminants there is a proportional improvement in average daily gain and hence growth performance. Similarly, increasing protein and energy levels in the diet improves the average daily body weight gain and feed conversion efficiency of animals (Ebrahimi *et al.,* 2007). Increasing the energy level may allow the production of more fermentable metabolizable energy for rumen microorganisms resulting in a rise in the synthesis of microbial protein and the amount of protein available to the animal (Sayed, 2009).

2.5 Nutrient Requirements of Sheep

Nutrient needs of Sheep may be classified as energy, protein, fiber, minerals, vitamins, and water. The nutrient requirements are the values considered necessary for maintenance, optimum production, and prevention of any signs of nutritional deficiency. Fiber (bulk) is necessary to maintain a healthy rumen environment and prevent digestive upsets. Water is the cheapest feed ingredient, yet often the most neglected (Susan Schoenian, 2003). Manyfactors affect the nutritional requirements of small ruminants: growth pregnancy, lact ation, fiber production, activity, and environment. Sheep require higher quality feed than cattle. The energy need of sheep is largely met through the consumption and digestion of roughages, from pasture and hay. It is BW and extent of growth (gain) and protein content of the ration (Cheeke, 1991) affects the energy requirement of Sheep. The energy requirements of Sheep and goats are similar. For dry non-pregnant animals, the maintenance requirements are 0.42 MJ ME/kg $W^{0.75}$ (NRC, 1981). Growing Sheep need protein, as do other classes of animals, for maintenance and growth. The requirements for digestible CP range from 2.3-2.8 g/kg $W^{0.75}$ for sheep at maintenance (NRC, 1981). The same source recommended that 0.28 g CP/ g of gain or 0.19 g DCP/g of gain were required for body weight gain without considering the physiological stage, dietary energy concentration, and rate of growth or protein degradation in the rumen. This value is comparable to 0.3-0.36 g CP/g of gain (NRC, 1985) and to 0.2-0.38 g CP/g of gain for growing sheep (ARC, 1980).

The protein requirement of growing Sheep is affected by growth, weight for age, body condition, rate of gain, and protein to energy ratio (Cheeke, 1991). Maintenance requirements increase as the level of the animals' activity increases. The level of maintenance and growth energy requirement estimated for sheep by different authors indicated that, a 10 kg live weight sheep requires 2 MJ ME for maintenance and 2.7-4.5 MJ ME for 50-150 g gain per day (Chesworth, 1992). Similarly, according to Cheeke (1991), lambs with 10 kg and 20 kg live weight and 250 g daily weight gain had daily ME requirements of 1.4 and 2.9 Mcal (5.99 and 12.42 MJ), respectively. The estimate for protein requirements for maintenance varies from 54 g DCP for 45 kg body weight to 36 g DCP for 30 kg adult sheep (Ranjhan, 1997). The author emphasized that the requirements relatively increase for growing and fattening animals as compared to the requirement of adult animals, and thus the daily DCP requirements for 20 kg body weight of growing and fattening sheep are 47 and 70 g/day, respectively.

According to NRC (1996), the nutrient requirement of lambs weighing 27 kg with 159 g average daily live weight gain is 145 g protein, 3 Mcal (12.83 MJ) DE, and DMI of 4.5% body weight. The ARC (1980) estimated the maintenance nutrient requirement for a 20 kg lamb to be 0.35 kg DMI; 31 g rumen degradable protein (RDP) and 0 g rumen undegradable protein (RUP); 107 g CP/kg DM and the ME requirement range of 3.7- 4.1 MJ/d. The maintenance and growth nutrient requirement of the same weight lambs also varies according to daily weight gain which is in the range 30-62 g rumen degradable protein (RDP) and 0-27 g rumen undegradable protein (RUP); 89 g CP/d and 124 g CP/kg DM and 4.5-7.9 MJ ME/d for lambs gaining 50-200 g/d.

2.5.1 Protein Requirements of Sheep

Sheep need protein, as do other classes of animals for maintenance, growth, reproduction, finishing and production of wool. Green pastures and legume hay are widely available and excellent sources of protein for sheep feeding in most areas. Protein is a critical nutrient, particularly for young and rapidly growing and for mature lactating animals. Consequently, optimal use of protein is important in practical animal feeding systems, since, protein supplements are much more expensive than energy supplements. The provision of by-pass proteins to ruminant animals fed low-quality roughages increases feed intake. Part of the response in growing animals might be attributed to the fact that by-pass protein provides amino acid in which microbial protein is deficient. Thus, by-pass protein increased growth rate, which in turn increase feed intake in addition to improving absorbed nutrient balance (Cheeke, 1999). Since sheep are ruminant animals, the amount of protein eaten is more important than the quality of the protein. Sheep, because of the symbiotic relationship with rumen microbes, can take nitrogen or other low-quality protein from the diet and synthesize useable protein for the animal. Protein is usually fairly expensive, and thus, should be supplemented rather judiciously. Most average quality forages have an adequate content of protein for much of the ewes needs throughout the production year. The most common times when protein would be supplemented would be in times of high production. For instance, when ewes are lactating, lambs are growing, etc. Protein can also need to be supplemented when pasture or range plants are borderline in protein content, usually in early winter or after the plants have stopped actively growing (Mike Neary, 2007).

In ruminant animals including sheep, the amount of protein consumed is more important than the quality of the protein (Mike Neary, 2007). In Sheep, the rumen microbes use any form of nitrogen to synthesize good quality useable protein. The most common time of protein supplementation would be during periods of high production and rapid growth, when pasture plants are borderline in protein content. Oilseed cakes contain 40-50% CP and are excellent sources of supplemental protein. McDonald *et al.* (2010) stated that the protein requirements of ruminant animals are stated in terms of effective rumen degradable protein and metabolizable protein.

A 25 kg sheep requires 806-891 g DM and 94-137 g CP for average daily body weight gain of 64-101g/h/d. Similarly, 20 kg growing sheep require 85 g of CP and 46.8 g of DCP (Ranjhan, 1993). The daily metabolizable protein requirements of growing lambs with a live weight gain of 0, 50, 100, and 150 g /day is 21, 47, 61, and 76 g per day respectively with a daily DM uptake of 0.837 kg/day (McDonald *et al*. 2010). The consumption of low-quality roughages such as straw and poor-quality grass hay can be increased markedly with the addition of protein supplements (Pond *et al*., 1995). The CP requirements for growing and fattening sheep with 20 kg body weight are 85 and 127g/head/day, respectively (Ranjhan, 1997), whereas according to Cheeke (1999), early-weaned lambs with 10 and 20 kg live weight have CP requirements of 127 g/head/day and 167 g/head/day with 26.2 and 16.9 % of DM diet, respectively. The growth performance of sheep under grazing conditions could be improved with supplementary feeding of a high protein diet. Sheep fed high protein diet 208 g per kg DM/day had improved DM intake 509 vs. 425.9 g/head/day and live weight gain 36.6 vs. 10.7 g/head/day as compared to those on low protein diet 168 g per kg DM/day (Kabir *et al*., 2004).

2.5.2 Energy Requirements of Sheep

Energy is the nutrient required in the single largest amount by sheep. It is also the nutrient most likely to be deficient or in excess. No doubt that the largest expense in raising Sheep is the supply of energy to them for either maintenance or productive functions. Energy needs of sheep are influenced by their body size (weight), the stage of production, the amount of exercise they get, fleece length, and environmental factors (temperature, wind chill, etc.). Bigger sheep need a larger intake of energy than small or average size Sheep. Sheep in a dry lot or small pastures need less energy than sheep grazing over large range or pasture areas. In winter, sheep with short fleece need more energy than those with a full fleece. The energy status of sheep is dependent on how much feed they are consuming, what the energy content of the feed is, and what the digestibility of the feed is. The energy content of feeds is often described by the TDN content of the feed. TDN stands for total digestible nutrients. Grains have TDN values in the 70 to 80% range, while, forages range from 50 to 60% TDN. For example, sheep can have access to all the corn cobs that they want and still be in an energy deficient situation. This is because they have a limited capacity to consume a bulky, poorly digested feed that lacks useable energy content. Conversely, lambs are often fed high grain diets to finish them for the market. They are eating similar amounts of feed daily as those eating cobs; however, they would be growing quite rapidly. Again, the difference being the digestibility and energy content of the two feedstuffs (Mike Neary, 1997).

The best sources of energy for small ruminants are the most plentiful feeds available. These are usually pasturing and browses, hay, and grains. Sheep and goats often lack nutrients, however, due to poor-quality pastures and roughage or inadequate amounts of feed. Because of this, energy is the most common limiting factor in small ruminant nutrition. Deficiency will result in decreased production, reproductive failure, increased mortality, and increased susceptibility to diseases and parasites. It is essential to evaluate the efficiency and overall performance of a feed or ration referred to as the total digestible nutrients (TDN). TDN is a broad term used to express the energy value of a feed or ration. The percentage of TDN is the most widely used method of evaluating feed for energy. As a rule, the greater the TDN is in a ration, the greater the rate of gain will be in the animal (Robert Spencer, 2018)

2.6 Partial budget analysis

Washera sheep supplemented with mixtures of *atella* and NSC had higher net income as compared to the other supplemented groups and non-supplemented ones (Almaz Ayenew *et al*.,2012). Sheep fed finger millet straw without supplementing, sheep lost their body weigth, due to the low quality of finger millet straw, which resulted in BW loss of sheep. The marginal rate of return for supplemented sheep higher. This indicates that to attain required BW by supplement feeding, each additional unit of 1 ETB increment per sheep to purchase supplement feed resulted in a profit of 3.07 ETB (Almaz Ayenew *et al*.,2012) . Supplementation of NSC and higher proportion of NSC: *atella* concentrate mixture was not efficiently utilized by rumen microbes and resulted in excess energy and protein loss through feces and higher cost of the concentrate feeds (49.7 and 60.5 ETB/head (Almaz Ayenew *et al*.,2012) as compared to the other treatments attributed in lower MRR. However, new technologies normally require investment, therefore, additional capital is necessary. When capital is limited, the extra (or marginal) cost should be compared with the extra (or marginal) net benefit. But with regard to economic profitability the results of this study suggested that supplementation of finger millet straw with 300 g *atella* is potentially more profitable and economically beneficial than the other supplement feeds(Almaz Ayenew *et al*.,2012).

The difference in the net return among treatments could be attributed mainly to feed conversion efficiency. In addition, the marginal rate of return below which farmers will not accept a new technology is usually between 50 and 100% (Awoke Kassa, 2015). The higher net return mainly due to the lower nitrogen content of fruit in supplementation than leaf and their mixture. supplementation of tree leaf and fruit in ruminant nutrition provides nutrients in the diet resulting in enhancement of microbial growth and digestion of cellulosic biomass in the rumen, source of undegradable protein, source of vitamins and minerals to complement deficiencies in the basal feed resource. It could also weakness the competition for conventional concentrates, reduced cost of production and maximized economic returns(Awoke Kassa, 2015). Sheep which had a better nutrient intake had superior ADG as a result of this, had a higher sale price to earn higher net return. On other side, the prices of the feed determine net profit/income.

The net return from the supplemented experimental treatments was higher than un supplemented (Hunachew Abebe, 2015). The difference in net return was in a similar trend with their weight gain, i.e., lambs in un supplemented group almost remain the same weight and resulted in the lowest net return, while lablab group resulted in higher ADG and recorded the highest net return. Generally, lambs that have a better nutrient intake had superior ADG, as a result of which they fetched higher sale price, and earn higher net return. The difference in the control and treatment was due to the difference in live weight change of the lambs in each treatment, which was a function of differences in feed quality and feed conversion efficiency. This indicates that lambs fed with better quality feed perform well and have higher body weight gain and sold at maximum price and earn better net return(Hunachew Abebe, 2015).

Chapter 3. MATERIAL AND METHODS

3.1 Description of the Study Area

The study was conducted at Zenzelima campus of Bahir Dar University Livestock farm, Amhara Regional State, Ethiopia, which is located between latitude and longitude of 11^0 37' N and 37 ^{0} 28' E coordinates and an elevation of 1912 m above sea level. The average daily minimum and maximum temperatures are 7 and 29 ^{0}C, respectively. The average annual rainfall is 1445 mm. The main rainy season is from June to September. The soils are nitosols i.e fertile agricultural soil (CAES, 2018).

3.2 Experimental Feed Preparations and Feeding

Natural pasture grass hay was purchased from the surrounding area and used as basal feed. The natural pasture hay was ransported by clean vehicles and stored properly to prevent spoilage by fungus and contamination by bacteria.

Noug seed cake was purchased from the surrounding market Bahir Dar town which was available and stored above the ground to prevent aflatoxin and local brewery by-product (Atella) was collected from local beer houses who are making local brewery (tella). The ingredients of atella were maize, barely and millet. After collection, by-products dried in the house on a woody bed on the canvas to remove the moisture contents and increase the dry matter of the feed for five to seven days. Finally, after preparation of feed those were measured and mixed as the required feed treatment that the supplementation of dried atella and noug seed cake as required amount level.

3.3 Experimental Animals and Their Management

Twenty- five Washera lambs with similar initial body weight were purchased from west Gojjam zone in Adet local market for use of the experiment. The age of animals was estimated based on information that was obtained from the owners of the Sheep (seller) during purchasing and was observed the dentition of animals. The animals were held in Quarantine for 21 days and were observed for any health problem. During the quarantine period, albendazole 300 gram/head were given for endo-and ivermectim were given for ecto- parasites treatment as well as vaccination for Ovine pasteurellosis and sheep pox. The sheep had collar for their identification on their necks. Washera lambs were blocked based on their initial body weight into five blocks of five yearling Washera Sheep each and place in individual pen equipped with a bucket and a feeding through in a well-ventilated experimental barn. Additional adaptation periods of 15 days before actual data collection were given to acclimatize the animals to the feed, pens, and experimental procedures. The experimental animals were carefully observed for the occurrence of any ill health and records were taken for any physiological disorder during the experimental period.

3.4 Experimental Design and Treatments

The experimental design used in this experiment was completely randomized block design (RCBD). The initial body weights of animals were determined after overnight fasting at the beginning of the acclimatization period. The five treatment diets were randomly assigned to each animal in the block. The basal diet was offered ad libitum, while supplements were offered twice a day in two equal portions at 0800 and 1600 hours. Dietary treatments are explained as follows treatments and summarize as follows in table1.

Table 1. Summary of the natural pasture hay and experimental treatment

Treatments	Feed			
	NPH	Dried atella (%)	NSC (%)	Amount of DM (g)
T1	Ad libitum	100	0	300
T2	Ad libitum	75	25	300
T3	Ad libitum	50	50	300
T4	Ad libitum	25	75	300
T5	Ad libitum	0	100	300

NPH=Natural pasture hay, NSC=Noug seed cake

3.5 Feeding Trial

The feeding trial was conducted for 90 days following an acclimatization period of 15 days to make animals adapt to the experimental diets and pens. The amount of feed offers and that of refusal was weighed and recorded daily. Daily feed intake was calculated as the difference between the quantity of feed offer and refusal. The sample was taken from batches of feed offer by thoroughly mixing for chemical analysis. Feed refusal samples were taken daily per animal, pool on treatment basis, mix thoroughly and subsample was taken for chemical analysis.

3.6 Digestibility Trial

The digestibility trial was conducted after the feeding trial. The digestibility trial was undertaken for 7 days. Feed offer and refusal were recorded daily. The total fecal collection for the digestibility trial was done by using fecal bags. Each animal was fitted with fecal collection bags (harness) for three days of the adaptation period. This was followed by a 7 days fecal collection period. The fecal output per animal was collected and weighing each morning before offering the morning meal. After weighing the daily total feces voiding by each animal, the feces were thoroughly mixed, and a sub-sample of 20% was taken to form a single weekly composite fecal sample for each animal. Composite samples per animal were stored in airtight plastic bags in a deep freezer at -20°C. The composite fecal samples were thaw and thoroughly mix for each animal and a sub-sample was taken for chemical analysis. A grab of fed samples from each feed and refusal for each animal was taken daily to make a weekly composite sample. The apparent digestibility nutrient and apparent DM digestibility coefficient of DM, OM, CP, NDF, and ADF was determined using the following equations:

$$\text{Apparent Nutrient Digestibility in (g/d)} = \frac{\text{Nutrient Intake} - \text{Nutrient in Feces}}{\text{Nutrient Intake}}$$

$$\text{Nutrient Digestibility Coefficient} = \frac{\text{Total amount of nutrients in feed} - \text{nutrients in feces}}{\text{Total amount of nutrients in feed}}$$

Digestible organic matter contents of treatment feeds was estimated by multiplying the OM content by its digestibility coefficient. The metabolizable energy content of treatment feeds estimated from the digestible organic matter contents of the feeds using the equation of McDonald et al. (2010) as:

ME (MJ/kg DM) = 0.016DOM, Where, DOM = g digestible OM/ kg DM

3.7 Body Weight Change, Average Daily Body Weight Gain and Feed Conversion Efficiency

The body weight of animals was taken every ten days after overnight fasting to determine body weight change during the experimental period using suspended balance. Average daily body weight gain (ADG) was calculated as the difference between final and initial weight divided by the feeding days. The weight taken every 10 days interval was used to show the growth pattern. The feed efficiency of experimental animals was determined by dividing the ADG into the amount of feed consumed. The live weight of animals was taken at the beginning of the experiment and the end of the experiment.

Bodyweight change (BWC) = Final body weight - Initial body weight

$$\text{Average Daily Body Weight Gain (ADG)} = \frac{\text{Final body weight - Initial body weight (g)}}{\text{Number of feeding day}}$$

$$\text{FCE} = \frac{\text{Daily body weight gain (g)}}{\text{Daily feed intake (g)}}$$

3.8 Chemical Analysis

Chemical analysis of experimental feeds, refusals, and feces were carried out on the representative samples. The samples were mixed and take to Bahir Dar Seed purity and forage laboratory and partially dry at 60 ^{0}C in a forcing draft oven for 72 hours and the dried fecal samples were ground to pass through 1mm sieve and kept in airtight containers at room temperature until chemical analysis. The ground samples were taken to Debere-Brihan agricultural research center, and were analyzed for dry matter (DM), ash, and nitrogen (N) following the procedure of AOAC (1990). Crude protein (CP) was determined by multiplying N by a value of 6.25 (N * 6.25). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedure of Van Soest and Robertson (1985).

3.9 Partial Budget Analysis

Partial budget analysis was performed to evaluate the economic advantage of the different feed treatments. The partial budget analysis involves the calculation of variable costs and benefits (returns). The difference in the selling price of lambs in each treatment before and after the experiment was considered as the total return (TR) in the analysis. For the calculation of the variable costs, the expenditures incurred on various feedstuffs were taken into consideration. The costs of the feeds were computed by multiplying the actual feed intake for the completely feeding period with the prevailing market price (Upton, 1979). The prevailing price of the feeds at the time of feed purchasing including the transportation cost incurred to move them to the experimental site are recording. Partial budget analysis method measured profit or loss, which was the difference between gains and expenses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) were subtracted from the total returns (TR): NR = TR-TVC

Total variable costs include the costs of all inputs that change due to the change in production technology. The change in net return (ΔNR) was calculated by the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC).

$\Delta NR = \Delta TR - \Delta TVC$

The marginal rate of return (MRR) measures the increase in net income (ΔNR) associate with each additional unit of expenditure (ΔTVC). This was expressed in percentage as

MRR (ratio) = ΔNR/ΔTVC

3.10 Data Analysis

All data related to feed intake, apparent digestibility coefficient, body weight change, and feed conversion efficiency were recorded. Data were subjected to analysis of variance using the General Linear Model Procedure of SAS (SAS. 2001 v. 9.1) When the treatment effect was significant, treatment means were separated using the least significant difference (LSD). The statistical model was used for data analysis were:

$Yij = \mu + Ti + Bj + Eij$

Where: Yij = Response of dependent variables (feed intake, body weight gained and digestibility).

μ = Overall mean

Ti = effect of treatment

B_j = effect of block

E_{ij} = random error

Chapter 4. RESULTS AND DISCUSSIONS

4.1 Chemical Composition of Experimental Feed

The chemical composition of natural pasture hay, dried atella, noug seed cake, and their mixtures are given in Table 2. The analysis showed that the dry matter content of natural pasture hay used in this experiment was 93%. The CP and OM contents of natural pasture hay were 6.06 and 89.2% respectively. These values were lower than the values of 7% and 93.2% reported for natural pasture hay by (Mulat Alem, 2006). However, the CP contents of natural pasture hay were higher than 5.1% reported by NRC (1980). On the other hand, the NDF (64.5%) content of natural pasture hay was higher than the values reported by Adugna Tolera *et al*. (2012), but in line with the values (66.39%), the reported by Alemu Tarekegn (2016). The ADF content of the studied natural pasture hay (42.4%) was lower than the value of 47.2% reported by Mulat Alem (2006). The ADL content of natural pasture hay (9.27%) in the present study was lower than ADL content (32.65%) of natural pasture hay reported by Alemu Tarekegn (2016).

The variation in chemical composition of natural pasture hay used in the different studies might be associated with the species composition, harvesting stage and environmental factors such as the geographical location, fertility of the soil and level of fertilization, sowing season and rainfall variation of the different areas from where the hay was obtained (Adugna Tolera *et al.,* 2012). Generally, natural pasture hay in this experiment could be characterized by its moderate CP contents.

The CP contents of the supplement feed ingredients, namely, dried *atella* and noug seed cake were 22.2% and 35.32%, respectively. This result was comparable with the report of (Almaz Ayenew *et al*., 2012). According to the report of Adugna Tolera *et al*. (2012), the chemical compositions of dried *atella* were 95.7% OM, 20.2% CP, and 52.8% NDF. Thus, the current study had higher chemical composition than the report of (Adugna Tolera *et al*., 2012). The chemical composition of NSC in this study was comparable with the report of (Tefera Mekonnen et al., 2015; Yeshambel Mekuraw and Bimirew Asmare, 2018). But this result was lower than the report of (Fekede Feyissa, 2015).

Table 2. Chemical composition of Experimental feed offers and refusals.

Types of feed sample	Chemical compositions (% DM)					
	Feed offers (%)					
	DM	OM	CP	NDF	ADF	ADL
NPH	93	89.2	6.06	64.5	42.4	9.27
DA (100%)	92	97.83	22.2	51.3	35.30	8.5
75% DA+25% NSC	90	96.67	27.75	45.66	34.7	7.11
50%DA+50%NSC	92	94.57	29.1	44.5	37.11	6.5
25%DA+75%NSC	92	92.4	29.23	43.5	35.78	5.82
NSC (100%)	93	91.4	35.32	43.5	34.97	4.43
Hay refusals (%)						
T1	93	89.48	4.7	81.5	65.26	13.71
T2	93	93.5	3.5	82.7	42.22	14.31
T3	93	92	4.12	3.12	79.83	13.21
T4	92	91.3	4.23	72.16	34.78	15.46
T5	93	90.3	3.93	70.57	43.10	10

NPH=natural pasture hay, DA= dried atella, NSC= noug seed cake, T1=100% DA, T2=75% DA + 25% NSC, T3=50% DA + 50% NSC, T4=25% DA + 75% NSC and T5= 100%NSC, ADF=acid detergent fiber; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; OM=organic matter and ADL=acid detergent lignin

When the chemical compositions of feed refusals were considered, the NDF, ADF, and ADL contents of the refusals of the natural pasture hay was higher than the corresponding contents of feeds offered, whereas the CP contents of the refusals were lower than the corresponding contents of feeds offered. Feeds that contain a lower proportion of ADF have better availability of nutrients due to ADF being negatively correlated with feed digestibility (McDonald *et al*., 2010). Hence, the value of ADF observed in the natural pasture hay used in the current study was relatively lower than that 52 and 51% values reported by Mulu Moges *et al*. (2008) and Jemberu Dessie (2008), respectively, indicating the relatively lower availability of nutrients contained in the hay to animals. But, the ADF content of the current study was higher (Bimirew Asimare *et al*., 2016).

4.2 Dry Matter and Nutrient Intake

The daily mean feed DM and nutrient intake of Washera lambs fed on natural pasture hay, dried *atella*, noug seed cake, and their mixtures supplements are presented in Table 3. The DMI of Washera lambs in this study were ranged from 735.2 to 941.8 g/d/h and from 2.9 to 3.32 the percentage of BW. This result was higher than the report of Nahom Ephrem *et al. (*2015) with the same breed on nutrient intake, digestibility and growth performance of Washera lambs supplemented with graded levels of sweet blue lupin *(Lupinus angustifoliu s L.*) seed. There were significantly higher differences ($P<0.001$) CP and ME intake in T1 and T5. The crude protein intake of Washera lambs in T1 was lower (93.2 g/d/h) than the crude protein intake in T2, T3, T4, and T5.

The NDFI was non-significant among all treatments. The result of dry matter, organic matter, neutral detergent fiber, and acid detergent fiber intake increased with increasing level of crude protein. However, the result of DMI and OMI intake was higher than the result reported by Yeshambel Mekuriaw and Bimirew Asmare (2018) with the same breed fed natural pasture hay supplemented with graded levels of Ficus thonningii (Chibha) leaves as replacement for concentrate mixture.

The level of ADF and NDF intake of the Washera lambs in T1 were increased with thelevel of dried *atella* supplementation decreased. The order of ADFI was $T1<T2<T4<T3<T5$ from lower to higher. There was significant difference ($P<0.01$) in total ADF intakes between the Sheep in T1 and T4. Generally, the ADF and NDF intake of this study were higher than those reported by Yeshambel Mekuriaw and Bimirew Asimare (2018). Similarly, neutral detergent fiber intake (NDFI) of Washera lambs in T5 was also lower ($P<0.001$) than the NDFI of Washera lambs in T2, which was supplemented 75% dried *atella* +25% NSC. The daily acid detergent fiber intake (ADFI) of Washera sheep in T1 was lower ($P<0.001$) than ADFI of Washera lambs in T2, T3, T4, and T5. According to the report of Almaz Ayenew *et al*. (2012), the ADFI was compared to the present study. The decreasing trend and low in DMI by sheep in the T1 group during the feeding trial might be associated with the poor nutrient composition of natural pasture hay that resulted in reduced body weight of sheep. On the other hand, the variations in DMI and NDFI among T2, T3, and T4 were highly significant ($P< 0.001$). However, there were highly significant (P<0.001) variations in CPI and ADFI among lambs fed the 75% DA + 25% NSC, 50% DA + 50% NSC, and 25% DA + 75% NSC (T2, T3 and T4).

The metabolizable energy (ME) intake of sheep in T5 in this trial was higher (8.4 MJ/Kg DM/day) than all other treatments and sheep in T3 and T4 also had significantly higher (P<0.001) ME intake than T1 and T2. The ME intake of Washera sheep in this study ranges from 5.04 to 8.4 MJ/day. This study was comparable with 7.12 to 7.48 MJ/day for Washera sheep fed nutrient intake, digestibility and growth performance of Washera lambs fed natural pasture hay supplemented with graded level of ficus thonningii (chibha) leaves as a replacement for concentrate mixture (Yeshambel Mekuriaw and Bimirew Asmare, 2018) and 5.0-7.8 MJ/day for Dangila lambs fed urea treated finger millet straws and supplemented with "noug" seed cake, wheat bran, and their mixtures (Melese Gashu *et al.,* 2014). But, higher than 3.8 to 6.7 MJ/day for Horro lambs fed L. sativus haulm supplemented with wheat bran, A. albida leaf meal or their mixtures reported by (Takele Feyera, 2010). The ME intake indicated that the energy intake in all treatments was in the range of 5.1-6.2 MJ/day energy necessary for a 20 kg Sheep gain 50-100 g/day (ARC, 1980).

Table 3. Dry matter and nutrient intake of Washera lambs fed natural pasture hay basal feed and supplement with dried *atella* , noug seed cake and mixtures.

Dry matter intake	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
HDMI(g/d)	435.2^{c}	499.6^{bc}	552.6^{ab}	562.8^{ab}	641.4^{a}	84.92	*
SDMI(g/d)	300	300	300	300	300	0.0	ns
TDMI(g/d)	735.2^{c}	799.6^{bc}	852.8^{ab}	862.0^{ab}	941.4^{a}	84.36	*
DMI (% BW)	2.9^{c}	3.0^{b}	3.12^{b}	3.12^{b}	3.32^{a}	0.088	***
		Nutrient intake (g/d)					
OM	644.2^{b}	698.6^{b}	742.0^{ab}	730.6^{ab}	801^{a}	75.72	**
CP	93.2^{e}	105.8^{d}	120.6^{c}	128.8^{b}	143.8^{a}	5.93	***
NDF	434.6	459.2	490.4	476.8	508.4	55.55	ns
ADF	290^{c}	315.6^{bc}	342.8^{ab}	341.4^{ab}	370.2^{a}	35.08	*
ME(MJ/kg/DM/d)	5.06^{c}	5.54^{b}	8.15^{ab}	8.15^{ab}	8.4^{a}	1.11	***

a, b, c ,d ,e ***= P<0.001, ** = P<0.01, * = p<0.05; SL=significance level, ns= non-significant, DA= dried *Atella,* NSC= noug seed cake, T1=100% DA, T2=75% DA + 25% NSC, T3=50% DA + 50% NSC, T4=25% DA + 75% NSC and T5= 100%NSC, HDM=hay dry matte, TDM=total dry matter, OM=organic matter, CP=crude protein, %B W = percentage of body weight, NDF=neutral detergent fiber and ADF= acid detergent fiber, SDMI=supplement dry matter intake, ME= metabolizable energy.

The Washera lambs supplemented with sole noug seedcake revealed the highest (941.4g/d/h) daily DMI and CP intake than sheep fed natural pasture hay supplemented with sole dried atella .The higher (P<0.001) intakes of DM and CP of sheep fed the noug seedcake supplemented diets was indicative of the better nutritive values of the NSC supplemented diets than the basal diet supplemented with dried atella alone in treatment one (T1).

Figure 1 showed that dry matter intake for all treatments was steadily increasing throughout the experimental period for sheep in all treatments. However, the dry matter intake of sheep in T4 and T5 becomes constant for some of the remaining periods of the experiment indicating that sheep in these treatments reached the maximum level of intake earlier and maintain that respective level across the remaining period. On the other hand, dry matter intake of sheep in all treatment showed a continuous increasing trend until maximum dry matter intake days and then after becomes constant during the finishing days.

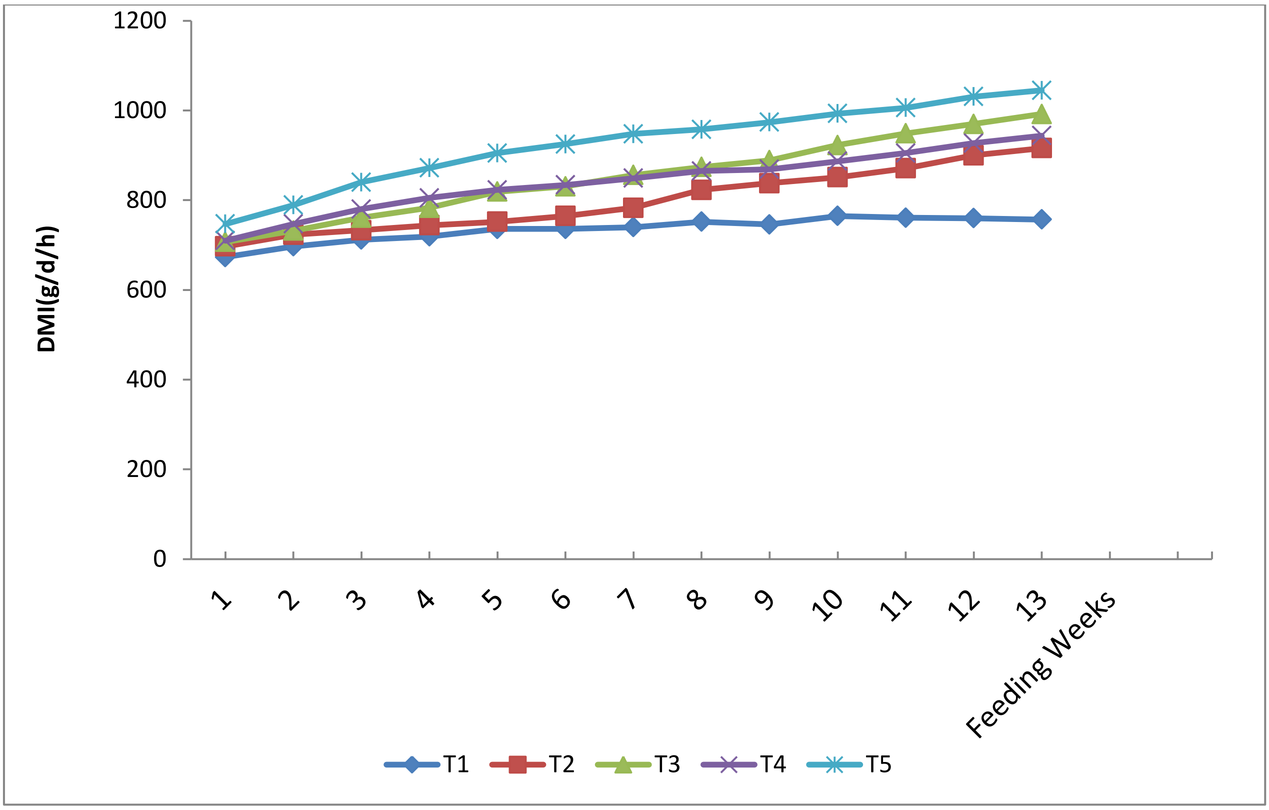

Figure 1. Daily dry matter intake of Washera lambs fed on natural pasture hay and supplemented with of dried *atella*, noug seed cake and their mixtures at different proportions

4.3. Dry Matter and Nutrients Digestibility

The apparent nutrients and DM digestibility coefficient of experimental feeds are shown in Table 4. The dry matter nutrient digestibility of feed supplemented with 100% NSC (T5) and 50% DA + 50% NSC (T3) had a higher value than the other all treatments while dry matter nutrient digestibility of feed supplemented with sole dried *atella* in treatment one had lower dry matter digestibility as compared to the other treatments. The crude protein nutrient digestibility of 100% NSC (T5) was higher than all other treatments. The result has shown that highly ($P<0.001$) significant differences were observed in apparent OM and CP digestibility coefficient among treatments. This is due to the differences in the nitrogen content of the supplements in different treatment groups.

The apparent digestibility coefficient of DM, OM, NDF and ADF in 50% DA+50% NSC (T3) were higher than all other treatments. The apparent digestibility coefficient of CP was higher in 100% NSC (T5) than all other treatments. This result was in line with the report of Nahom Ephram *et al*. (2015) with the same breed supplemented the graded level of sweet lupins and concentrate mixtures. The higher DM digestibility in T3 was not compared to other treatments might be due to their lower average feces voided dry matter and lower NDF and ADF intake in this treatment group. The result of the current study showed that DM digestibility was adversely influenced by the lignin concentration in the experimental diet. The digestibility of a feed is determined largely by the chemical composition of the feed (Khan *et al*., 2003). In T5, higher CP content results could have created a better environment by providing more nitrogen for rumen microorganisms, which was, make higher digestibility of DM for this treatment (Yinnesu A. and Ajebu Nurfeta, 2012). McDonald et al. (2010) reported that the primary chemical composition of feeds that determines the rate of digestion is neutral detergent fiber (NDF). The apparent DM digestibility of T5 (NPH + 100% NSC) was comparable with the report of Assefu Gizachew (2012) mentioned that for the same breed. The apparent digestibility of feeds should exceed 70% on a dry weight basis for the good performance of the animals and when apparent digestibility is 60%, the performance will be intermediate and the minimum range of apparent digestibility to assure body maintenance needs is 42-45%, whereas at animals loss weight (McDonald *et al*., 2010). Based on this classification the feed used in the present study in T4 and T5 were classified as excellent digestibility of feeds whereas T1, T2, and T3 were classified as medium digestibility.

The apparent CP digestibility coefficient of T4 and T5 were higher ($P<0.001$) than T1 and T2. Moreover, apparent CP digestibility was higher ($P<0.001$) for T5 as compared to T1, T3, and T4. This significant difference between treatments was ($p<0.001$) due to the higher CP content of noug seed cake than dried atella. Since high CP intake is usually associated with better CP digestibility (McDonald *et al*., 2010). This result was comparable to the range from the values of (84.12 - 94.61%) reported for noug seed cake supplemented by Alemu Tarekegn (2016). Generally, the CP digestibility was higher than other chemical composition due to the high nitrogen content (McDonald *et al*., 2010).

The apparent NDF digestibility of T3 and T5 was highly significant ($P<0.001$) than T1, T2 and T4. The NDF digestibility and apparent ADF digestibility coefficient of T3 was highly significant ($P<0.001$) among treatments. This result similar to the report of Yeshambel Mekuriaw and Bimirew Asmare (2018) shown that the digestibility values of

NDF and ADF did slightly positively affect the total dry matter intake across the treatments.

Table 4. Apparent Nutrient digestibility coefficient and digestible nutrients intake (g/d) of washera lambs fed on natural pasture hay and supplemented with different proportions of dried atella, noug seed cake, and their mixtures.

Digestible Nutrient per day(g/d)	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
DM	411^{c}	491^{b}	603^{a}	556^{ab}	639^{a}	79.56	**
OM	316^{c}	409^{b}	509^{a}	509^{a}	526^{a}	69.7	***
CP	47^{d}	66^{c}	85^{b}	90^{b}	110^{a}	6.0	***
NDF	174^{b}	168^{b}	298^{a}	186^{b}	206^{b}	46.7	**
ADF	98^{b}	77^{b}	168^{a}	105^{b}	106^{b}	33.18	**
Nutrient digestibility coefficient							
DM	0.56^{c}	0.61^{bc}	0.70^{a}	0.64^{ab}	0.68^{ab}	0.05	**
OM	0.49^{c}	0.58^{b}	0.68^{a}	0.62^{ab}	0.65^{ab}	0.06	***
CP	0.51^{c}	0.56^{c}	0.69^{b}	0.74^{b}	0.84^{a}	0.05	***
NDF	0.39^{b}	0.37^{b}	0.61^{a}	0.39^{b}	0.41^{b}	0.08	**
ADF	0.33^{b}	0.24^{b}	0.49^{a}	0.31^{b}	0.29^{b}	0.09	**

a, b, c, d- means with different superscripts in a row significantly differ.;**=(p<0.01)& ***= (P<0.001); DA= dried Atella, NSC= noug seed cake, T1=100% DA, T2=75% DA + 25% NSC, T3=50% DA + 50% NSC, T4=25% DA + 75% NSC and T5= 100%NSC, ADF=acid detergent fiber; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; ns=non-significant; OM=organic matter; SEM= standard error of mean; SL=significant level

4.4. Body Weight Change and Feed Conversion Efficiency

The mean initial and final body weight, average daily body weight gain (ADG) and feed conversion efficiency (FCE) of Washera lambs fed on sole and mixtures of noug seed cake and dried *atella* supplement are presented in Table 5. The final body weight of the washera lambs had no significant (p>0.05) difference among treatments. When the supplementation level of noug seed cake was increased in the diet, the average body weight change was significantly (P<0.001) increased. Similarity, following the variations in the body weight change of Washera lambs, fed the experimental diets, there was also a significant (P<0.001) variations in average daily weight gains (ADG) of sheep on the different diets. This result was comparable with the report of Bimirew Asmare *et al.* (2016), Yeshambel Mekuriaw (2018). Simachew Gashu (2009), Anteneh Worku (2015), and Alemu Tarekegn (2016) reported that as the level noug seed cake supplementation increased.

Accordingly, sheep fed the basal diet and supplemented with 100% dried *atella* (T1), had highly significantly (P<0.001) ADG. But, lower than Washera lambs fed basal diets and supplemented 50%DA + 50% NSC (T3) and 25% DA +75% NSC (T4) with the same basal diet taken ad libitum. This is might be due to the CP contents of the supplement. The average daily body weight gain and feed conversion efficiency increased due to the increment of noug seed cake supplement. According to the report of Melese Gashu *et al.* (2014) had comparable results with the same Washera lambs.

Table 5. Bodyweight parameters and feed conversion efficiency of Washera lambs fed on natural pasture hay, dried *atella*, noug seed cake, and their mixtures.

Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Initial BW (kg)	20.44	21.3	20.92	20.56	20.9	2.31	ns
Final BW(kg)	25.64	26.749	27.36	27.58	28.24	2.5	ns
BWC(kg)	5.2^{d}	5.44^{c}	6.44^{b}	7.02^{a}	7.34^{a}	0.52	***
ADG(g/d/h)	58^{d}	60^{c}	72^{b}	78^{a}	82^{a}	4.22	***
FCE	0.079^{b}	0.078^{b}	0.084^{a}	0.09^{a}	0.088^{a}	0.009	**

a, b, c, d=means within rows having different superscript are significantly different at,***= P<0.001; ** = P<0.01; DA= Dried *Atella,* NSC= Noug Seed Cake, T1=100% DA ,T2 = 75% DA + 25% NSC, T3 = 50% DA + 50% NSC, T4 = 25% DA + 75% NSC and T5 = 100% NSC, BW = Body Weight; BWC=Body Weight Change; ADG=Average Daily Gain; FCE = Feed Conversion Efficiency; SEM=standard error means;
SL= Significance Level; ns=non-significant.

The mean daily body weight gain of Washera lambs ranged from (60-82g/d/h) brought by the groups fed on the basal diet natural pasture hay containing the inclusion of noug seedcake (NSC) was significantly higher (P<0.001) than all others. On the opposite side, there was a lower significant difference among the treatment groups fed on the diets containing 100% dried *atella* in the mean daily body weight gain (P<0.001). The improved feed conversion efficiency although highly significant (P<0.001), in the current result, might presumably be due to higher CP values of the basal diet due to the increment the level of crude protein content in the noug seed cake and dried atella and their mixtures. Owing to the total increment of CP intake from T1 to T5. The body weight change of Washera lambs fed natural pasture hay basal diet and concentrate mix supplement had similar development with the average daily body gain. The Mean daily body weight gain(58-80.8 g/d/h) of yearling Washera Sheep obtained from this study was higher than the results of Simachew Gashu (2009) who reported that the mean daily gain of Washera sheep fed natural pasture hay supplemented with maize bran, noug seed meal and their mixtures ranged between 38.9 and 55.6 g/day. The ADG and FCE of sheep in the current result was comparable to the report of Anteneh Worku *et al.* (2015) for Washera sheep fed natural pasture hay and supplemented with concentrate mixture and sugar cake tops. On the other side, the result of the current study was comparable to the result of Bimirew Asmare *et al*. (2016) who reported 52.2-76.4 g/day from Washera sheep fed on natural pasture hay basal diet and supplemented desho grass hay with concentrate NSC and wheat bran mixture (300g/d DM). The general trends in body weight changes of Washera sheep fed on the combination of natural pasture with supplementation of concentrate mixture are shown in table 5. As figure 2 illustrates, the bodyweight of experimental Sheep in the current study continued in an increasing trend throughout the experimental period.

The study illustrates that supplementation of died *atella* improves the performance of animals due to positive body weight gain of Washera lambs. This statement supported by the result of Almaz Ayenew *et al*. (2012) who reported that the nutritive value of dried atella has a moderate level of crude protein, but supplementation with nitrogen and energy improves the performance of Washera lambs (Bimirew Asimare *et al.*, 2016). The current result was supported by the work of Awoke Kassa (2015) who indicated that Washera lambs fed high protein ration (adlibitum) had greater DM intakes, mean daily weight gain, and feed conversion efficiency within a shorter period of feeding compared to those fed diets with normal protein concentrates. Generally, the current result was in agreement with the work of Naphom Ephram *et al.*(2015) who recommended supplement level of 300 g/day DM concentrate for sheep fed crop residue as a basal diet. Alemu Tarekegn (2016) who recommended a supplementary level of 400 g/day DM concentrate for Sheep fed natural pasture hay as a basal diet

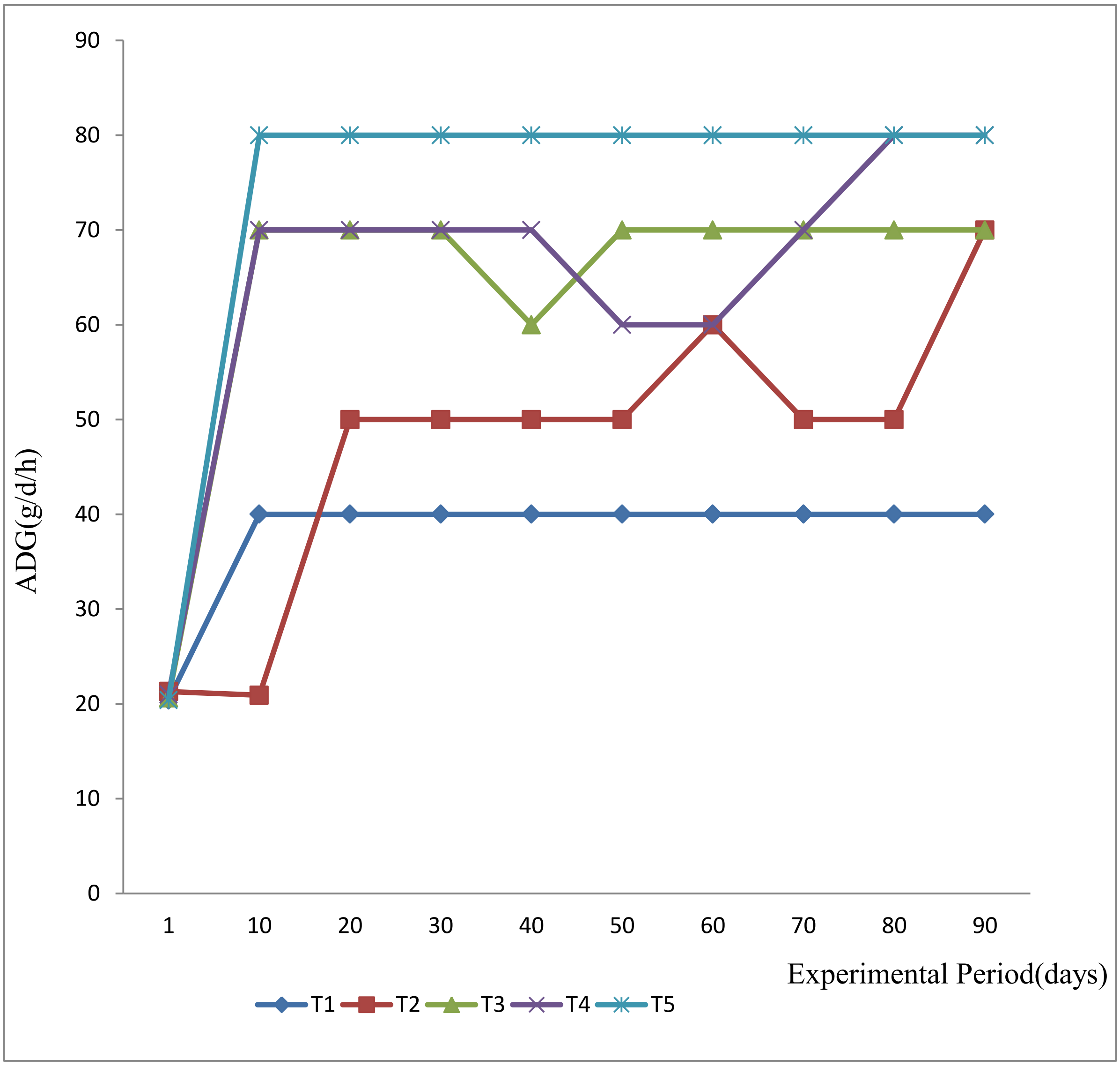

Figure 2. Body weight change over time of Washera lambs fed natural pasture hay and supplemented with of dried *atella*, noug seed cake and their mixtures at different proportions.

The study illustrates that supplementation of died *atella* improves the performance of animals due to positive body weight gain of Washera lambs. This statement supported by the result of Almaz Ayenew *et al*. (2012) who reported that the nutritive value of dried atella has a moderate level of crude protein, but supplementation with nitrogen and energy improves the performance of Washera lambs (Bimirew Asimare *et al.*, 2016). The current result was supported by the work of Awoke Kassa (2015) who indicated that Washera lambs fed high protein ration (adlibitum) had greater DM intakes, mean daily weight gain, and feed conversion efficiency within a shorter period of feeding compared to those fed diets with normal protein concentrates. Generally, the current result was in agreement with the work of Naphom Ephram *et al.*(2015) who recommended supplementary level of 300 g/day DM concentrate for sheep fed crop residue as a basal diet. Alemu Tarekegn (2016) who recommended a supplementary level of 400 g/day DM concentrate for Sheep fed natural pasture hay as a basal diet.

4.4 Correlation Among Nutrients Intake, Digestibility, and Daily Body Weight Gain of Washera Sheep

The correlation among nutrient intake, digestibility, and daily body weight gain yearling Washera Sheep of the current study is shown in Table 6. Dry matter intake and digestibility were positively correlated (P<0.05) with CP, OM, NDF, and ADF intake and digestibility and with each other. This result is in agreement with previous results reported by Bimirew Asimare *et al*. (2016). The DMI and DMD were positively correlated with mean body weight gains and the organic matter intake was positively correlated with CP, NDF, ADF digestibility except ADF intake which was significantly (P>0.05) correlated with ADG.

The result of the correlation analysis indicated that daily body weight gain was positively (P<0.01) correlated with DM, OM, CP, NDF, and ADF intake and digestibility which is in agreement with previous results obtained from the feeding trial conducted with Washera Sheep (Assefu Gizachew, 2012 and Awoke Kassa, 2015) and Gumuz breed of Sheep (Alemu Tarekegn, 2016) in northwestern Ethiopia. But, ADG was negatively correlated with TNDFI. The improved averagely daily gain for increased noug seedcake to dried atella proportion in the total diet of sheep may presumably be due to higher nutrient concentration and nutrient digestibility, which increased the bodyweight of sheep.

The result of the correlation analysis indicated that daily body weight gain was positively (P<0.01) correlated with DM, OM, CP, and ADF intake and digestibility which is in agreement with previous results obtained from the feeding trial conducted with Washera sheep (Assefu Gizachew, 2012; and Awoke Kassa, 2015). The correlation among TNDFI TADFI, DMD, OMD, CPD, NDFD, and ADFD were non-significant. The correlation between TNDFI and ADG was negatively.

Table 6. Correlation between nutrient intake, digestibility, and body weight gain in Washera lambs fed natural pasture hay, and supplemented with dried *atella*, noug seed cake and their mixture.

	TDMI	TOMI	TCPI	TNDFI	TADFI	DMD	OMD	CPD	NDFD	ADFD	ADG
TDMI	1										
TOMI	957*	1									
TCPI	.862**	.729**	1								
TNDFI	.381	.513**	.055	1							
TADFI	.726**	.719**	.582**	.102	1						
DMD	.842**	.755**	.845**	.177	.575**	1					
OMD	.837**	.755*	.842**	.183	584*	987*	1				
CPD	.853**	.725**	.976**	.017	.545**	.916**	.915**	1			
NDFD	.550**	.526*	.513**	.417	.322	.806**	823*	.603**	1		
ADFD	.645**	.605**	.595**	.286	.529**	.883**	.893**	.682**	946*	1	
ADG	.788**	.676**	.902**	-00	.766**	.728**	.741**	.858**	.379**	.544**	1

** Correlation is significant at the 0.01 level, *correlation is significant at the 0.05 level, TDMI= total dry matter intake, TOMI= total organic matter intake, TCPI = total crude protein intake, TNDFI = total neutral detergent fiber intake, TADFI = total acid detergent fiber intake, DMD = dry matter digestibility, OMD = organic matter digestibility, CPD= crude protein digestibility, NDFD= neutral detergent digestibility, ADFD =acid detergent digestibility and ADG= average daily gain

4.5 Partial Budget Analysis

Partial budget analysis result of washera lambs fed natural pasture hay, dried *atella*, noug seed cake, and their with mixtures is presented in Table 7. The partial budget analysis was performed to evaluate the economic advantages of the use of locally available dried *atella* at different proportions instead of commercial concentrate mixture like noug seed cake. The result of this study indicated that higher net return (658.8 ETB/sheep) was obtained from the sheep supplemented with 75% dried atella and noug seed cake (T2), followed by T4, T3, T1, and T5 in decreasing order. The net return was 658.8, 650.3, 641.05, 604.7, and 592.6 ETB/head for T2, T4, T3, T1, and T5, respectively. This result indicated that there was no economic loss of Birr/sheep in all treatments yearling Washera sheep fed on natural pasture hay, dried atella, noug seed cake, and their mixtures. In this study, the difference in total return followed the same trend with the cost of supplement feed to the experimental animals. This showed that low-cost supplements, which had higher, net income. The higher total net returns were based on the cost supplement, which is used in the experiment that the experimental animals fed on *atella* T2 (75% dried *atella* + 25% NSC). This result was obtained to the intake of moderate crude protein and dry matter intake.

The net return of supplemented sheep in the current study was relatively higher compared to the results reported by Ermias Tekletsadik (2008), Melese Gashu *et al*. (2012) and Tesfaye Negewo (2008) which is in the range of 59.60 - 88.6, 52.00 - 82.16, and 60.10 - 153.20 ETB/head for Horo sheep fed natural pasture hay and supplemented with barley bran, linseed and their mixtures, Washera lambs fed urea treated finger millet straw and supplemented with noug seed, wheat bran and their mixtures and Arsi- bale sheep fed urea treated Maize cob basal diet and supplemented with graded levels of wheat bran and noug seed cake mixtures, respectively. The observed difference in net return might be due to the variations in purchasing and selling price of sheep, variations in sheep breeds used and differences in basal diet and supplements used in different experiments. According to the report of Almaz Ayenew *et al.* (2012), sheep supplemented with mixtures of 70% atella and 30% NSC mixture had higher net income. However, sheep fed natural pasture hay with 75% dried *atella* + 25% NSC (T2) had a higher change in net income than other treatments on this study.

Table 7. Partial budget analysis of washera lambs fed natural pasture hay, dried *atella*, noug seed cake, and their mixtures supplemented with natural pasture hay as basal diet.

Parameters	Treatments				
	T1	T2	T3	T4	T5
Number of animals	5	5	5	5	5
Purchase price of sheep (ETB/head)	1120	1150	1140	1100	1130
Total feed consumed (kg/head)	58	52.4	46.8	46.75	62.4
Total basal diet consumed (NPH) (kg/head)	31	32.2	33.3	34.6	35.4
Dried *Atella* (kg/head)	27	20.25	13.5	6.75	-
Noug Seed Cake (Kg/head)	-	6.75	13.5	20.25	27
Cost of basal diet (hay) (ETB/head)	55.8	58	60	62	63
Cost dried *atella* (ETB/head)	67.5	50.6	33.75	16.9	-
Noug seed cake (ETB/head)	-	48.6	97.2	145.8	194.4
Total feed cost (TVC)(ETB/head)	123.3	157.2	190.95	224.7	257.4
Gross income (selling price of sheep) (ETB)	1848	1966	1972	1975	1980
Total return (ETB/head)	728	816	832	875	850
Net return (ETB)	604.7	658.8	641.05	650.3	592.6
ΔTVC	-	33.90	67.65	101.40	134.10
ΔNI	-	54.10	36.35	45.60	-12.10
MRR (ratio)	-	1.6	0.54	0.45	-0.09

ETB =Ethiopian Birr; ΔNI = change in net income; ΔTVC = change in total variable cost; MRR= marginal rate of revenue; NPH=Natural pasture hay; DA=Dried *Atella*; NSC=Nou g seed cake; T1=NPH+100% DA; T2=NPH+75% DA+25% NSC; T3= NPH +50% DA+5 0% NSC; T4= NPH+25% DA+75% NSC and T5=NPH +100% NSC

The marginal rate of return ratio for supplemented sheep in T2, T3, and T4 was 1.6, 0.54, and 0.45 respectively. This indicates that to attain required BW by supplement feeding, each additional unit of 1ETB increment per Sheep to purchase supplement feed resulted in a profit of 1.6 ETB for T2 and 0.54 ETB for T3.

However, new technologies normally require investment, therefore, additional capital is necessary. When capital is limited, the extra (or marginal) cost should be compared with the extra (or marginal) net benefit. This technology was needed for the drying of atella.

Thus, even though sheep in T3, T4, and T5 showed good performance in BW gain, it was not found to be economically feasible compared to the other supplemented treatments but from the biological point of view, these three treatments T3, T4, and T5 resulted from better final and average body weight gain and recommended. However, concerning economic profitability, the results of this study were suggested that supplementation of natural pasture hay with 75% dried *atella* and 25% NSC out of 300 g dried *atella* is potentially more profitable and economically beneficial than the other supplement feeds. The marginal rate of return or ratio for supplemented sheep in T2, T3, and T4 was 1.6, 0.54, and 0.45 ETB, respectively. The result achieved in the present study was lower than 1.3 - 2.8, 1.0 - 3.8, 0.9 - 1.9 and 1.2 - 2.0 reported by Ermias Tekletsadik (2008), Hirut Yirga *et al.* (2011), Melese Gashu *et al.* (2012) and Tesfaye Negewo (2008) for Arsi- Bale, Harerge Highland, Washera and Arsi- Bale sheep, respectively fed different basal diet and supplements. This may be the variations in purchasing and selling price of sheep, variations in sheep breeds used, and differences in basal diet and supplements used in different experiments. Noug seed cake and dried *atella* supplementation in a proportion of 100% NSC (300g/head/d on DM basis) had more satisfactory daily BW gain (82 g/d), but had low net income (592.6 ETB/head). This due to the high cost of noug seedcake supplement. Generally, feed supplements, which had low cost a better ADG to earn higher net returns.

Chapter 5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was conducted at Bahir Dar University Zenzelima Campus animal experimental site. The treatments were used to this experiment 100% DA, 75% DA+25% NSC, 50%DA +50% NSC, 25% DA+75% NSC and 100 % NSC for T1, T2, T3, T4, and T5, respectively The objective of this study to evaluate the effect of dried *atella*, noug seed cake and their mixtures as a supplement on natural pasture hay on feed intake, digestibility, BW change, feed conversion efficiency and economic feasibility parameters of intact males washera lambs. According to, the result in chemical analysis of the treatment diets were, CP, NDF and ADF contents of NPH was 6.06, 64.5, and 42.4%, respectively. The CP contents of the treatments 100% DA, 75% DA + 25% NSC, 50% DA+ 50% NSC, 25% DA+75%NSC and 100% NSC concentrate mix were 22.2, 27.75, 29.1, 29.23 and 35.32, respectively.

The percentage BW, ME, CP and NDF intake was higher (P<0.001) for T5 (300 g/day NSC) than T2 (225g/day DA + 75 g/day NSC), T3 (150 g/day DA + 150g/day NSC), T4 (300 g/day DA) and T1 (75g/day DA + 225 g/day NSC). Intake of OM in T5 was estimated metabolizable energy and basal feed were highly significant (P<0.0001) among the treatments. Contrary to supplement feed intake, total NDF intake (434.6, 463.2, 476.8, 490.9, and 508.4) for T1, T2, T3, T4, and T5 respectively, was not different (P>0.05) among treatments. Sheep fed T1, T2, T3, T4, and T5 diet was had significantly higher CP intake as compared to sheep fed T1 diet (concentrate mixture). The CP intake was higher (P<0.001) for sheep in T5 (143.8g/day) than in T4 (128.8g/day), T3 120.6g/day), T2 (107. 8g/day) and T1 (93.2g/day).

The apparent DM digestibility coefficient for T3 was higher (P<0.05) than T1, T2, T4 and T5. Apparent CP digestibility coefficient for T5 (0.84), and T4 (0.74%), were higher (P<0.001) than T2 (0.56) and T1 (0.51). Moreover, apparent CP digestibility coefficient for T5 was higher than T1, T2, T3, and T4. The apparent NDF digestibility coefficient values of T3 were higher than T1, T2, T4, and T5 (P<0.05). The CP had the highest digestible nutrient than other nutrient compositions. There were no significant (P>0.05) differences among the treatments in final body weight. However, BW change (4.62, 5.54, 6.44, 7.12, and 7.26), average daily gain (51.2, 65.6, 71.4, 79.2, and 80.8), feed conversion efficiency coefficient (0.07, 0.084, 0.084, 0.088, and 0.094) for T1, T2, T3, T4, and T5, respectively.

The partial budget analysis result of the current study showed that feed cost decreased as the level of dried atella increased. The use of sole dried atella instead of NSC was displayed it reduced feed cost and increased net return. In conclusion, from an economic point of view, T2 exhibited lower feed cost, increased net return than other treatments, and therefore, it is recommended. However, all supplements were used in this study induced favorable average daily gain and net return and thus can be employed in feeding systems depending on their availability and relative cost.

5.2 Recommendations

Based on this result, even if noug seed cake in (T5) had higher CP value and brought higher body weight gain in the experiment with in short period but from the point of getting a total return and higher profit by supplement of the higher proportion of dried atella in treatment (T2 and T3) were recommended. Therefore, awareness should be created among producers about the significance of supplementing local brewery byproduct particularly, dried atella. Natural pasture hay-based feeding of lambs should be supplemented with low-cost supplementary feeds (dried *atella*) for higher economic return. A study on the digestibility and rumen degradability characteristics of experimental for local brewery byproduct (dried *atella*) should be carried out to better understand the significance of local brewery byproduct supplements for feeding ruminants. Further research will be investigated on-farm for the partial budget analysis to get real profit by experiment.

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7. APPENDICES

Table1. Summary of ANOVA for the dry matter and nutrient intake of washera sheep fed natural pasture hay basal diet and supplemented with mixtures of dried atella and noug seed cake at different proportions in g/d.

Parameters	DF	MS	F value	Pr>F	SL
HDMI	16	24223.86	3.49	0.026	*
TDMI	16	28851.14	4.21	0.0124	*
OMI	16	16329.94	2.95	0.0454	*
CPI	16	1880.74	71.19	<.0001	***
NDFI	16	3908.56	1.31	0.299	ns
ADFI	16	4521.66	3.82	0.0182	*
%BW	16	0.1444	18.51	<0001	***
ME(MJ/kg DM)	16	9.147	7.38	0.0008	***

***= P<0.001; ** = P<0.01;*=p<0.05, DF= degree of freedom; MS= mean square of treatments; SL = significance level, ns= non-significant, HDMI=hay dry matter intake, TDMI=total dry matter intake, OMI=organic matter intake, CPI=crude protein intake, NDFI=neutral detergent fiber intake, ADFI= acid detergent fiber intake, BW=body weight and ME=metabolizable energy.

Table 2. Summary of ANOVA for the dry matter and nutrient intake digestibility of washera lambs fed natural pasture hay basal diet and supplemented with mixtures of dried *atella* and noug seed cake at different proportions in g/d.

Parameters	DF	MS	F value	Pr>F	SL
DMD	16	41308.84	6.53	0.0016	**
OMD	16	35767.64	7.36	0.0008	***
CPD	16	2856.36	79.12	<.0001	***
NDFD	16	14272.7	6.55	0.0015	**
ADFD	16	55855.16	5.32	0.0044	**

***= P<0.001, ** = P<0.01, *=p<0.05, DF= degree of freedom, MS= mean square of treatments, SL = significance level, ns= non-significant, DMD=dry matter digestible, OMD=organic matter digestible, CPD=crude protein digestible, NDFD=neutral detergent fiber digestible and ADFD=acid detergent fiber digestible.

Table 3. Summary of ANOVA for the dry matter and nutrient digestibility coefficient of washera lambs fed natural pasture hay basal diet and supplemented with mixtures of dried *atella* and noug seed cake at different proportions.

Parameters	DF	MS	F value	Pr>F	SL
DMDC	16	0.17	5.06	0.0055	**
OMDC	16	0.03	8.16	0.0005	***
CPDC	16	0.09	35.61	<.0001	***
NDFDC	16	0.048	8.16	0.0005	***
ADFDC	16	0.043	5.21	0.0048	**

***= P<0.001, ** = P<0.01,*=p<0.05, DF= degree of freedom; MS= mean square of treatments; SL = significance level, ns= non-significant, OMDC =organic matter digestible coefficient, CPDC=crude protein digestible coefficient, NDFDC=neutral detergent fiber digestible coefficient, ADFDC=acid detergent fiber digestible coefficient and DMDC=dry matter digestible coefficient.

Table 4. Summary of ANOVA for the Body weight gain change and feed conversion efficiency of washera lambs fed natural pasture hay basal diet and supplemented with mixtures of dried *atella* and noug seed cake at different proportions.

Parameters	DF	MS	F_{Value}	Pr > F	SL
Initial body weight	16	0.6	0.11	0.98	Ns
Final body weight	16	4.71	0.75	0.569	Ns
BWC	16	6.19	22.88	<.0001	***
ADG	16	719.24	40.32	<.0001	***
FCE	16	0.00039	154.04	0.0073	**

***= P<0.001, ** = P<0.01, *= p <0.05, DF= degree of freedom, MS= mean square of treatments, SL = significance level, ns= non-significant, ADG=Average daily body weight gain, BWC=Body weight change, and FEC=feed converision efficiency.

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