EFFECTS OF FEEDING DIFFERENT VARIETIES OF FABA BEAN (*Vicia faba* L.) STRAWS WITH CONCENTRATE ON FEED INTAKE, DIGESTIBILITY, BODY WEIGHT GAIN AND CARCASS CHARACTERISTICS OF ARSI-BALE SHEEP

MSc THESIS

BY
TEKLU WEGI FEYISA

JANUARY 2016

HARAMAYA UNIVERSITY, HARAMAYA

Effects of Feeding Different Varieties of Faba Bean (*Vicia faba* L.) Straws with Concentrate on Feed Intake, Digestibility, Body Weight Gain and Carcass Characteristics of Arsi-Bale Sheep

A Thesis Submitted to the Postgraduate Program Directorate
(School of Animal and Range Science)

HARAMAYA UNIVERSITY

In Partial Fulfillments of the Requirements for the Degree of
MASTER OF SCIENCE IN AGRICULTURE
(ANIMAL PRODUCTION)

By
Teklu Wegi Feyisa

January 2016

Haramaya University, Haramaya

HARAMAYA UNIVERSITY

POSTGRADUATE PROGRAM DIRECTORATE

We hereby certify that we have read and evaluated this thesis entitled on '**Effects of Feeding Different Varieties of Faba Bean (*Vicia faba* L.) Straws with Concentrate on Feed Intake, Digestibility, Body Weight Gain and Carcass Characteristics of Arsi-Bale Sheep',** prepared under our guidance by **Teklu Wegi.** We recommend that it be submitted as fulfilling the thesis requirement.

<u>Professor Adugna Tolera (PhD)</u>	________________	______________
Major Advisor	Signature	Date
<u>Getachew Animut (PhD)</u>	________________	______________
Co-advisor	Signature	Date
<u>Jane Wamatu (PhD)</u>	________________	______________
Co-advisor	Signature	Date

As member of the *Board of Examiners* of the *MSc. Thesis Open Defense Examination*, We certify that we have read and evaluated the Thesis prepared by Teklu Wegi and examined the candidate. We recommended that the Thesis be accepted as fulfilling the *Thesis* requirement for the Degree of *Master of Science* in Agriculture (Animal Production).

<u>Yesihak Yusuf (PhD)</u>	______________	______________
Chairperson	Signature	Date
<u>Professor Khushi Ram Yadav (PhD)</u>	______________	______________
Internal Examiner	Signature	Date
<u>Ajebu Nurfeta (PhD)</u>	______________	______________
External Examiner	Signature	Date

DEDICATION

This piece of work is dedicated to the memory of my grandmother **W/r Atatu Sembeta** and grandfather **Ato Feyisa Ararame** who passed away while I am preparing this manuscript.

STATEMENT OF THE AUTHOR

I hereby declare that this thesis is my original work and all sources of materials used for this work have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc. degree in Animal Production at Haramaya University, College of Agriculture and Environmental Sciences and is deposited at the University's Library to be made available to borrowers under the rules and regulations of the University library.

Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the college or Coordinator of the Graduate Program or Head of the Department of Animal Production when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Teklu Wegi Feyisa

Signature____________________

Place: Haramaya University

Date of Submission: __________

BIOGRAPHICAL SKETCH

The author was born at Teso, Jeldu Woreda, West Shoa Zone of Oromia Regional state on 12th August, 1983 from his mother Fanaye Lemma and his father Wegi Feyisa. He attended his Elementary and Junior Secondary School Education at Teso Elementary and Shukute Junior Secondary School respectively and High School Education at Ambo Compressive Senior Secondary School. He completed his high school education in 2002 and joined Jimma University and graduated on 12 July, 2006 with BSc. Degree in Animal Production and Health.

After his graduation he was employed as livestock expert by Oromia Region, West Shoa Zone, Chelia Woreda from December, 2006 to February, 2010. He was again employed by Oromia Agriculture Research Institute (OARI), Sinana Agricultural Research Center (SARC) in March, 2010 joined Animal Feed and Nutrition Team as forage breeder. He served as Junior Researcher to Assistant Researcher of forage breeder in the center until he left in October 2013 to pursue his MSc. study in Animal Production at Haramaya University.

ACKNOWLEDGEMENT

Above all, I would like to thank the Almighty God for his blessing by keeping me healthy, provide me strength and patience throughout my study. Had it not been the will of God, the work would have not been possible for me.

I wish to express my sincere and profound gratitude to my major advisor Professor Adugna Tolera for providing direction from proposal writing to my research and his unmeasurable support and useful advice and comments, encouragement, which inspired me to work hard and brought this study to completion. I am greatly indebted to my co-advisor Dr. Getachew Animut for his encouragement, tireless support and constructive comments through email and telephone at all stages of this work. I am also highly indebted to my co-advisor Dr. Jane Wamatu for her commitment especially for the purchase of equipment's, budget and lab facilitation as well as comments and follow up from the initial conception to the end of this work.

I am grateful to Oromia Agricultural Research Institute for providing me study leave and paying my salary during the study time. I am very grateful to the ICARDA/Africa RISING project for sponsoring my thesis as well as equipment purchased especially the feed chopper, water storage tank, deep freeze, generator, weighing balances among others for my trial. I wish to express my thanks to Sinana Agricultural Research Center and the Animal Feed and Range Land Improvement Case Team for creating a favorable environment to conduct the experiment and providing the necessary materials used in this study. The unreserved support of Nuguse Hurisa, Kidane Kebeba, Tesfaye Dekaba, Damoz Siyoum, Mulunesh Alemu, Kabtamu Abera and Gudeta Shelema from Animal Feed and Range Land Improvement Case Team is highly acknowledged.

My deep gratitude also directed to W/rt Sada Kemal for her follow up and sending my salary timely, Mr Tadele Tadesa, Bekele Diriba and Yonas Worku for materials support, Abiyot Tufa and Sime Mengistu for faba bean threshing and straws chopping, Solomon Indale for water and electric line installations to the barn and timely responses during electricity failure. My appreciation goes to Teshome Tolera, Amedin Husen, Yerom Girma, Meserat K/Bacho and Meskerem Feyisa for guarding and cleaning the barn as well as feed and water provision during the whole trial. My special thanks go to Mr Shure Soboka, Tamane Midksa, Tilahu Bayisa, Tamaro Gelgalo, Bekele Tesfaye, Ermias Teshome, Birhanu Tesaw, Kisi Wakweya and Mahammed Beriso for their timely supervision, valuable comments and support in various aspects during my trial.

Finally, I would like to express my gratitude to my parents, my brothers and sisters for their moral supports and strengthen during the work.

ACRONYMS AND ABBREVIATIONS

ADF	Acid Detergent Fiber
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
ARC	Agricultural Research Council, UK
BWC	Body Weight Change
CCW	Chilled Carcass Weight
CP	Crude Protein
CSA	Central Statics Agency
DAGRIS	Domestic Animals Generic Resources Information System
DM	Dry Matter
EBW	Empty Body Weight
EE	Ether Extract
EOC	Edible Offal Component
EPA	Ethiopian Privatization Agency
FBW	Final Body Weight
FCE	Feed Conversion Efficiency
FT	Fat Thickness
HARC	Holeta Agricultural Research Center
HC	Hemicellulose
HCW	Hot Carcass Weight
IBW	Initial Body Weight
ILRI	International Livestock Research Institute
IVDMD	*Invitro Dry Matter Digestibility*
IVOMD	*Invitro Organic Matter Digestibility*
LS	Level Of Significance
LSD	Least Significant Difference
ME	Metabolizable Energy
NDF	Neutral Detergent Fiber

ACRONYMS AND ABBREVIATIONS(CONTINUED)

NEOC	Non Edible Offal Components
NSC	Noug Seed Cake
OM	Organic Matter
Om-ab	Omasium abomasum
REA	Rib Eye Area
Ret-rum	Reticulo-Rumen
SARC	Sinana Agricultural Research Center
SAS	Statistical Analysis System
SBW	Slaughter Body Weight
SD	Standard Deviation
SEM	Standard Error Of The Mean
TDN	Total Digestible Nutrients
WB	Wheat Bran

TABLE OF CONTENTS

TABLE OF CONTENT (CONTINUED)

LIST OF TABLES IN THE TEXT

LIST OF FIGURES

LIST OF TABLES IN THE APENDEX

Appendix Table

EFFECTS OF FEEDING DIFFERENT VARIETIES OF FABA BEAN (*Vicia faba* L.) STRAWS WITH CONCENTRATE ON FEED INTAKE, DIGESTIBILITY, BODY WEIGHT GAIN AND CARCASS CHARACTERISTICS OF ARSI-BALE SHEEP

ABSTRACT

A study was conducted using 40 yearling Arsi-Bale sheep with initial body weight of 19.85±0.29 kg (mean ± SD). The objectives were to evaluate the varietal differences among faba bean straws and to evaluate effects of feeding different varieties of faba bean straws with concentrate *(2 parts wheat bran: 1 part noug seed cake) fed at the rate 70% straws and 30% concentrate mixture on feed intake, digestibility, body weight gain and carcass characteristics of the animals. The varieties included Mosisa (T1), Walki (T2), Degaga (T3), Shallo (T4) and local (T5) which were grown at Sinana Agricultural Research Center. The experiment consisted of 7 days of digestibility trial and 90 days of feeding trial followed by evaluation of carcass parameters at the end of the feeding period. Randomized complete block design was used for the experiment. The experimental animals were grouped into eight blocks of five animals each based on their initial body weight and each animal within each block was randomly assigned to one of the five treatment diets. Yield were significantly different (P<0.001) among varieties evaluated. Crude protein (CP) contents of faba bean straws were 4.9, 5.1, 5.2, 4.3 and 6.2% for Mosisa, Walki, Degaga, Shallo and local respectively and that of wheat bran (WB) and "noug" seed cake (NSC) were 13 and 26.8% respectively. The DM intake of sheep in T2 (754.3 g/day) was higher (P<0.001) than T1, T4 and T5 but did not differ (P>0.001) from T3 (717.9 g/day) and sheep in T3 had higher (P<0.001) DM intake than sheep in T1 and T4. CP intake for T5 was significantly greater (P<0.001) than T3, T1 and T4 whereas no significant difference (P>0.001) from T2. The apparent digestibility of DM of T1, T2 and T3 were greater (P<0.05) than T4 but did not differ (P>0.05) from T5. The OM digestibility was significantly higher (P<0.05) for sheep in T2 than T4. The CP digestibility of sheep in T5 was higher (P<0.001) than that of T3 and T4 but similar (P>0.001) with sheep in T1 and T2 whereas CP digestibility of T1 and T2 were also higher (P<0.001) than T4. Sheep in T2 had greater (P<0.01) average daily gain (64.6 g/day) than sheep in T3 (43.2 g/day), T4 (37.5 g/day) and T5 (48.3 g/day) but no difference (P>0.01) from T1 (52.2 g/day). Feed conversion efficiency was higher (P<0.05) for sheep in T2 as compared to T3, T4 and T5 whereas similar with values obtained for T1. Slaughter body weight and empty body weight were higher (P<0.05) for sheep in T1 and T2 as compared to sheep in T4 but similar (P>0.05) among others. Apart from this, the other carcass components were not affected (P>0.05) by variety of the faba bean straws. It can be concluded that there is significant difference between faba bean straws from different varieties in feed intake, digestibility, body weight gain and feed conversion efficiency and that faba bean straws when supplemented with concentrate had higher potential as animal feed. Based on these results,* Walki *and* Mosisa *varieties could be recommended as pulse crop rotation with cereals in the study area.*

Key words: Arsi Bale sheep, Body weight gain, Digestibility, Faba bean Straw, Intake

1. INTRODUCTION

More than 80% of the Ethiopian population are dependent on agriculture for their livelihoods (Azage, 2005) and usually keep livestock as pastoralists or in mixed crop livestock systems. Ethiopia is among the countries that possess large livestock and sheep population in the tropics. The sheep population is estimated to be around 25.9 million heads (CSA, 2010). Indigenous sheep in Ethiopia have a multipurpose role for smallholder farmers as sources of income, meat, skin, manure and coarse wool or long hairy fleece. They are also a means of risk avoidance during crop failure according to Tesfaye *et al*. (2010). Sheep production provides an opportunity for smallholder farmers that requires low initial capital and is able to use the marginal land as well as crop residues for feeding; additionally, care-taking of sheep can be carried out by any family members. The average holding of sheep per household in Ethiopia ranges between 3.7 (Yenesew, 2010) to 31.6 (Tesfaye *et al.,* 2010). Ethiopia's sheep population is the second in Africa and sixth in the world (Demelash *et al*., 2006).

Despite their number, the productivity of sheep per head is low mainly because of inadequate year round nutrition, both in terms of quantity and quality, unimproved genetic potential and prevalence of diseases and parasites (DAGRIS, 2006; Marcos *et al*., 2006). The low performance of local sheep in terms of live weight gain and carcass yield is mainly due to inadequate nutrition associated with reliance on sole natural pasture, crop residues and/or stubble grazing, which are inherently low in nutrients available being subjected to great seasonal variations (Solomon *et al*., 2008). The annual off-take rate for sheep is estimated to be 33% (EPA, 2002) with an average carcass weight of about 10 kg, which is the second lowest of the sub-Saharan African countries.

Human population growth in Ethiopia is forcing the conversion of many former grazing areas into croplands needed for increased food production and as a result the use of crop residues as animal feed is becoming important. Depending on age, different classes of livestock require 8-18% crude protein on dry matter (DM) basis in their diet to achieve good nutrient digestibility, rumen microbial function, maintenance and production (Perry *et al*., 2003).

One of the crucial aims in livestock feeding is to promote the use of local feeds and by-products in order to decrease feeding costs (Lanza *et al*., 2001). Similarly, Bell and Keith (1994) reported that concentrate supplementation to sheep feed increased total feed intake, nutrient digestibility and utilization. The goal of feeding concentrate feed mixture to growing lambs is to achieve maximum growth rates, better conversion of feed to body weight gain and best carcass characteristics, leading to optimum profit opportunities (Bodas *et al*., 2007**).** Agro-industrial by-products such as oil seed cakes and wheat bran could be used as supplements in sheep diet. This is particularly important in farming systems where crop residues, such as cereal straws and haulms of pulses are major feed resources for sheep production (Adugna, 2008).

Crop-livestock farming is the major source of food and income in rural farm households in the highlands of Bale (Solomon, 2004). Similarly, livestock and crop production are interdependent where livestock holding was observed to have significant effect on crop cultivation in this area (Solomon *et al*., 2009). In Bale highlands, wheat mono cropping is a wide spread practices in many farming systems. However, mono cropping generates a number of agronomic and management problems. Increased weed populations, greater proliferations of pests and diseases and less efficient use of water and nutrients are among the causes of reduced yield in wheat monoculture. Government highlights these drawbacks and point to the advantages and the greater efficiency of crop rotations in various situations and farming systems. Incorporations of legumes in rotation with cereals have resulted in a marked increase in cereal yield compared with monoculture. The increase in yield may be not only due to biologically fixed nitrogen but also to other factors, including improvement of the physical characteristics of the soil, reduced incidence of pests and disease and weed related problems, elimination of phytotoxicity and increased presence of growth promoting substances. Similarly, use of legumes in a cropping system may lead to an improvement in soil structures through changes in organic matter content, soil microbial activity and deep root growth which facilitate root penetrations by the following cereal crops (SARC, 2014). Moreover, legume breaks the cycle of many cereal diseases. Farmers in Bale highlands practice crop rotation especially rotation of cereals and faba bean to alleviate these problems.

Crop residues vary greatly in chemical composition and digestibility depending on species and variety of the crops (Reed *et al*., 1986), time of harvest, handling and storage conditions and other factors (Adugna, 2008). Research conducted at Haramaya University showed that from five varieties of faba bean evaluated at Haramaya and Hirna sites, straw DM yield varied from 3.4-7.1 t/ha, straw to grain ratio were significantly different with mean value of 1.55 and 3.22, and plant cell wall contents were significantly different among the varieties (Yetmwork, 2005). This shows great variations among faba bean varieties which enable us to select faba bean varieties with high straw yield and quality without sacrificing grain yield. In order to sustain crop rotation, there is a need to fill the gaps in faba bean straw utilization and also to identify faba bean varieties with good straw qualities as animal feed together with concentrate mix supplements that can significantly improve productivity and profitability of farmers. Thus, the objectives of this study were:

- to evaluate the varietal differences of faba bean straws

- to evaluate effects of feeding different varieties of faba bean straws with concentrate on feed intake, digestibility, body weight gain and carcass characteristics of Arsi-Bale sheep

2. LITERATURE REVIEW

2.1. Status and Role of Sheep Production in Ethiopia

Small ruminants are found widely spread in the tropics and play an important role to the livelihoods of a large number of people in this area. In Ethiopia, sheep are distributed throughout all ecological zones of the country, though the largest numbers are concentrated in the mid- altitude and highland areas. Sheep production in the crop livestock mixed system of the highland areas has a very important role in contributing to the food security as well as in generating direct cash income (ILRI, 2000). Export of live sheep, mutton and skin make significant contribution to the foreign currency earnings of the country (CSA, 2006).

The productivity of sheep in smallholder production system is low, which is manifested in slow growth rates, delayed age of sexual maturity and low carcass yield of slaughter animals (Tembley, 1998). Indigenous sheep breeds have small body size, produce low quality wool, and have low lamb growth rate and quite high lamb mortality (Markos *et al*., 2006). In Ethiopia, most sheep are slaughtered at about 12 months of age with live weight of 18-20 kg (Ameha, 2006). Awet (2007), Mulu *et al.* (2008) and Tesfaye and Solomon (2008) reported carcass yield of 9.7, 9.6 and 9.6 kg in different indigenous breeds of sheep on different types of feeds, respectively. Even if the production potential of indigenous sheep breeds is low as compared to temperate breeds, their ability to survive and produce in the harsh and mostly unpredictable tropical environment is remarkable (Payne, 1990). This shows that there is scope for improvement through management practice such as improved feeding and veterinary service.

2.2. Characteristics of Arsi-Bale Sheep

Arsi-Bale sheep are fat-tailed and covered with course wool (wavy wool). They are widely distributed in the highlands of eastern and southern Ethiopia, in Arsi, Bale, Hararghe and eastern Showa zone of Oromia Region and in parts of the southern region. The climate in this area varies from semi-arid to sub-humid. The production systems range from agro-pastoral to mixed agriculture and some urban and peri-urban production. Arsi-Bale lambs weigh 2.7 kg at birth and 14.2 kg at 120 days of weaning (Kassahun and Solomon, 2008).

Male Arsi-Bale sheep have minor wool growth in some parts of the body. Both males and females (about 52%) are horned and are large in size. The coat color is variable including brown (35.1%), brown with white patches (24.3%), black, white and combinations of these colors (Solomon *et al*., 2009). Crossbreeding of local Arsi-Bale with exotic breeds such as Hampshire, Merino and Corriedale improved lamb weights and the total weight per ewe lambing. The birth weights (kg) were 2.78 $\pm$ 0.04 and 3.08 $\pm$ 0.03 (50% exotic) and the weaning weights were 14.59 $\pm$ 0.22 and 18. 41 $\pm$ 0.17 (50% exotic) in Arsi-Bale and cross breed (Arsi X Exotic) sheep, respectively. It was also higher for 75% and 87.5% cross than for 50% crosses (Teferawork, 1989).

2.3. Feed Resource for Sheep Production in Ethiopia

Feed resources as reported by Adugna *et al*. (2012) can be classified as natural pasture, crop residue, improved pasture and forage and agro industrial by-products of which the first two contribute the largest share. The fibrous agricultural residues contributes a major part of livestock feed especially in densely populated areas where land is prioritized for crop cultivation. The same authors reported that crop residues contribute about 50% of the total feed supply in Ethiopia. Similarly, the naturally occurring grasses, legumes, herbs, shrubs and tree foliage are used as animal feed (Adugna, 2008). The availability of feed resources in the highlands of Ethiopia depends on the mode and intensity of crop production as well as population pressure (Seyoum *et al*., 2001). Crop residues represent a large proportion of feed resources in mixed crop-livestock systems (Malede and Takele, 2014). Reliance on crop residues for animal feed is increasing from time to time as more land is cropped to feed the fast growing human population.

Feed is the single largest cost associated with raising small ruminants, typically accounting for 60-65% of the total production cost of sheep (Lemus and Brown, 2008). In most production system of Ethiopia, extensive free grazing in communal lands and stubble grazing are the most common practices of sheep feeding (Solomon *et al*., 2010), whereas limited grazing areas and cultivation of pasture lands causes loss of palatable forage species due to high grazing pressure. Agro-industrial by-products are also other potential feed resources that can be used as supplements to crop residues and poor quality natural pasture based diets. These include the by-products from flour milling, oil processing, sugar and brewery factories (Alemayehu, 2006). Supplementation with agro-industrial by-products has been used in many developed countries for improving locally available nutrients of feed resources. Since feed cost accounts more to total cost in any livestock production, it is of paramount importance to incorporate locally available byproducts and raw materials into the feed of ruminant animals.

2.3.1. The use of crop residues as animal feed

Crop residues (cereal straw, stovers and grain legume haulms) make the bulk of the feed supply for ruminants in tropical farming systems. Crop residues are the plant materials remaining after food crops had been harvested. Straws from cereals such as *tef*, barley and wheat and pulse crops are stored after threshing and serve as a useful feed to animals in Ethiopian highlands (Solomon, 2004). In most intensively cultivated central highland, crop residues and aftermath grazing account for about 60-70% of the basal diet (Seyoum *et al*., 2001). According to CSA (2004), residues of cereals and pulses account for about 26% of the total feed utilized and ranked second to grazing (64%) in mixed crop livestock production system of Ethiopia. The dominant crops grown in Sinana district of Bale highland are cereals (wheat, barley and emmer wheat) and highland pulses (field pea and faba bean). The crops grown are mainly used as household consumptions as well as a means of income generation whereas residues from cereal and pulse crops are the major source of livestock feed which contribute approximately 40% of dry matter of the total diet (Dawit *et al*., 2012). The principal crop residues available for livestock feeding in Sinana district of Bale highlands includes residues from cereals (maize, wheat, barley and emmer wheat), pulses (field pea and faba bean) and linseed (Solomon *et al*., 2008).

Faba bean is an annual legume botanically known as *Vicia faba* L. Ethiopia is the third main faba bean producing country in the world, next to China and UK, and there are large faba bean varietal diversifications in Ethiopia (Metayer, 2004). Even though faba bean is grown in most parts of Ethiopia, up to an altitude of 3200 m above sea level, the highest concentration of production is observed in cereal-pulse Zones, between 2000-2700 m above sea level (Alem, 1993). Pulse residues in Ethiopia are small in quantity as compared to cereal straws, but have higher nutritive quality compared to cereal straws (Lulseged and Jamal, 1989). The haulms of pulse crops (grain legumes) represent good quality roughage with a crude protein content of 5-12% (Adugna, 2008). The palatability of faba bean haulms to animals is least compared with the palatability of other pulse hay or straws. However, it is totally consumed once animals become accustomed to it (Hawthorne, 2006). If bean haulm is properly harvested, it is a useful roughage feed for sheep but because of its thick fibrous stems, it is more difficult to dry than cereal straws and frequently become moldy during storage (McDonald *et al.*, 2002). According to the same author, faba bean haulms are richer in protein, calcium and magnesium than cereal straws.

According to Solomon *et al.* (2008), faba bean haulm had 94.4% DM, 10.3% Ash, 8.8% crude protein (CP), 59.2% neutral detergent fiber (NDF), 46.8% acid detergent fiber (ADF), 13.2% lignin, 12.4% hemicelluloses, 32.2% cellulose and 58.8% in vitro dry matter digestibility (IVDMD). Similarly, Ermias (2008) reported that faba bean haulm contained 94.9% DM, 6.8% Ash, 7.7% CP, 48% NDF, 43.3% ADF, 17.9% lignin, 4.2% hemicelluloses and 25.9% cellulose. Additionally, Yetimwork (2005) reported that haulms of different faba bean varieties contained 90.5-92.4% DM, 83.9-88.7% OM, 10-13.6% CP, 11.3-16.2% ash, 33.1-51.5% NDF, 30.4-42.4% ADF and 5.46-8.3% ADL, depending up on the varieties.

Research conducted at Haramaya University showed that from five varieties (CS-20-DK, Tesfa, Mesay, Bulga-70 and local bean) of faba bean evaluated at Haramaya and Hirna sites, straw dry matter yield varied from 3.4 t/ha to 7.1 t/ha, and also straw to grain ratio significantly different at both sites with the mean value of 1.5 and 3.2 and similarly plant cell wall contents (NDF and ADF), grain yield and harvest index were significantly different among the varieties at both locations (Yetmwork, 2005). The same author observed that in vitro dry matter digestibility (IVDMD) of these varieties ranges from 65% to 73.8%, and also there was significant deference in dry matter degradability and the potential utility index indicated that there are varieties, which combined high grain yield, IVDMD, straw dry mater yield and potential utility index. This shows that there is a possibility of selecting faba bean varieties for straw yield and straw quality without negatively affecting grain yield.

2.3.2. The use of agro-industrial by-products as animal feed

Agro-industrial by-products are the by-products of the primary processing of crops, including bran and related by-products of flourmills, oilseed cakes from small and large-scale oil processing plants and by-products of the sugar factory such as molasses. These by-products such as oilseed cakes and meals, wheat bran and molasses are important components of the concentrate feeds. Most tropical forages are low in nutrient content and cannot supply adequate nutrient for optimum animal performance. Agro-industrial by-products along with grazing and scavenging are important source of feed ingredients for sheep production and they can be grouped according to their nutrient contents namely: energy rich supplements (<20% CP and <18% CF), protein rich supplements (≥ 20% CP and < 18% CF), and miscellaneous by-products mostly supply minerals as well as energy and protein such as by-products from brewery, fruit and vegetable industries (Ranjhan, 2001). Agro-industrial by-products such as noug seed cake, linseed meal, barley and wheat bran are important source of protein and energy for supplementing basal diet (Getahun, 2006).

Effect of supplementing noug seed cake on the performance of sheep

"*Noug*" seed (*Guizotia abyssinica*) cake is one of the by-products of oil processing from "*noug*" seed that can be used as a protein supplement in animal feeding. 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, 2003). The protein content of *"noug"* seed cake depends on variety and method of processing, as processes that affect efficiency of edible oil extraction equally affect the cake quality (Alemu, 1981). With the exception of cystine and methionine, which are low in *"noug"* seed cake, the balance among the essential amino acids in the cake is good. When added to energy source feeds, it can improve feed intake, digestibility and animal performance.

Research report showed that *"noug"* seed cake contains 91.9% DM, 29% CP, 11.2% ash, 38.5% NDF, 28.3% ADF, 11.2% ADL and 7.1% EE (Wondwosen, 2008). Mesganew (2014) observed the average daily gain of 45.1-64.4 g/day for Washera sheep fed grass hay as a basal diet and supplemented with field pea hull and concentrate mix (wheat bran and "noug" seed cake in 2:1 ratio). Better response in live gain (78.4g/day) in Farta sheep fed grass hay and supplemented with "noug" seed cake and wheat bran at a ratio of 67:33 was recorded (Fentie, 2007). Sheep fed a basal diet of hay supplement with rice bran, "noug" seed cake and their mixtures at different proportions recorded mean daily body weight gain in the range of 55.5-57.8 g/day (Abebaw, 2007).

Effect of supplementing wheat bran on the performance of sheep

Wheat bran is the course outer covering of the wheat kernel as separated from cleaned and scoured wheat in a usual process of commercial milling. The wheat grain consists of about 82 percent endosperm, 15 percent bran and 3 percent germ. In modern flour millings, the objective is to separate the endosperm from the bran and germ (McDonald *et al*., 2002). Wheat bran consists primarily of the seed coat of wheat, which is removed in the manufacture of wheat flour. It is quite palatable and is well known for its laxative characteristics because of its swelling and water holding capacity. These characteristics of wheat bran are due to its fiber and non-starch carbohydrate content (Cheeke, 1991). It will act as an addition to pasture feed, it may even help when the quality of pasture is poor or in limited supply. Wheat bran pellets when fed at recommended rates are comparatively safe to use and provide another opportunity to increase productivity, without decreasing pasture intake or adversely affecting the rumen environment.

Wheat bran is very variable in composition. The chemical composition of wheat bran on as dry matter basis was reported to be 89% DM, 18% CP, 14% ADF, 47% NDF and 70% TDN (Stanton and Levalley, 2008). In another study, Awet (2007) reported the chemical composition of wheat bran to be 87.4% DM, 4.0% ash, 96.0% OM, 16.4% CP, 35.3% NDF, 8.3% ADF and 2.2% ADL. Study conducted on Arsi-Bale sheep fed a basal diet of hay and supplemented with linseed meal, wheat bran and their mixtures in different proportions reported that the supplemented animals gained in the range of 69.0-104.1 g/day (Abebe, 2006).

2.4. Effect of Crop Residues with Concentrate on Sheep Performance

2.4.1. Feed intake

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 up on many factors like the density of energy in the diet, digestibility, succulence, amount of crude fiber and the physical nature of the feed (Rehrahie *et al*., 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*., 2002). 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 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 of 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 *et al*., 2002).

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 (Do Thi, 2001). Concentrate supplies more easily degradable components to fibrolytic microorganisms that improve fiber degradation (Liu and Lee, 2005). The highest roughage DM intake comes synchronously with the highest ruminal fibrolytic activities. If ruminants are offered un-supplemented low quality roughage, there will be a loss in body weight because of inability to meet both energy and protein requirements.

In 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. Addition of crude protein supplement may stimulate efficient rumen fermentation, more passage rate and intake. Awet (2007) reported that 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. Similar research conducted at Bekoji Agricultural Technical Vocational Education and Training College showed that the daily dry matter intake of Arsi-Bale sheep fed faba bean haulms and supplemented with barley bran, linseed meal and their mixtures at different proportions was 434.8- 753.3 g/head/day (Ermias, 2008).

2.4.2. Digestibility

The digestibility of a feedstuff is the proportion of the feed or of any single nutrient of the feed which is not recovered in feces (Ranjhan, 2001). Although the potential value of a feed can be approximately determined by proximate analysis, the actual value of the feed to the animal can be determined only if the digestibility is known. The digestibility coefficients of various nutrients from the same feedstuffs is affected by species of the animal, age of the animals, level of feeding, feed composition and ration composition (Ranjhan, 1999). The primary chemical composition of feeds that determines the rate of digestion is neutral detergent fiber which is itself a measure of cell wall content; thus there is a negative relationship between the neutral detergent fiber content of feeds and the rate at which they are digested (McDonald *et al*., 2002). The fiber fraction of feed has the greatest influence on its digestibility (McDonald *et al*., 2002). Barkie and Hogan (1996) indicated that much of the energy contained in the fiber of sheep diet requires fermentation by microbial enzymes to hydrolyze the linkage in the fiber.

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 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).

For satisfactory digestion of poor roughage, adequate amount of supplementation is needed. The addition of small amount high quality concentrate will increase rumen digestion. Apparent digestibility was improved when “noug” seed cake was used as a sole supplement or at higher proportions as compared to hay alone or supplementation with sole rice bran (Abebaw, 2007). Similarly, supplementation with legume crop residues contributes fermentable energy to the rumen in the form of available cellulose and hemicellulose, which stimulate fiber digestion (Silva and Ørskov, 1985). Reddy (1997) reported that supplementation of legume straw increase nutritive value and crude protein digestibility of rice straw. According to Koralagama *et al.* (2008), supplementation of cowpea haulms increased digestibility of dry matter, organic matter and neutral detergent fiber in male Ethiopian highland sheep fed a basal diet of maize stover. Additionally, supplementation of linseed meal, barley bran and their mixture to faba bean haulms fed to Arsi-Bale sheep improved the digestibility of organic matter, crude protein and neutral detergent fiber without affecting dry matter digestibility (Ermias, 2008). Similarly, Ajayi *et al*. (2008) showed that forage legume supplementation significantly improved dry matter, organic matter, crude protein and acid detergent fiber digestibility due to the fact that forage legumes enhance efficient rumen fermentation which optimizes microbial growth for increased digestibility.

2.4.3. Body weight change

Body growth commonly refers to an increase in size or weight of animals (Warriss, 2000). It is crude because change in body weight of intestinal contents, which in ruminants may often account for 20% of body weight gain (McDonald et al., 2002) affects body weight 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 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 towards nutrient availability (Topps, 1995).

Rate of weight gain of sheep is influenced by the type of management of animals and stage of growth (Takele *et al.,* 2006). 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 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).

2.4.4. Carcass characteristics

Definition of carcass varies somewhat in the different species and in different live dressing specification and methods of preparation for sale. Carcass is made up of various proportions of muscle, bone and fat and that eventually to be sold as joint or steaks. The ideal carcass can be described as the one that has a minimum amount of bone, a maximum amount of muscle and an optimum amount of fat (Ameha, 2008). According to Pinkerton (2009) the most common carcass quality assessment in small ruminants is particularly focusing on dressing percentage and muscling or meatiness. The same author stressed that muscling, not body fat, is the most important measure of sheep and goat carcass characteristic evaluation.

Carcass weight depends on the rate of gain, weight at slaughter and dressing percentage of the animals (Rahman, 2007a). Dressing percentage is an important trait in carcass merit evaluation. It is affected by age, sex, castration and plane of nutrition (Pond *et al.,* 1995), amount of gut fill at slaughter and whether the carcass is weighed hot or cold. It might also be affected by organ to be included in dressed carcass or removal of some visceral organ during hot carcass measurement (Tesfaye *et al*., 2008). Concentrate supplementation can improve the performances of animals in carcass parameters. Concentrate supplementation reduces age at slaughter, increases carcass quality and meat output of animals (Hango *et al.*, 2007). Meat production from sheep was improved in terms of body weight gains and better composition by increasing energy and protein levels in the diet (Maghomp and Early, 2000). The energy and protein feeding level for sheep growth should be higher than maintenance requirement. Hosseini *et al*. (2008) also concluded that increasing energy level in lambs' diet resulted in increasing growth and carcass performance.

Research conducted at Alage Agricultural Technical and Vocational Education and Training College showed that there where high DM intake, mean daily body weight gain, dressing percentage and large rib-eye muscle area in sheep fed high level of supplementation of wheat bran and "noug" seed cake on DM basis compared to the low level of supplementation (Tesfaye, 2008). Arsi Bale sheep fed a basal diet of hay and supplemented with linseed cake and wheat bran at different proportion had better weight in carcass parameters and a significantly higher rib-eye muscle area (Abebe, 2006). Birhanu (2010) reported that carcass weight decreased with decrease of dietary protein and energy level which resulted in decreased slaughter weight and dressing percentage when Arsi-Bale sheep were fed a basal diet of faba bean haulm supplemented with malt barley byproduct, wheat bran and their mixture. Awet (2007) reported that there were high dressing percentage and large rib-eye muscle area in sheep fed high level of supplementation (350 g) of wheat bran compared to sheep supplemented with the low (150 g) and medium level of supplementation (250g).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The experiment was conducted at Sinana Agricultural Research Center (SARC) which is located in Bale zone of Oromia Regional State, south eastern Ethiopia. The center is in Sinana district of Bale highland, 463 km south east of Addis Ababa at 07 07' N latitude and 40^0 10’ E longitudes and at an altitude of 2400 m above sea level. The average annual maximum and minimum temperature are 21^0C and 9^0C, respectively. The rainfall pattern is bimodal with annual precipitation ranging from 750 to 1000 mm. Two cropping seasons are known in the study area, locally known as *Bona* (Meher) from August to December and *Ganna* (Belg) from March to July. The farming system is mainly mixed crop livestock production system and the major livestock raised in the study area are cattle, sheep, goats, equines and poultry. The common food crops grown around Sinana area are cereals (mainly wheat), highland pulses, highland oil crops and horticultural crops (SARC, 2014).

3.2. Data for Grain and Straw Yield, straws to Grain Ratio and Harvest Index of Faba Bean Varieties

The experimental faba bean varieties (Mosisa, Walki, Degaga, Shallo and local) were planted at Sinana on station by farm management of the center on 0.25 hectare (50m X 50m) each during 2014 “*bona” (mehar)* cropping season. The soil is vertsol and the mean rain fall and temperature during the study period were 697 mm and 15.6 ^{0}C respectively. The varieties were sown by broadcasting method with uniform seed rate without fertilizer application and all agronomic practices were uniformly employed. From the larger plot of 50m X 50m, by using a quadrant of 1m X 1m (1m^2), thirty representative plots for each varieties were taken for grain and straw yield, straw to grain yield and harvest index determination. Harvesting of the plots was done after proper drying of the grain (at ca. 10% moisture content in the grain). After the plots were harvested and separated into grain and straw yield, grain yield was taken as the total weight of seeds harvested per plot and straw weight was obtained by subtracting grain weight from total biomass weight and converted to DM basis based on their oven DM percentage. Straws to grain ratio was determined and harvest index (HI) was calculated as the percent proportion of grain yield to total above ground DM yield multiplied by 100 (Fleischer et al., 1989).

3.3. Experimental Animals and their Management

Forty sheep with similar initial body weight were purchased from the nearby town (Selka and Alemgena) and selected and used for the experiment. Ages of the sheep were estimated based on dentition and information obtained from the owners of the sheep (seller) during purchasing. The animals were held in quarantine for 21 days and observed for any health problem. During quarantine period, albendazole 300 gram/head was given for endo- and ecto- parasites as well as vaccinated for Ovine pesteurellosis and sheep pox. The sheep were ear tagged for identification. Animals were blocked on the basis of their initial body weight into eight blocks of five animals each and placed 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 experimental period.

3.4. Feed Preparation and Feeding

Crop residues of faba bean varieties, i.e. Mosisa, Walki, Degaga, Shallo and local varieties (Table 1) were collected in 2014 cropping *Bonna (Meher)* season from the Farm Management Team of SARC. Straws of each variety were threshed by a combiner and chopped using a chopping machine (Trapp forage shredder and hammer mill, TRF 300E) to pass a strainer of 12 mm in order to minimize wastage and selection by sheep. Concentrate feeds; *"noug"* seed cake and wheat bran were purchased from oil extracting industry (Modjo) and flour milling industry (Robe) respectively and stored properly at the experimental site. A local mineral soil known as "*Bole*" from Lake Abjata was purchased and 12 grams/head were included in the feed according to Sisay *et al*. (2007) which found 11.8 g/head mineral soil "bole" in take by Black head Somali sheep provided free access. Salt (1%) was added. Diet formulation was done on DM basis and to prepare a complete ration composed of 30% of concentrate (2:1 ratio of wheat bran and *"noug"* seed cake, respectively) and 70% of straws of each variety were mixed uniformly. Feeds enough for the entire experimental period were prepared before the actual experiment commences. Sheep were offered uniformly mixed ration *ad libitum* at 20% refusal rate and the amount of feed offered was adjusted every five days based on the average feed consumed during the previous period. The diet was divided in to two equal portions and offered at 08:00 and at 16:00 h. Water was provided to all animals' free choice.

Table 1. History of faba bean varieties from their respective crop variety registration book.

No	Variety	Yield (Qt/ha)	Days to Maturity	Year of Release	Maintainer/ Breeder
1	Mosisa (EH99047-1)	32-48	142	2013	SARC
2	Walki (ET96049-2)	24-52	140	2008	HARC
3	Degaga (R-878-3)	27-42	125	2002	HARC
4	Shallo (ET011-22-1)	31-46	118	2000	SARC
5	Local	-	-	-	-

SARC= Sinana Agricultural Research Center, HARC= Holleta Agricultural Research Center

3.5. Experimental Design and Treatments

The experiment was conducted in a randomized complete block design. Animals were categorized into eight blocks each containing five animals based on initial body weight of the sheep. Animals from each block was randomly allocated to the five treatment groups (Table 2), giving eight replications per treatment.

Table 2. Experimental treatments

Treatment	Faba Bean Crop Residues	Roughage:Concentrate1 Ratio	Amount Offered
T1	Mosisa	70:30	*Ad libitum*
T2	Walki	70:30	*Ad libitum*
T3	Degaga	70:30	*Ad libitum*
T4	Shallo	70:30	*Ad libitum*
T5	Local	70:30	*Ad libitum*

[1]Concentrate mix 2:1 ratio of wheat bran (WB) and "noug" seed cake (NSC), respectively

3.6. Measurements

3.6.1. Digestibility trial

Digestibility trial was conducted using all experimental sheep before the commencement of the feeding trial. Following an adaptation period of 15 days, the digestibility trial lasted for 10 days with a 3 days adaptation period to accustom the sheep to carrying the fecal bags, which was followed by a total collection of feces for seven consecutive days. During this period, daily feed offered and refusal per animals was collected and the latter was bulked per treatment. Fresh feces were collected into a fecal collection bag carried by the animal and recorded for each sheep throughout the digestibility trial. The total fecal output was collected by emptying the bag per day per animal each morning prior to offering feeds and water. The feces were weighed fresh, thoroughly mixed and 20% of the feces was sampled for each sheep and stored in a deep freezer at -18°C. The samples were pooled per animal over the collection period and 20% of the composite sample was taken, weighed and partially dried at 60°C for 72 hours. The dried fecal samples were milled to pass through a 1mm sieve and stored in airtight polyethylene bags for further chemical analysis. The laboratory DM of the feces was determined by drying the partially dried samples in oven at 105 ^{0}C overnight. The total feces DM were determined by multiplying partial DM of the feces with laboratory DM of the feces. Apparent digestibility of DM and other nutrients was determined as a percentage of the nutrient intake not recovered in the feces using the following formula:

$$\textbf{Percent Apparent Digestibility} = \frac{\textbf{(Nutrient Intake – Nutrient in Feces)}}{\textbf{Nutrient Intake}} \textbf{ X 100}$$

3.6.2. Feeding trial

The 90 days of feeding or growth experiment was conducted after the completion of the digestibility trial and 10 days of rest period. The sheep were re-randomized based on their body weight at the beginning of the feeding trial and allocated to each treatment diet. The daily feed offered and refusals were weighed and recorded for each sheep. Daily feed and nutrient intake were calculated as the difference between the feed offered and refused. Samples of feed offered were collected per batch while samples of refusal were taken from each sheep daily and pooled per treatment over the experimental period and stored in plastic bags. Sub-samples of feed offered and refusal were taken after thorough mixing for nutrient composition determination, and the sub-samples taken were dried at 60^0C for 72 hours in a forced draft oven for chemical analysis.

3.6.3. Body weight change

Body weight of the animals was taken at the beginning of the feeding trial after overnight fasting and every 10 days during the 90 days of feeding trial. All animals were weighed in the morning hours after overnight fasting before feed provision using weighing balance with a sensitivity of 100 grams. Daily body weight gain was calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Feed conversion efficiency (FCE) was calculated according to the following formulas (Brown et al., 2001) as follows:

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

3.6.4. Carcass parameters

At the end of the experiment, half of the sheep in each trial were slaughtered after 24 hours fasting to determine the effects of treatment feeds on carcass parameters. Immediately before slaughter, slaughter body weight was taken. The animals were killed by severing the jugular vein and the carotid artery with a knife. Blood was collected, weighed and recorded. Skin was properly flayed and weighed. Empty body weight was calculated as the difference between slaughter weight and gut content. The hot carcass weight was estimated after removing weight of the head, thorax, abdominal and pelvic cavity contents as well as legs below the hock and knee joints.

The edible offal components (EOC) namely, blood, liver, kidney, heart, tongue, reticulo-rumen, omasum- abomasum, small and large intestine, testicles, tail and fats (kidney, heart, omental, scrotal and pelvic) were weighed and recorded individually. Total edible offal components (TEOC) were calculated as the total sum of the edible offal components. The non-edible offal components (NEOC), namely, head (without tongue), skin, lung plus trachea, pancreas, spleen, bladder, gall bladder, gut fill, genital organ and feet with hooves were weighed and recorded. Total non-edible offal components (TNEOC) were calculated as the total sum of the non-edible offal components.

The main carcass component was split down at the vertebral column having the two sides as symmetrically as possible and the right parts were stored in a deep freeze at -4^{0}c over night for properly partitioning the carcass in to bone, muscle and fat. The frozen carcass (right part) was divided in to five main primal cuts carcass components namely: leg, loin, rack, breast and shank and shoulder and neck. The carcass was cut perpendicular to the back bone between the 12th and 13th ribs to measure the cross-sectional area of the rib-eye (*longissimus dorsi*) muscle area (Purchas, 1978). The rib eye area were traced first on transparency paper then on a graph paper and the area was calculated by counting the squares on graph paper and multiplying with their area after the rib eye area was transferred to graph paper. The five main primal cut carcass components were partitioned to bone, muscle and fat and each part was weighted and recorded. The dressing percentage was calculated as the proportion of hot carcass weight to slaughter and empty body weight.

3.7. Laboratory Analysis

The chemical analysis of the experimental feeds, refusals and feces were carried out after taking the representative samples and taken to International Livestock Research Institute (ILRI) nutrition lab, Ethiopia. Samples of feed offered, refusals and feces were ground to pass a 1 mm sieve mesh. Analysis for DM, ash and N contents were done according to AOAC (2005) procedures. Dry matter and ash contents of representative samples of feed and feces were determined by oven drying at 105^{0}C overnight and by igniting in a muffle furnace at 600^{0}C for 6 h, respectively. Nitrogen (N) content was determined by using Kjeldahl method and crude protein (CP) was calculated as N×6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by using the procedures of Van Soest and Robertson (1985). The in vitro organic matter digestibility (IVOMD) and Metabolizable energy (ME) content of the experimental feeds were estimated using the equation of Menke and Steingass (1979).

3.8. Data Analysis

Data on feed intake, digestibility, body weight change and carcass parameters were subjected to analysis of variance using the General Linear Model Procedure of SAS (SAS, 2002). When significant, least significant difference (LSD) was used to locate differences between the treatment means. Data were analyzed using the following model for complete randomized block design:

$$\mathbf{Y_{ij} = \mu + T_i + B_i + E_{ij}}$$, where:

Y_{ij} = Response variable

μ = Overall mean

T_i = Treatment effect

B_i = Block effect, and

E_{ij} = Random error

4. RESULTS AND DISCUSSIONS

4.1. Evaluation of Grain and Straw Yield, Straws to Grain Ratio and Harvest Index of Faba Bean Varieties

Grain and straw yield, straws to grain ratio and harvest index of the varieties used for this experiment is presented in Table 3. Improved varieties (Mosisa, Walki, Degaga, shallo) had greater ($P<0.001$) grain yield than the local variety. The grain yield (4.1-4.4 t/ha) obtained from improved varieties of faba bean in the current study were higher than 3.1-3.98 t/ha and 1.9-2.6 t/ha at Haramaya and Hirna sites respectively for four improved varieties (Tesfa, Bulga-70, CS-20-Dk, Mesay) of faba bean evaluated by Yetimwork (2005). The same author revealed that local bean grain yield obtained from the two sites (Haramaya and Hirna) ranges from 2.1-3.9 t/ha in which the current grain yield (2.9 t/ha) of the local bean was in the range of the previous results. The variations in grain yield among the current and earlier results might be due to variation in location and environmental condition of the study area. Straw yield from Mosisa (5.1 t/ha) variety had significantly greater ($P<0.001$) than all other varieties and that obtained from Shallo (4.5 t/ha) variety was higher ($P<0.001$) than Walki, Degaga and local varieties. The straw obtained from Walki (4 t/ha) and Degaga (3.9 t/ha) were higher ($P<0.001$) than straw obtained from local (3.3 t/ha) variety. The straw obtained (3.3-5.1 t/ha) from the current experiment was in the range of 3.4-7.1 t/ha straw obtained from five varieties of faba bean evaluated at Haramaya and Hirna sites by Yetimwork (2005).

As far as straws to grain ratio concerned, Mosisa, Shallo and Local varieties had significantly higher ($P<0.001$) straws to grain ratio than Walki and Degaga varieties. The crop residue to grain ratio (0.9-1.2) for the current study were lower than 1.5-3.2 crop residue to grain ratio reported by Yetimwork (2005) for five varieties of faba bean. This might be attributed to the higher grain yield of the current varieties than the earlier varieties. Harvest index for Walki and Degaga varieties had significantly greater ($P<0.001$) than Mosisa, Shallo and local varieties. The harvest index (45.8-51.8%) obtained from the present study were greater than 23.9-49.6% harvest index for five varieties of faba bean evaluated at Haramaya and Hirna sites by Yetimwork (2005). Even though this study was based on a single growing year and a single location and should be confirmed across year and location, the overall results of grain and straw yield, straws to grain ratio and harvest index showed significant varietal differences among the tested varieties and Mosisa variety in straw yield and Walki and Degaga varieties in harvest index performed better than others.

Table 3. Grain and straw yield, straws to grain ratio and harvest index of faba bean varieties

Parameters	**Varieties**					**Mean ± SEM**	**CV (%)**	**lsd**	**LS**
	Mosisa	**Walki**	**Degaga**	**Shallo**	**Local**				
GY (t/ha)	4.4^{a}	4.2^{a}	4.2^{a}	4.1^{a}	2.9^{b}	3.9 ± 0.08	23.7	0.5	***
SY (t/ha)	5.1^{a}	4.0^{c}	3.9^{c}	4.5^{b}	3.3^{d}	4.2 ± 0.08	21.5	0.5	***
SY : GY	1.17^{a}	0.96^{b}	0.95^{b}	1.19^{a}	1.22^{a}	1.1 ± 0.02	26.4	0.2	***
HI (%)	46.6^{b}	51.3^{a}	51.8^{a}	46.8^{b}	45.8^{b}	48.5 ± 0.47	10.8	2.7	***

CV=coefficient of variation; GY=grain yield; HI=harvest index; lsd=least significant difference; LS=level of significance; SEM=standard error of the mean; SY=straw yield; SY: GY=straw yield to grain yield ratio

4.2. Chemical Composition of Treatment Feeds and Refused

The chemical compositions of experimental feeds offered and refused are given in Table 4. The CP contents of different varieties of faba bean straws in this study varied from 4.3% (Mosisa straw) to 6.2% (local straw). This level of CP contents for all straws in this study was below the CP content of 7-7.5% required to satisfy ruminal microbial demands for nitrogen that would provide sufficient CP for the maintenance requirement of the animal (Van Soest, 1994). The values were comparable with 5.8% CP for faba bean haulms reported by Seyoum *et al.* (2007) but lower than the values previously reported by others such as 7.2% CP content of faba bean haulms reported by Lulseged and Jamal (1989), 10-13.6% CP for five varieties of faba bean straws reported by Yetimwork (2005), 7.7% CP for faba bean haulm reported by Ermias (2008). Various studies noted a range of 5.4-12.7% CP values for haulms of other pulse crops such as haricot bean, lentil, chick pea and vetch (Likawent *et al*., 2005; Emebet, 2008; Takele, 2010).

The values of NDF contents of all faba bean straws in the present study were 75.9-82.2% which categorized these straws as low quality feed since Singh and Oosting (1992) pointed out that roughage feeds containing NDF values of less than 45% to be classified as high, those with values ranging from 45 to 65% as medium and those with values higher than 65% as low quality. The NDF contents of different faba bean straws in the present study were higher than 74.3%, 33.1-51.5%, 74.4% and 48% NDF for faba bean haulms reported by Lulseged and Jamal (1989), Yetimwork (2005), Seyoum *et al.* (2007) and Ermias (2008) respectively. The values of ADF contents obtained from different varieties of faba bean straws in this study ranging from 63.4-69.9% also categorized all straws as low quality feed as Kellems and Church (1998) indicated that roughage with less than 40% ADF are categorized as high quality and those with greater than 40% as poor quality. The values were consistent with earlier reports of 63.9% ADF reported by Seyoum *et al.* (2007) and higher than 30.4-42.4% and 43.3% of ADF reported by Yetimwork (2005) and Ermias (2008) in that order for faba bean haulms. The higher the ADF content of a feed, the lower the nutritive value of that feed and vice versa.

Table 4. Chemical composition of experimental feed offered and refused

Feed offered	DM (%)	Ash	CP	NDF	ADF	ADL	HC	Cel	IVOMD	ME MJ/kg DM
		(%DM)								
Mosisa	89.8	5.5	4.9	78.8	69.1	13.3	9.7	55.8	48.1	6.9
Walki	89.2	7.1	5.1	75.9	63.4	12.8	12.5	50.6	49.4	7.1
Degaga	89.8	6.2	5.2	79.7	67.0	13.3	12.8	53.7	51.6	7.5
Shallo	90.9	5.6	4.3	82.2	69.9	13.9	12.8	56.1	45.1	6.5
Local	89.6	8.5	6.2	79.6	65.6	13.7	14.0	51.9	62.6	9.2
WB	86.3	3.4	13.0	44.7	10.9	2.1	33.7	8.8	84.5	11.9
NSC	88.6	11.6	26.8	44.6	32.9	12.9	11.7	20.0	69.4	8.1
Refused feed										
T1	91.8	4.8	4.0	81.0	70.7	16.6	10.3	54.1	43.6	6.2
T2	91.1	5.0	3.9	82.0	70.7	15.9	11.2	54.8	45.6	6.6
T3	90.9	6.2	4.0	78.6	68.8	14.7	9.76	54.1	46.7	6.8
T4	90.4	4.3	3.5	84.6	70.5	15.0	14.1	55.5	40.4	5.7
T5	91.1	6.6	3.9	76.0	68.2	15.2	7.8	53	42.0	5.9

ADF=acid detergent fiber; ADL=acid detergent lignin; Cel=cellulose; CP=crude protein; DM=dry matter; HC=hemicelluloses; IVOMD=*invitro organic matter digestibility*; ME=metabolizable energy, NDF=neutral detergent fiber; NSC=noug seed cake; WB=wheat bran. T1=70% mosisa straw + 30% concentrate mix; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

Even though all faba bean straws in the current study were categorized under low quality feeds based on their NDF and ADF contents, there is a difference in the values of the different varieties. A straw obtained from Walki variety had 75.9% NDF and 63.4% ADF, which was lower than other varieties whereas Shallo variety had the highest cell wall fraction with 82.8% NDF and 69.9% ADF compared to the other faba bean straws considered. This slight variation might have impact on feed intake as NDF and ADF contents of feedstuffs are generally negatively correlated with voluntary feed intake and digestibility of feeds, respectively.

The IVOMD values of straws for Local (62.2%) and Degaga (51.1%) were higher, that of Walki (49.4%) were comparable whereas that of Mosisa (48.1%) and Shallo (45.1%) were lower than the critical threshold level of 50% required for feeds to be considered as having acceptable digestibility (Owen and Jayasuriya, 1989). This variation of straws among varieties indicates the possibilities of selecting faba bean varieties for crop rotation and simultaneously obtaining better quality straws that can be used as animal feed. The experimental straws contained 6.5-9.2 MJ/kg DM (Table 4) of metabolizable energy. In addition, the CP content of the refused feed recorded in the present experiment was lower than that of the offered feed. The NDF, ADF and ADL contents were higher in refusal than that of the offered feed indicating the ability of sheep to select for feed fractions with lower fiber content and hence better nutritive value.

The inconsistency in proximate chemical composition of the feeds used in the present study from previous similar studies might be related to varietal difference and plant morphological components mainly leaf to stem ratio (Adugna, 2001). Factors such as time of harvest, handling and storage conditions and threshing methods affect the nutritive value of crop residues and might have brought the difference observed between different studies. The current faba bean straws were harvested after they were fully dried and stored in the field until threshed using a threshing machine, which resulted in leaf shattering. Leaves shattering have its own effects on protein contents as leaf has high proportions of CP contents. Moreover, chemical composition of a feeds is highly variable not only between straw types, but also within each class of straw (López *et al*., 2005).

The CP content of wheat bran obtained in this study (13%) was higher than 11.2% reported by Eyob (2010), comparable with 13.7% reported by Meaza (2012) and lower than the earlier reports of 16.1%, 14.9% and 16% reported by Jemberu (2008), Tesfaye (2008) and Takele (2010) in that order. It was also within the range of 13-22% CP reported by others (Hamid *et al*., 2007; Eiman *et al.*, 2008). The NDF content of wheat bran used in the present experiment (44.7%) was greater than 39.2 and 41% NDF reported by Jemberu (2008) and Tesfaye (2008) respectively and lower than 58%, 50% and 61.2% NDF reported by Emebet (2008), Dejene (2010) and Takele (2010) respectively. Similarly the ADF values of wheat bran obtained from the current study (10.9%) were lower than the range of 12-14.6 % ADF values previously reported by some other researchers (Emebet, 2008; Jemberu, 2008; Stanton and LeValley, 2008; Tesfaye, 2008 and Dejene, 2010) but higher than 8.27% reported by Awet (2007). The differences in nutrient composition of wheat bran among the different studies may be attributed to efficiency of the processing method during milling (more flour contents of the wheat bran), quality of the raw material used and nutrient availability in the soil. Even sample of the same variety of wheat from the same region may vary up to 10% and sometimes more in content of protein due to processing and/or milling methods (Morrison, 1984). The IVOMD for wheat bran in this study was 84.5% and had 11.9 MJ/kg DM metabolizable energy.

The CP obtained from *"noug"* seed cake in the current study were 26.8% which is higher than 25.7% reported by Jemberu (2008) and lower than the values of 29.4%, 29% and 31% CP previously reported by Tesfaye (2008), Wondwosen (2008) and Dejene (2010) respectively. According to Lonsdale (1989) feeds that have <12%, 12-20% and >20% CP are classified as low, medium and high protein sources, respectively and "noug" seed cake in this study is among the high protein sources that can serve as a protein supplement for low quality feeds like faba bean haulms. The NDF and ADF contents of *"noug"* seed cake in the present study were 44.6% and 32.9% respectively which had a slight variation from the values of 32.8-43.5% NDF and 28.3-41.1% ADF reported by others earlier (Jemberu, 2008; Tesfaye, 2008; Wondwosen, 2008 and Dejene, 2010). The slight variation of *"noug"* seed cake observed might be due to the difference in efficiency of extraction while extracting oil, variety of the *"noug"* used and storage time and condition of cake after extraction until use. The IVOMD of *"noug"* seed cake used for this trial were 69.4% (Table 3) and also had 8.1 MJ/kg DM metabolizable energy values which is greater than lower critical threshold of 7.5 MJ/kg DM (Owen and Jayasuriya, 1989).

4.3. Feed Intake of Arsi-Bale Sheep Fed Faba Bean Straws with Concentrate

The daily feed and nutrient intake of the experimental sheep fed faba bean straws and concentrate are presented in Table 5. The total DM and OM intake (g/day) of sheep in T2 was higher (P<0.001) than T1, T4 and T5 and also sheep in T3 was greater (P<0.001) than T1 and T4. Since the concentrate supplementation for all treatments were similar, the difference observed among the treatments stemmed from the differences of faba bean straws included in the trial. The straw used in T2 (Walki variety) was consumed more than straws from other varieties (Mosisa, Shallo and Local) and the variation might be related to less fiber (NDF and ADF) contents of Walki straw compared to the other varieties (Table 4). Similarly, the total

DM and OM intake was higher ($P<0.001$) in sheep fed Degaga straw compared to those fed straws from Mosisa and Shallo with no statistical difference with sheep fed Walki straw. 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 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 of more retention time in the rumen for further fermentation (Bruinenberg *et al.,* 2003).

Table 5. Feed intake of Arsi Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

Feed intake	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
DM intake (g/d)	671.7^{c}	754.3^{a}	717.9^{ab}	660.3^{c}	695.9^{bc}	8.17	***
DM intake (% BW)	2.8^{c}	2.9^{ab}	3.0^{a}	2.8^{bc}	2.9^{ab}	0.03	*
DM intake (g/kg $W^{0.75}$)	61.6^{b}	66.2^{a}	66.5^{a}	62.4^{b}	63.7^{ab}	0.65	**
OM intake (g/d)	632.9^{c}	703.8^{a}	673.9^{ab}	621.8^{c}	644.4^{bc}	7.44	***
CP intake (g/d)	70.9^{c}	75.8^{ab}	74.2^{b}	68.3^{d}	77.1^{a}	0.61	***
ME intake (MJ/d)	5.4^{c}	6.1^{b}	5.9^{b}	5.2^{c}	6.4^{a}	0.09	***
NDF intake (g/d)	425.8^{b}	477.7^{a}	466.4^{a}	431.0^{b}	448.0^{ab}	5.86	*
ADF intake (g/d)	309.4^{b}	340.5^{a}	332.6^{ab}	304.5^{b}	312.3^{ab}	4.69	*
ADL intake (g/d)	65.9^{c}	74.6^{a}	71.9^{ab}	66.5^{bc}	70.8^{ab}	0.99	*

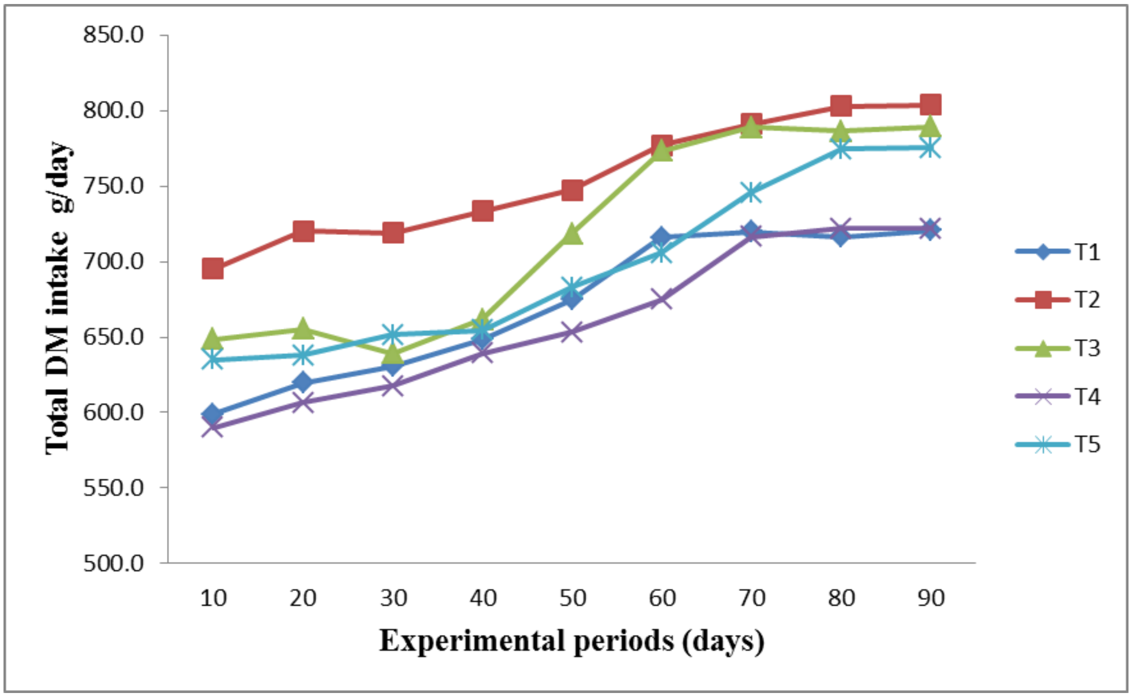
[a, b, c, d] means with different superscripts in a row are significantly different. ***=($P<0.001$), **=($P<0.01$); *($P<0.05$); ADF=acid detergent fiber; ADL=acid detergent lignin; BW=body weight; CP=crude protein; DM=dry matter; ME=metabolizable energy; NDF=neutral detergent fiber; OM=organic matter; SEM=standard error of the mean; SL=significance level; T1=70% mosisa straw + 30% concentrate mix; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

Sheep in T3 consumed significantly higher ($P<0.05$) DM as percent of body weight than sheep in T1 and T4 but similar with sheep in T2 and T5, which were higher ($P<0.05$) than sheep in T1. The total DM intake as percent of body weight for this study fall in the range of 2.8-3%, which was comparable with the values (1.9-3.2%) reported by Ermias (2008) for the same breed of sheep fed faba bean haulm supplemented with 300 g concentrate mix (barley bran, linseed meal and their mixture) supplement. The observed dry matter intake as percent of body weight fall within the range of 2-6% suggested to be consumed by small ruminants (Susan, 2003). The slight differences are presumably arising from the variation in the nutrient composition of straws obtained from different varieties of faba bean for this trial that associates with their relative feed intake. Similarly, sheep in T2 and T3 consumed higher ($P<0.01$) DM intake per unit of metabolic body weight than sheep in T1 and T4 whereas no significant differences ($P>0.01$) observed between T5 and the other treatments.

CP intake for sheep in T5 was significantly higher ($P<0.001$) than T3, T1 and T4 whereas no significant difference ($P>0.001$) was observed between sheep in T5 and T2. CP intakes of the other treatments were varied ($P<0.001$) in the order of sheep in T2 and T3 >T1>T4. The variation in CP intake was as expected since straw obtained from local variety in T5 had higher CP than Degaga variety in T3 and Walki variety in T2 and the latter two had greater CP than Mosisa variety in T1 and Shallo variety in T4 (Table 4). The CP intake of sheep in this experiment (68.3-77.1 g/d) were within the range of 54.1-103.3 g/d for 150-350 g/day concentrate supplemented of the same breed of sheep fed urea treated maize cob basal diet (Ermias, 2008). On the other hand, it was lower than earlier report of 81.1-126.9 g/day for 300 g/day concentrate supplemented of the same breed fed faba bean haulms as a basal diet (Tesfaye, 2008). The lower CP intake in the current study might be related to the lower crude protein contents of the feed used for this experiment.

The metabolizable energy (ME) intake of sheep in T5 in this trial was higher ($P<0.001$) than all other treatments and sheep in T2 and T3 also had significantly higher ($P<0.001$) ME intake than T1 and T4. The ME intake of sheep in this study (5.4-6.4 MJ/day) was comparable with 3.6-6.8 MJ/day for local sheep fed finger millet straw alone or supplemented with mixtures of *atella* and *"noug"* seed cake at different proportions (Almaz, 2008), 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, 2008) and 3.8-6.7 MJ/day for Horro lambs fed *L. sativus* haulm supplemented with wheat bran, *A. albida* leaf meal or their mixtures (Takele, 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).

Figure 1 showed that dry matter intake for all treatments was steadily increasing until 70 days except for sheep in T3, which showed a decreasing trend between 20-30 days. However, the dry matter intake of sheep in T1, T3 and T4 becomes constant for the remaining periods of the experiment indicating that sheep in these treatments reached maximum level of intake earlier and maintain that respective level across the remaining period. On the other hand, dry matter intake of sheep in T2 and T5 showed continuous increasing trend until 80 days and then after becomes constant during the remaining days.



T1=70% “mosisa” straw + 30% concentrate mix; T2=70% “walki” straw + 30% concentrate; T3=70% “degage” straw + 30% concentrate; T4=70% “shallo” straw + 30% concentrate; T5=70% local straw + 30% concentrate.

Figure 1. Trends in dry matter intake of Arsi Bale sheep fed faba bean straws and concentrate (2WB:1NSC) mixtures *ad libitum* in the ratio of 70:30 respectively.

4.4. Apparent nutrient Digestibility of Arsi-Bale Sheep Fed Faba Bean Straws with Concentrate

Apparent nutrient digestibility of Arsi-Bale sheep fed faba bean straws and concentrate is presented in Table 6. The apparent digestibility of DM for sheep in T1, T2 and T3 were higher ($P<0.05$) than T4 although the DM digestibility of sheep in T5 was not significantly different ($P>0.05$) from the other treatments. The OM digestibility was significantly higher ($P<0.05$) for sheep in T2 than T4. The lower apparent dry matter and organic matter digestibility for sheep in T4 might be attributed to the higher fiber (NDF, ADF and ADL) content of straws from Shallo variety of faba bean consistent with the lower in vitro organic matter digestibility of straw of the same variety (Table 4) compared to straws from other varieties. Neutral detergent fiber, which is a measure of cell wall content, is the primary chemical component of feeds that determines the rate of digestion; thus there is a negative relationship between the neutral detergent fiber content of feeds and the rate at which they are digested (McDonald *et al*., 2002). The same author revealed that the fiber fraction of a feed has the greatest influence on its digestibility.

Table 6. Apparent nutrient digestibility of Arsi-Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

	Treatments					**SEM**	**SL**
Digestibility (%)	**T1**	**T2**	**T3**	**T4**	**T5**		
DM	54.9^{a}	56.6^{a}	55.5^{a}	49.5^{b}	54.0^{ab}	0.86	*
OM	52.1^{ab}	54.7^{a}	50.5^{ab}	46.0^{b}	47.8^{ab}	1.27	*
CP	60.3^{ab}	55.4^{ab}	54.3^{bc}	47.5^{c}	61.9^{a}	1.32	***
NDF	51.9	53.3	53.7	51.9	54.7	0.59	ns
ADF	50.7	52.3	49.8	50.0	50.0	1.26	ns

[a, b, c] means with different superscripts in a row are significantly different.***=(P<0.001), *(P<0.05); ADF=acid detergent fiber; CP=crude protein; DM=dry matter; NDF=neutral detergent fiber; ns=non-significant; OM=organic matter; SEM=standard error of the mean; SL=significant level; T1=70% mosisa straw + 30% concentrate mix; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

The apparent DM digestibility of T1, T2 and T3 (54.9-56.6%) used in the present experiment were slightly lower than 56-64% reported by Emebet (2008) for Black head Ogaden sheep fed haricot bean haulm alone or supplemented with 300 g/day of mixtures of wheat bran and brewers dried grain. Similarly, Ermias (2008) also reported 69-76% total apparent DM digestibility for the same breed of sheep fed faba bean haulm and supplemented with 300 g/day of barley bran, linseed meal and their mixture. The variation of DM and OM apparent digestibility of the current result with earlier findings might be related to age of the animals, level of feeding, feed and ration composition (Rajihan, 1999) and also the varietal differences of faba bean used. Moreover, digestibility of a feed is influenced not only by its composition, but also by the composition of other feeds consumed with it.

The CP digestibility of sheep in T5 was greater ($P<0.001$) than T3 and T4 but did not differ ($P<0.001$) from sheep in T1 and T2 whereas CP digestibility of sheep in T1 and T2 were also higher ($P<0.001$) than T4. The lower CP digestibility for sheep in T4 might be due to lower CP content of straws from Shallo variety (Table 4) and inadequate CP intake of sheep from this treatment (Table 5). The apparent CP digestibility for sheep in T1, T2 and T5 (55.4-61.9%) in this trial were within the range of CP digestibility of 55-71% reported by Emebet (2008) for Black head Ogaden sheep fed haricot bean haulm alone or supplemented with the mixtures of wheat bran and brewers dried grain 300 g/day. The current result revealed that there were no significant difference ($P>0.05$) in the digestibility of fiber components among treatments which is in line with the reports of others (Aschalew, 2011; Nuguse, 2011; Mesgenew, 2014) who found no variation in digestibility in NDF and ADF for different breeds of small ruminants and different feed types.

4.5. Body Weight Change of Arsi-Bale Sheep Fed Faba Bean Straws with Concentrate

The body weight parameters of the experimental sheep fed different faba bean straws and concentrat are presented in Table 7. There were significant ($P<0.01$) differences in final body weight, body weight change, average daily gain and feed conversion efficiency among different treatments. Sheep in T2 had higher ($P<0.01$) average daily gain than sheep in T3, T4 and T5 but no significant difference ($P>0.01$) with T1. The variation in average daily gain might be obtained from differences in the feeding values of faba bean straws used for the trial because of the fact that the concentrate provided for all treatments were similar. This variation in average daily weight gain could be attributed to the better DM and CP intake and nutrient digestibility in sheep fed straws obtained from Walki and Mosisa varieties in T2 and T1 respectively. The highest average daily gain (64.6 g/day) for the current study was higher than 41.8-56.4 g/day average daily weight gain for Black head Ogaden sheep fed haricot bean haulm as a basal diet supplemented with the mixtures of wheat bran and 300 g/day brewers dried grain (Emebet, 2008). Similarly, it was comparable with the highest average body weight gain (64.4 g/day) for Washera sheep fed grass hay basal diet and 350 g/day concentrate (field pea hull, wheat bran and *"noug"* seed cake) supplemented (Mesganaw, 2014).

The final body weight in the current study was higher (P<0.01) for sheep in T2 than the other treatments. Feed conversion efficiency for this trial was greater (P<0.05) for sheep in T2 as compared to T3 and T4 whereas similar with values obtained for T1 and T5. Feed conversion efficiency of sheep in T1 was significantly greater (P<0.05) than T4 but no difference (P>0.05) among other treatments. The improved FCE seemed to be related to higher nutrient contents of faba bean straws in T1 and T2 and the consequent increase in body weight gain and the ability of sheep to convert feed efficiently to flesh. The variations in final body weight, average daily gain and feed conversation efficiency among the treatments tested stemmed from variations in nutrient contents, cell wall constituents and digestibility within different faba bean straws since the concentrate mixture was similar for all treatments. This indicates that there is a possibility for selecting faba bean crops for planting based on their straws qualities in addition to the grain yield and quality attributes for enhanced use of the whole plant value. The current study demonstrated that 70% faba bean straws from Walki and Mosisa varieties with 30% concentrate resulted in higher average daily gain than other varieties.

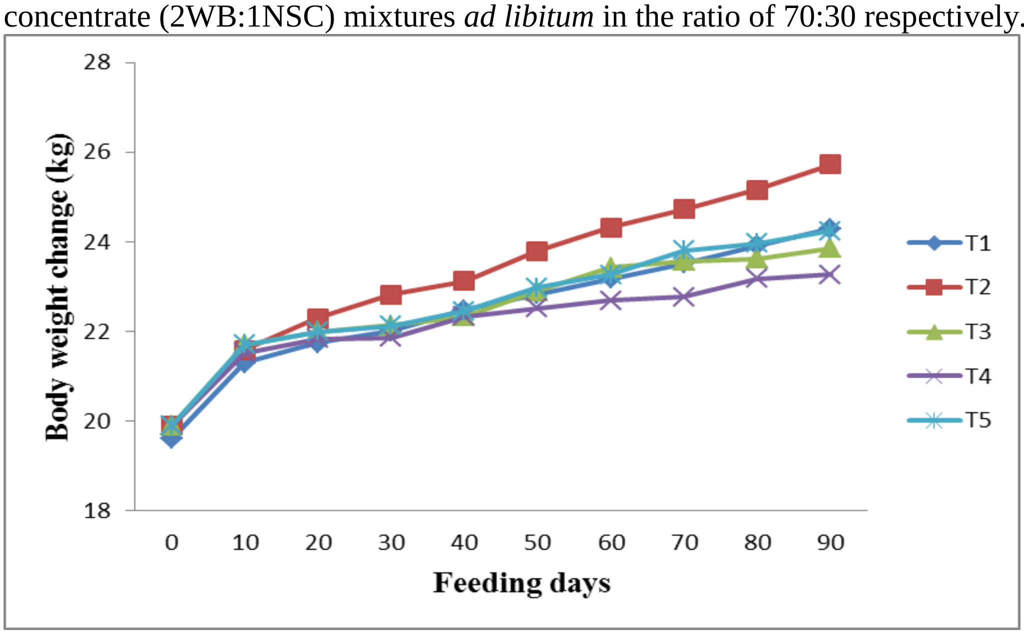
Table 7. Body weight changes of Arsi-Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

Parameters	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
IBW (kg)	19.6	19.9	19.9	19.9	19.9	0.19	ns
FBW (kg)	24.3^{b}	25.7^{a}	23.9^{b}	23.3^{b}	24.2^{b}	0.27	**
BWC(kg)	4.7^{ab}	5.8^{a}	3.9^{bc}	3.4^{c}	4.4^{bc}	0.23	**
ADG (g/day)	52.2^{ab}	64.6^{a}	43.2^{bc}	37.5^{c}	48.3^{bc}	2.55	**
FCE	0.077^{ab}	0.085^{a}	0.059^{bc}	0.056^{c}	0.069^{abc}	0.003	*

$^{a, b, c,}$ means with different superscripts in a row are significantly different. **=(P<0.01), *=(p<0.5); ADG=average daily gain; BWC=body weight change; FBW=final body weight; FCE=feed conversion efficiency; IBW=initial body weight; ns=not significant; SEM=standard error of the mean; SL=level of significance; T1=70% mosisa straw + 30% concentrate mix; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

Ermias (2008) reported that Arsi-Bale sheep fed faba bean haulms alone lost body weight (-15 g/day) whereas those supplemented with 300 g/day concentrate (barely bran and/or linseed meal) gained 55.6-87.8 g/day. Similarly, Takele (2010) observed a body weight loss of 40.9 g/day for Horro sheep fed sole vetch haulm and 28.1-52.9 g/day daily gain for groups supplemented with 300 g/day wheat bran and Acacia leaf mixtures. On the contrary, Emebet (2008) reported a positive weight gain (15.3 g/day) for Black Head Ogaden sheep fed haricot bean haulm alone and 39.7-56.4 g/day gain for groups supplemented with 300 g/day concentrate (wheat bran and brewers dried grain mixture). Additionally, Likawent et al. (2005) showed that yearling Menz rams fed sole lentil, grass pea and chickpea straws gained 62.8, 26.5 and 18.3 g/day, respectively, whereas those sheep fed faba bean straw suffered serious weight loss. The chemical composition of faba bean straws in the current study (Table 4) and earlier findings revealed that faba bean straws as a sole feed may not fulfill even the maintenance requirement of sheep because of low CP and high fiber content and low digestibility. But when the level of concentrate supplementation increased up to 30% of the daily offered feed, considerable daily body weight gain (37.5-64.6 g/day) was observed depending on the faba bean varieties used (Table 7). The present results agree with the previous findings (Emabet, 2008; Ermias, 2008; Takele, 2010) which reported higher weight gain when different pulse crops residues were supplemented with 300 g/day concentrate mixtures.

Figure 2. Trends in body weight change of Arsi-Bale sheep fed faba bean straws and concentrate (2WB:1NSC) mixtures *ad libitum* in the ratio of 70:30 respectively.



T1=70% mosisa straw + 30% concentrate mix; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate

The trend of weight changes across the feeding days (Figure 2) revealed that all sheep up to the 10th days showed body weight gain almost in a similar steady increasing manner. This might be related to the compensatory growth from digestibility trial even though 10 days of adaptation periods were given before the commencement of the feeding trial. After the 10th days, sheep in T2 showed higher growth rate than sheep in other treatments throughout the experimental period and from 10th day up to 40th day, the growth of sheep in T1, T3, T4 and T5 moved with the same trend. After the 40th day, the growth of sheep in T4 was lower than other treatments which may be the inability of the feed in T4 to maintain constant growth as sheep advance in weight.

4.6. Carcass Evaluations of Arsi-Bale Sheep Fed Faba Bean Straws with Concentrate

4.6.1. Carcass parameters of Arsi-Bale sheep fed faba bean straws with concentrate

Slaughter body weight, hot carcass weight, empty body weight, chilled carcass weight, dressing percentage, fat thickness and rib eye area of Arsi-Bale sheep fed faba bean straws with concentrate is given in Table 8. Slaughter body weight was higher ($P<0.05$) for sheep in T1 and T2 as compared to sheep in T4 and there were no significant ($P>0.05$) difference among T1, T2, T3 and T5. This might be due to higher feed conversation efficiency and body weight gain (Table 7) of those groups fed on Walki and Mosisa straws as compared to those fed Shallo straw since slaughter body weight depends on feed conversation efficiency and body weight gain (Rahman, 2007a). The absence of significant difference among sheep in T1, T2, T3 and T5 indicates that variation among straws in these treatments had no effect on these carcass parameters.

Hot carcass weight, chilled carcass weight and dressing percentage on both slaughter and empty body weight basis did not differ ($P>0.05$) among treatments in this trial. The lack of significant difference among treatments in the above mentioned parameters showed that straws obtained from different faba bean varieties had similar effect on these carcass parameters. Dressing percentage is the proportion of body weight considered to be edible and it is an important trait in carcass merit consideration. The dressing percentage of Arsi-Bale sheep in the current study were 31.5-37.3% and 42.6- 46.5% (Table 8) on slaughter and empty body weight basis, respectively. According to Gatenby (2002) dressing percentage of sheep generally range between 40-50% (in EBW base), but it depends very much on what parts of the carcass is sold as meat. The dressing percentage on empty body weight basis for the current study was also in this range. Abebe (2006) reported that the same breed of sheep weighing 14.67-24.43 kg at slaughter had a dressing percentage of 38.4-45.6% and 47.5-56.3% on slaughter body weight and empty body weight basis, respectively, which were slightly higher than the current finding.

Table 8. Carcass characteristics of Arsi-Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

Parameters	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
SBW (kg)	24.0^{a}	23.8^{a}	22.8^{ab}	21.7^{b}	23.4^{ab}	0.30	*
HCW (kg)	8.5	8.4	8.4	8.1	8.7	0.11	ns
CCW (kg)	8.3	8.1	8.3	7.7	8.2	0.11	ns
EBW (kg)	19.5^{a}	19.7^{a}	18.6^{ab}	17.5^{b}	18.8^{ab}	0.32	*
Dressing percentage on							
SBW basis	31.5	35.3	36.9	37.3	37.1	0.44	ns
EBW basis	43.2	42.6	45.5	46.5	46.1	0.61	ns
Fat thickness (mm)	0.18^{b}	0.23^{ab}	0.33^{ab}	0.2^{ab}	0.35^{a}	0.03	*
REA (cm^2)	7.3	7.3	8.3	8.0	8.0	0.24	ns

$^{a,\ b,}$ means with different superscripts in a row are significantly different. *=(p<0.5); CCW=chilled carcass weight; HCW=hot carcass weight; EBW=empty body weight; ns=non-significant; REA=rib eye area; SBW=slaughter body weight; SEM=standard error of the mean; SL=significance level; T1=70% mosisa straw + 30% concentrate; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

When compared on empty body weight basis, sheep in T1 and T2 had higher (P<0.05) empty body weight basis than sheep in T4 but there were no significant difference (P>0.05) among within sheep in T3 and T5. The higher empty body weight of sheep in T1 and T2 might be due to their higher slaughter body weight (Table 8). Sheep in T5 had higher (P<0.05) fat thickness than T1, which might be related to the higher metabolizable energy content (Table 4) of faba bean straws used and the relatively higher ME intake (Table 5) for animals in T5 leading to increased fat thickness (Ryan *et al.*, 2007) than animals in T1, whereas no significance (P>0.05) difference was observed between the other treatments. Similarly, no difference (P>0.05) was observed among treatments in rib-eye area, which is an indicator of the amount of carcass produced from the animals (Rahman, 2007b). Rib eye area indicates the muscular development of the animal that will be increased through the live weight gain. The rib eye area (7.3-8.3 cm^2) for the present study was slightly higher than 4.4-8.1cm^2 reported by Tesfaye (2010) for the same breed of sheep fed urea treated maize cob and supplemented with different levels of *"noug"* seed cake and wheat bran mixture. The values of rib-eye area found in the current study was within the range of 5.5-9.9 cm^2, 5.6-9.2cm^2 and 6.7-10.4cm^2 rib eye area reported earlier by Mesgenew (2014), Simachew (2008) and Emebet (2008) respectively for different sheep breeds.

4.6.2. Edible offal components of Arsi-Bale sheep fed faba bean straws with concentrate mixture

Carcass offal components are categorized into edible and non-edible based on tradition, beliefs, culture, and differences in preference of the people from one locality to the other and is so more or less subjective (Getahun, 2001). Edible offal components of Arsi-Bale sheep fed different faba bean straws with concentrate mixture are presented in Table 9. The majority of the edible offal components including total edible offal components in this study were not affected (P>0.05) by the variety of faba bean straws. Riley *et al.* (1989) indicated that differences in internal organs are more influenced by age, breed and sex of the animals rather than plane of nutrition which support the current result. Sheep in T1 had higher (P<0.05) kidney and testicles weight than sheep in T4 but similar with other treatments, on the other hand, it had lower empty gut weight than other treatments and the later might be related to lower total DM intake (Table 5) of sheep in T1 as compared to the others. This implies that as animals consume more feed, their stomach may be enlarged to accommodate the larger ingesta and thicker to resist the work load in it and this may increase the volume and weight of the gastrointestinal tract as a whole. The same is true for large intestine weight as sheep in other treatments had higher (P<0.05) than sheep in T1.

Table 9. Edible offal components of Arsi-Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

Edible offal	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
Blood (gm)	943.6	829.8	915.8	835.5	876.0	21.40	ns
Liver (gm)	287.3	284.8	264.3	272.8	260.8	4.67	ns
Kidney (gm)	69.0^{a}	63.8^{ab}	65.5^{ab}	58.3^{b}	62.8^{ab}	1.39	*
Heart (gm)	104.6	97.5	99.3	99.3	99.0	1.29	ns
Tongue (gm)	75.5	70.0	82.5	71.5	72.0	2.09	ns
Ret-rum (gm)	3933.7	3525.8	3716.5	3648.8	3989.0	107.05	ns
Om-ab (gm)	558.1	536.8	537.3	612.0	623.8	22.14	ns
Empty gut (gm)	624.3^{b}	797.8^{a}	780.8^{a}	780.0^{a}	771.3^{a}	18.33	**
SI (gm)	1325.5	1399.3	1282.5	1286.0	1462.0	39.20	ns
LI (gm)	536.7^{b}	754.0^{a}	634.0^{ab}	617.3^{ab}	617.8^{ab}	29.02	*
Testicles (gm)	385.4^{a}	342.5^{ab}	333.0^{ab}	245.3^{b}	328.5^{ab}	18.75	*
Tail (gm)	466.4	579.0	462.0	540.7	493.7	29.18	ns
Kidney fat (gm)	71.5	70.8	83.3	67.3	75.3	6.40	ns
Heart fat (gm)	53.7	42.5	40.0	49.8	48.5	3.05	ns
Omental fat (gm)	62.1	62.0	69.3	53.5	56.0	5.18	ns
Scrotal fat (gm)	30.3	35.5	39.3	32.5	39.5	2.09	ns
Pelvic fat (gm)	32.5	38.0	39.0	27.8	30.5	1.73	ns
TEOC (kg)	9.6	9.5	9.4	9.3	9.9	0.14	ns

$^{a,\ b,}$ means with different superscripts in a row are significantly different. *=(P<0.5); **=(P<0.01); LI=large intestine; ns=non-significant; Om-abo=omasum-abomasum; Ret-rum=reticulo-rumen; SEM=standard error of the mean; SI=small intestine; SL=significance level; TEOC=total edible offal component; T1=70% mosisa straw + 30% concentrate; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

4.6.3. Non-edible offal components of Arsi-Bale sheep fed faba bean straws with concentrate

The non-edible offal components of Arsi-Bale sheep fed different faba bean straws with concentrate are presented in Table 10. Except lung with trachea and spleen, all non- edible offal parameter together with total non-edible offal components were not affected (P>0.05) by treatments and indicating that variation in straws from different varieties of faba bean majorly have no influence on non-carcass parameters. Sheep in T1 had higher (P<0.05) lung with trachea as compared to sheep in T4. This might be related to the smaller slaughter weight of sheep in this treatment than sheep in T1. In the same manner, sheep in T1 and T5 had also higher (P<0.5) spleen than sheep in T2, T3 and T4. Sheep in the present study had 18.7%, 17.1%, 18.7%, 19.6% and 19.7% gut fill on their slaughter body weight basis for T1, T2, T3, T4 and T5 respectively. Lack of significant difference in gut fill between different treatments of sheep in the current study might be due to the time elapsed (24 hour fasting time prior to slaughter) until slaughtering that made to shrink their gut fill equally. In line with the present study, Ermias (2008) reported gut fill weight of 4.8-5.5 kg (17.6-20.4% on slaughter body weight basis) for the same breed of sheep fed faba bean haulms supplemented with linseed meal, barley bran and their mixture and weighted 18.5-27.6 kg at slaughter.

Table 10. Non edible offal components of Arsi-Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

Non-edible offal	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
Head without tongue (gm)	1573.9	1582.0	1493.3	1523.3	1561.3	36.87	ns
Skin (gm)	2127.9	1867.3	1758.3	2031.8	1934.0	55.73	ns
Lung with trachea (gm)	320.8[a]	284.5[ab]	285.0[ab]	206.3[b]	260.5[ab]	14.67	*
Pancreas (gm)	36.3	32.5	33.3	33.0	22.5	0.87	ns
Spleen (gm)	44.6[a]	34.8[bc]	36.0[bc]	28.3[c]	38.5[ab]	2.03	**
Bladder (gm)	13.5	15.3	16.0	13.0	12.5	1.23	ns
Gall bladder (gm)	3.6	5.3	5.0	7.5	6.3	1.35	ns
Full gut (gm)	4491.8	4062.5	4254.0	4260.8	4612.8	120.90	ns
Penis (gm)	60.7	56.5	59.0	50.5	58.5	1.80	ns
Feet with hooves (gm)	461.6	411.8	421.3	413.0	445.5	8.86	ns
TNEOC (kg)	9.1	8.4	8.4	8.6	8.9	0.16	ns

[a, b, c,] means with different superscripts in a row are significantly different. **=(P<0.01); *=(P<0.5); ns=non-significant; SEM=standard error of the mean; SL=significance level; TNEOC=total non-edible offal component; T1=70% mosisa straw + 30% concentrate; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

4.6.4. Five primal cuts of right half carcass of Arsi-Bale sheep fed faba bean straws with concentrate

The five primal cut from the right half of carcass from Arsi-Bale sheep fed faba bean straws with concentrate are given in Table 11. Except for bone from loin and breast and shank, all the five primal cut components such as bone, muscle, fat and their total were not affected (P>0.05) by feeding different varieties of faba bean straws with the same concentrate mixture for all treatments. The absence of significant difference for the five primal cuts in the present study among treatments showed the similarities of straws obtained from different faba bean varieties on carcass parameters.

Table 11. Five primal cuts for the right half of carcass from Arsi-Bale sheep fed faba bean straws and concentrate mixtures *ad libitum* in the ratio of 70:30 straw and concentrate (2WB:1NSC) respectively.

Primal cut (gm)	**Treatments**						
	T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
Leg total	1491.8	1429.8	1358.5	1337.5	1472.0	22.10	ns
Bone	397.0	362.8	344.3	366.5	394.5	10.58	ns
Muscle	994.8	962.3	910.0	943.3	964.0	13.99	ns
Fat	100.0	104.8	104.3	67.8	113.5	7.87	ns
Loin total	410.0	465.0	430.0	414.3	469.0	13.99	ns
Bone	117.5^{ab}	173.3^{a}	93.5^{b}	105.0^{b}	93.3^{b}	11.58	*
Muscle	267.5	243.3	281.3	264.5	331.3	15.25	ns
Fat	25.0	48.5	55.3	44.8	44.5	5.29	ns
Rack total	496.5	492.3	508.0	453.5	510.3	17.74	ns
Bone	139.5	157.0	163.8	138.8	165.5	8.59	ns
Muscle	304.3	261.0	275.0	262.8	566.3	9.99	ns
Fat	52.8	74.3	69.3	52.0	78.5	9.14	ns
Breast and shank total	465.8	452.5	395.5	420.3	425.3	10.78	ns
Bone	165.8^{a}	145.5^{ab}	135.8^{b}	146.3^{ab}	136.8^{b}	3.86	*
Muscle	239.0	244.8	198.3	224.5	210.0	8.94	ns
Fat	61.0	62.3	61.5	49.5	78.5	4.77	ns
Shoulder and neck total	1312.8	1280.8	1403.0	1323.0	1397.5	35.02	ns
Bone	376.3	340.3	366.3	397.3	390.3	11.59	ns
Muscle	859.3	872.0	947.8	859.8	925.5	25.43	ns
Fat	77.3	68.5	89.0	66.0	81.5	7.12	ns

[a, b,] means with different superscripts in a row are significantly different. *=(p<0.5); ns=non-significant; SEM=standard error of the mean; SL=significance level; T1=70% mosisa straw + 30% concentrate; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

Mean tissue weight and proportions from the five primal cuts of the right half of carcass from Arsi-Bale sheep fed different faba bean straws with concentrate mixtures are present in Table 12. Mean tissue weight and their proportions in dissected half carcass of all primal cuts were not affected (P>0.05) by feeding straws obtained from different varieties of faba bean and concentrate mixtures. Muscle (2.55-2.69 kg) followed by bone (1.1-1.9 kg) and fat (0.28-0.39

kg) had the highest amount in each primal cut for all treatment groups. In agreement with the current study, Tesfaye *et al.* (2008) reported 2.52-3.29 kg, 1.08-1.33 kg and 0.11-0.19 kg for muscle, bone and fat respectively for browsing Arsi-Bale goat fed sweet potato vines as a concentrate feed. Large amounts of muscle were found on the leg followed by shoulder and neck parts of primal cuts which was in line with earlier reports by other (Daskiran *et al.*, 2006). Similar results were also reported for Borana and Arsi-Bale goats kept in feedlot for different durations (Hailu *et al.*, 2005). On the other hands, breast and shank followed by rack had higher proportion of fat compared to other primal cuts in this trial.

Table 12. Mean tissue weight and proportions in dissected half carcass of all primal cuts of Arsi Bale sheep fed different faba bean straws and concentrate mixtures

Tissues		**Treatments**						
		T1	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
Muscle,	kg	2.7	2.7	2.6	2.6	2.7	0.04	ns
	%	62.2	58.8	61.0	61.8	60.8	0.90	ns
Bone,	kg	1.2	1.2	1.1	1.2	1.2	0.03	ns
	%	29.3	30.9	27.9	29.6	28.0	0.73	ns
Fat,	kg	0.3	0.4	0.4	0.3	0.4	0.02	ns
	%	8.4	10.3	11.0	8.6	11.2	0.61	ns

ns=non-significant; SEM=standard error of the mean; SL=significance level; T1=70% mosisa straw + 30% concentrate; T2=70% walki straw + 30% concentrate; T3=70% degaga straw + 30% concentrate; T4=70% shallo straw + 30% concentrate; T5=70% local straw + 30% concentrate.

The proportions of muscle in the present study varies from 58.8-62.2% which was within the range of 51.09-76.77% lean meat of Arsi-Bale goats with different age group and feeding regime (Mesfin, 2007) and slightly lower than 63-67.4% lean meat for Borana and Arsi-Bale goats under different durations of feedlot management (Hailu *et al*., 2005). The proportions of bone in the current study also varies from 27.9-30.9% which was comparable with 25.7-30.9% reported by Hailu *et al*. (2005) and within the range of 25.11-35.89% reported by Mesfin (2007). Even though the difference was not significant (P>0.05), sheep in T5 and T3 had figuratively higher values of fat percentage than other treatments. This may be attributed to the higher metabolizable energy in local and Degaga varieties straws (Table 4), the straws consumed by these treatment groups leading to higher metabolizable energy intake for T3 and T5 when compared to the other treatments.

5. SUMMARY AND CONCLUSIONS

The study was conducted at Sinana Agricultural Research Center. The varieties were planted on station on 0.25 hectare of land each and grain and straw yield, straws to grain ratio and harvest index were determined from 30 plots of $1m^2$ area for each varieties. An animal experiment was conducted by using forty yearling male Arsi-Bale sheep in digestibility and feeding trials. The aim of the study was to evaluate the varietal differences among faba bean straws and to evaluate effects of feeding different varieties of faba bean straws with concentrate on feed intake, digestibility, body weight gain and carcass characteristics of Arsi-Bale sheep. The experiment was conducted using a randomized complete block design with five treatments and eight animals per treatment. The treatments include 70% faba bean straws of five different varieties viz. Mosisa (T1), Walki (T2), Degaga (T3), Shallo (T4) and local varieties (T5) and with 30% concentrate composed of wheat bran and noug seed cake in a 2:1 ratio and the total mixed diet was fed *ad libitum*. Water was available free choice throughout the experimental periods. The digestibility trial was undertaken for seven days after 15 days acclimatization period. The feeding trial followed the digestibility trial after 10 days of rest period and re-acclimatization to the experimental feeds and lasted for 90 days. Carcass evaluation carried out at the end of the experiment with half of the sheep (four per treatment) in the trial.

Improved faba bean varieties in the current study had greater ($P<0.001$) grain yield than local variety as expected. Straw yield from Mosisa (5.1 t/ha) variety had significantly higher ($P<0.001$) than all other varieties and that obtained from Shallo (4.5 t/ha) variety was higher ($P<0.001$) than Walki, Degaga and local varieties. The straw obtained from Walki (4 t/ha) and Degaga (3.9 t/ha) were higher ($P<0.001$) than straw obtained from local (3.3 t/ha) variety. Mosisa, Shallo and Local varieties had significantly higher ($P<0.001$) straws to grain ratio than Walki and Degaga varieties. Harvest index for Walki and Degaga varieties were significantly greater ($P<0.001$) than Mosisa, Shallo and local varieties. The overall results of grain and straw yield, straws to grain ratio and harvest index from the current experiment showed that there were significant varietal differences among the tested varieties.

The CP and ME contents of the faba bean straws were 4.3-6.2% and 6.5-9.2 MJ/kg DM respectively. The CP content of wheat bran was 13% whereas that of *"noug"* seed cake was 26.85%. The DM intake of sheep in T2 (754.3 g/day) was higher (P<0.001) than T1, T4 and T5 but did not differ (P>0.001) from sheep in T3 (717.9 g/day). The DM intake of sheep in T3 was higher (P<0.001) than T1 and T4. The differences in DM intake were mainly due to differences among the different varieties of faba bean straws since the concentrate supplement was the same for all treatments. The higher total DM intake for all treatments in the current study (61.6-66.5 g/kg $W^{0.75}$) indicates that sheep consumed chopped faba bean straws with concentrate mixture well and no ill-health /cough problems observed which was the previously concern of farmers in the study area. CP intake for sheep in T5 was greater (P<0.001) than T3, T1 and T4 whereas no significant difference (P>0.001) with sheep in T2. CP intakes of the other treatments were higher (P<0.001) in the order of sheep in T2 and T3 >T1>T4. The NDF and ADF intake of T2 and T3 were higher (P<0.05) than T1 and T4 but no variation (P>0.05) among T5. The higher NDF and ADF for sheep in T2 and T3 could be attributed to the higher DM intake of the sheep in these treatments.

The DM and OM digestibility of sheep in T1, T2 and T3 were higher (P<0.05) than T4 but did not differ (P>0.05) with T5. The CP digestibility of sheep in T5 was higher (P<0.001) than that of T3 and T4 but did not differ (P>0.001) with sheep in T1 and T2 whereas CP digestibility of T1 and T2 was also greater (P<0.001) than T4. There were significant (P<0.01) differences in final body weight, average daily gain and feed conversion efficiency among treatments. Sheep in T2 (64.58 g/day) had higher (P<0.01) average daily gain than sheep in T3 (43.19 g/day), T4 (37.5 g/day) and T5 (48.33 g/day) but no significant difference (P>0.01) with T1 (52.22 g/day). Feed conversion efficiency for this trial was higher (P<0.05) for sheep in T2 as compared to T3, T4 and T5 whereas similar with values obtained for T1. Similarly, FCE of sheep in T1 was significantly greater (P<0.05) than T4.

Slaughter body weight and empty body weight were higher (P<0.05) for sheep in T1 and T2 as compared to T4 but similar (P>0.05) among others. This might be due to higher feed conversation efficiency and body weight gain of the groups fed Walki and Mosisa varieties of faba bean straws as compared to others. Hot carcass weight, chilled carcass weight, dressing percentage on both slaughter and empty body weight basis, rib eye area, majority of edible and non-edible offal components, all five primal cuts of carcass components were not affected ($P>0.05$) by using straws from different varieties of faba bean.

From the results of this study, it was concluded that there is significant varietal difference between straws obtained from faba bean varieties related to yield parameters of the varieties and feed intake, digestibility, body weight gain and feed conversion efficiency of sheep fed faba bean straws supplemented with concentrate feed and also observed that straws from faba bean when supplemented with concentrate had higher potential as animal feed. Based on these results, Walki and Mosisa varieties found to be the most promising ones in terms of feeding value of the straws and hence could be recommended as more suitable candidates for pulse crop rotation with cereals in the study area because of their potential for providing better quality straws that can help in enhancing livestock production and productivity in addition to grain yield for human consumption.

Scope for future work

- It is important to determine the level of concentrate mixture in order to exploit the full genetic potential of the sheep within the given time

- In order to confirm the varietal differences among the straws of faba bean varieties based on yield parameters, it should be further evaluated across different year and location and comparisons should include determination of the potential utility index that integrates grain yield with the digestible straw yield of the varieties.

6. REFERENCES

Abebaw Nega. 2007. The effect of supplementation with rice bran, "*noug*" (*Guizota abyssinica*) seed cake and their mixtures on feed utilization and live weight change of Farta Sheep. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Abebe Tafa. 2006. Supplementation with linseed (*Linum usitatssimum)* cake, wheat bran and their mixtures on feed intake, digestibility, live weight change and carcass characteristics in intact male Arsi Bale sheep. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Adugna Tolera, Alemu Yami and Dawit Alemu. 2012. Livestock feed resources in Ethiopia: Challenges, Opportunities and the need for transformation. Ethiopia Animal Feed Industry Association, Addis Ababa, Ethiopia.

Adugna Tolera, Merkel, R.C., Goetsch, A.L., Tilahun Sahlu and Tegene Negesse. 2002. Nutritional constraints and future prospects for goat production in East Africa. In: Merkel, R.C. Adebe, G. Goetch, A.L. (eds.). Langston University, Oklahama, United States.

Adugna Tolera. 2001. Integrated food and feed production on small-holder mixed farms: Effect of early harvesting or variety on maize grain and stover yield and nutritive value of stover. pp. 187-194. *In: Enhancing the contribution of maize to food security in Ethiopia. Second National Maize Workshop of Ethiopia,* 12-16 November 2001. Addis Ababa, Ethiopia.

Adugna Tolera. 2008. Feed resources and feeding management: A manual for feedlot operators and development workers. SPM-LMM program. Addis Ababa, Ethiopia.

Ajayi, F.T., Babayemi, O.K. and Taiwo, A.A. 2008. Effects of supplementation of *Panicum maximum* with four herbaceous forage legumes on performance, nutrient digestibility and nitrogen balance in West African dwarf goats. *Animal Science Journal*, 79(6): 673-679.

Alem Berhe. 1993. Component analysis of the characters determining seed yield in faba bean (*Vicia faba L*.). MSc Thesis, Alemaya University, Haramaya, Ethiopia.

Alemayehu Mengistu. 2006. *Country pasture/forage resources profiles*. In: Francias, J. M. Suttie and S.G. Reynolds (eds). FAO publications, Rome, Italy.

Alemu Yami. 1981. Laboratory evaluation and estimation of nutritive value of some feedstuffs produced in the Alemaya Woreda. MSc Thesis, Alemaya University, Haramaya, Ethiopia.

Almaz Ayenew. 2008. Supplementation of dried *atella, noug* seed cake (*Guizotia abyssinica*) cake and their mixture on feed intake, digestibility and live weight change of local sheep fed finger millet (*Eleuine coracana*) straw basal diet. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Ameha Sebsibe. 2006. Meat quality of selected Ethiopian goat genotypes under varying nutritional condition. PhD Thesis, University of Pretoria, South Africa.

Ameha Sebsibe. 2008. Sheep and goat meat characteristics and quality. pp. 323-338. In: Alemu Yami and Merkel, R.C. (eds.), *Sheep and Goat Production Handbook for Ethiopia*. Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP), Ethiopia.

AOAC (Association of Official Analytical Chemists). 2005. *Official Methods of Analysis*. Association of Official Analytical Chemists, Washington DC.

ARC (Agricultural Research Council). 1980. The nutrient requirement of livestock. Common Wealth Agricultural Bureau, Slough, England.

Aschalew Assefa. 2011. Supplementation of raw, malted and heat treated grass pea (*Lathyrus satvas*) grain on feed intake, digestibility, body weight gain and carcass characteristics of Farta sheep fed grass hay. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Awet Estifanos. 2007. Feed utilization, body weight and carcass parameters of intact and castrated Afar sheep fed on urea treated *tef* straw supplemented with wheat bran. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Azage Tegegne. 2005. Improving productivity and market success of Ethiopian farmers. *ESAP Newsletter*, *Issue No. 11*. ESAP (Ethiopian Society of Animal Production), Addis Ababa, Ethiopia.

Barkrie, B. and Hogan, J. 1996. *Ruminant nutrition and production in the tropics and subtropics.* ACIAR Monograph series, Australia.

Bell, J.M and Keith, M.O. 1994. Effect of adding barley hulls and linseed meal to wheat and hulless barley diets fed on growing pigs. *Animal Feed Science. and Technology,* 45(2):177-191.

Birhanu Mammo. 2010. Effect of supplementation of malty barley byproduct, wheat bran and their mixtures on feed intake, digestibility, body weight change and carcass parameters in field pea haulms based feeding of Arsi Bale sheep. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Bodas, R., Giraldez, F.J., Lopez, S., Rodrıguez, A.B. and Mantecon, A.R. 2007. Inclusion of sugar beet pulp in cereal-based diets for fattening lambs. *Small Ruminant Research*, 71(3): 250–254.

Brown, L., Hindmarsh, R. and Mcgregor, R. 2001. *Dynamic agricultural book three, 2nd edition.* McGraw-Hill Book Company, Sydney.

Bruinenberg, M.H., Valk H. and Struik, P.C. 2003. Voluntary intake and in vivo digestibility of forages from semi-natural grasslands in dairy cows. *National Journal of Applied Science, 51(3): 219-235.*

Cheeke, R. Peter. 1991. *Applied Animal Nutrition*. Feed and Feeding. Macmillan, New York and Toronto.

CSA (Central Statistical Agency). 2003. Statistical Report on Area and Production of Temporary Crops Part III A: Ethiopian Agricultural Sample Enumeration, 2001/02. Central Statistical Agency, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). 2010. Agricultural sample survey. The 2009/10 national statistics. Report on livestock and livestock characteristic. Volume II, February, 2010, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 2004. Report on livestock and livestock characteristics. Agricultural sample survey 2003/2004. II. Statistical Bulletin 302: 29-30. Central Statistical Authority of the Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

CSA (Central Statistics Authority). 2006. Report on area and production of Belg season crops for private peasant holdings. Agricultural sample survey of 2005/06. Central Statistical Authority of the Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

DAGRIS (Domestic Animals Generic Resources Information System). 2006. Domestic animals generic resources information system. In: J.E.O Rege, W. Ayalew, E. Getahun ,O. Hanotte and T. Dessie (eds.). International livestock Research Institute, Addis Ababa, Ethiopia.

Daskiran I., Askin, K. and Mehmet, B. 2006. Slaughter and carcass characteristics of Norduz male kids raised in either intensive or pasture conditions. *Pakistan Journal of Nutrition*. 5(3): 274-277.

Dawit Abate, Sisay Belete, Teklu Wegi, Sultan Usman, Wamatu, J. and Duncan, A. 2012. Characterization of the livestock production systems and the potential of feed-based interventions for improving livestock productivity in Sinana district, Bale Highland, Ethiopia. International Livestock Research Institute (ILRI), Nairobi, Kenya.

Dejene Alemu. 2010. The effect of feeding different proportions of maize stover and haricot bean (*phaseolus vulgaris*) haulms supplemented with concentrate mix on the performance of Hararghe highland Goats. MSc Thesis, Haramaya University, Haramaya. Ethiopia.

Demelash, Biffa., Yilma, Jobre. and Hassen, Chaka. 2006. Ovine helminthiasis, a major health constraint to productivity of sheep in Ethiopia. *Anim. health Res. Rev*., 7(1-2): 107-118.

Do Thi Thanh Van. 2001. Local feed resources in diets for small ruminants in Vietnam. MSc Thesis, Swedish University of Agricultural Sciences, Sweden.

Ebrahimi, R., Ahmadi, H.R., Zamri, M.T. and Rowghani, E. 2007. Effect of energy and protein levels on feedlot performance and carcass characteristics of Mehraban lambs. *Pakistan Journal of biological Science,* 15(10): 1679-1684.

Eiman, G.H., Amir, M.A.A. and Abdel, M.I.M. 2008. Effect of fermentation and particle size of wheat bran on the antinutritional factors and bread quality. *Pakistan Journal of Nutrition,* 7(4): 521-526.

Emebet Legesse. 2008. Supplementation of Blackhead Ogaden sheep fed haricot bean (*Phaseolus vulgaris*) haulms with mixtures of wheat bran and brewers dried grain:

Effects on feed utilization, live weight gain and carcass parameters. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

EPA (Ethiopian Privatization Agency). 2002. Investment and innovation policy review of Ethiopia. United Nations Conference on Trade and Development. United Nations, New York and Geneva.

Ermias Tekletsadik. 2008. The Effect of supplementation with barley bran, linseed meal, and their mixtures on the performance of Arsi Bale sheep fed a basal diet of faba bean haulms. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Eyob Gebregziaber. 2010. The effect of substitution of dry bamboo leaves at different proportions with concentrate mixture on feed intake, digestibility, live weight gain and carcass characteristics of local sheep fed *tef* straw. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

Fentie Bishaw. 2007. Effect of supplementation of hay with noug seed cake (*Guizotia abyssinica),* wheat bran and their mixtures on feed utilization, digestibility and live weight change in Farta Sheep. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Fleischer JE, Barnes AR, and Awubila B. 1989. Grain yield and nutritive value of crop residues from three varieties of maize *(Zea mays L.)* crop. PP. 239-255. In: Said AN, Dzowela BH (eds). Overcoming constraints to efficient utilization of agricultural by-products as animal feed. *Proceeding of 4th Annual Workshop held at the Institute of Animal Research*. Mankon Station, Bamenda, Cameroun, 20-27 October 1987, Africa Research Network for Agriculture By products (ARNAB). Addis Ababa, Ethiopia.

Gatenby, R.M. 2002. *Sheep. The tropical agriculturalist*, Macmillan, Oxford, UK.

Getahun Legesse. 2001. Growth pattern and carcass characteristics of Somali and Mid-rift Valley goats. MSc Thesis, Alemaya University, Haramaya, Ethiopia.

Getahun Kebede, 2006. Effect of urea treatment and leucaena (*leucaena leucocephala*) supplementation on the utilization of wheat straw by sheep. An MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

Hailu Dadi, Tatek Woldu and Tesfaye Lemma. 2005. Comparison of carcass characteristics of Borana and Arsi-Bale goats under different durations of feedlot management. *Livestock Research for Rural Development*, 17(12).

Hamid, P., Akbar, T., Hossein, J. and Ali, M.G. 2007. Nutrient digestibility and gas production of some tropical feeds used in ruminant diets estimated by the in vivo and in vitro gas production techniques. *American Journal of Animal and Veterinary Sciences, 2(4): 108-113.*

Hango, A., Mtenga, L.A., Kifaro, G.C., Safari, J., Mushi, D.E. and Muhikambele, V.R.M. 2007. A study on growth performance and carcass characteristics of small East African goats under different feeding regimes. *Livestock Research for Rural Development*, 19(9).

Hawthorne, W. 2006. Using pulse as forage crops. Pulse in Australia Bulletin, South Central. Australia.

Hosseini, S.M., Akbary, S.M., Maheri-Sis, N. and Aghsaghali, A.M. 2008. Effect of different energy levels of diet on feed efficiency, growth rate and carcass characteristics of fattening Bahmaei lambs. *Journal of Animal and Veterinary Advances,* 7(12): 1551-1554.

ILRI (International Livestock Research Institute). 2000. *Hand book of livestock statics for developing countries.* Socio-economic and policy research working paper 26. Nairobi, Kenya.

Jemberu Dissie. 2008. Effect of supplementation of Simada sheep with graded levels of concentrate meal on feed intake, digestibility and live weight parameters. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Kassahun Awgichew and Solomon Abegaz. 2008. Breeds of sheep and goats. pp. 5-26. In: Alemu Yami and Merkel, R.C. (eds.), *Sheep and goat production hand book for Ethiopia*. Ethiopian Sheep and Goat Productivity and Improvement Program (ESGPIP), Ethiopia.

Kellems, R.O. and Church, D.C. 1998. Livestock feeds and feeding, 4th edition, Prentice-Hall, Inc., New Jersey, USA.

Koralagama, K.D.N., Mouldi, F.L., Fernandez-Rivera, S. and Hanson, J. 2008. The effect of supplementing maize stover with cowpea (*Vigna unguiculata*) haulms on the intake and growth performance of Ethiopian sheep. *Cambridge Journal of Animal*, 2(6): 954-961.

Lanza, M., Priolo, A., Biondi, L., Bella, M. and Salem, H.B. 2001. Replacement of cereal grains by orange pulp and carob pulp in faba bean-based diets fed to lambs: effects on growth performance and meat quality. *Animal Research*, 50(1): 21–30.

Larbi A. and Olaloku, E.A. 2005. Influence of plane of nutrition on productivity of ruminants in the sub-humid zone of West Africa. pp.149-156. In: Ayantunde A.A., Fernández-Rivera S. and McCrabb G. (Eds). Coping with feed scarcity in smallholder livestock systems in developing countries. International Livestock Research Institute, Nairobi, Kenya.

Lemus, R. and Brown, K. 2008. Feeding small ruminants: developing a grazing system for sheep and goats.

Likawent Yeheyis, Aschalew Tsegahun, Yohannes Muchie and Seyoum Bediye. 2005. Growth performance of yearling Menz ram lambs fed on different pulse crop residues. pp. 229-232. In: Asfaw Yimegnuhal and Tamrat Degafa (eds.), *Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production*, 12-14 August 2004. Ethiopian Society of Animal Production, Addis Ababa, Ethiopia.

Liu, X., Wang, Z. and Lee, F. 2005. Influence of concentrate level on dry matter intake, N balance, nutrient digestibility, ruminal outflow rate and nutrient degradability in sheep. *Small Ruminant Research*, 58(1): 55-62.

Lonsdale, C. 1989. *Raw Materials for Animal Feed Compounders and Farmers. Straights.* (Book) Chalcombe publications, Great Britain.

López, S., Davies, D.R., Giraldez, F.J., Dhanoa, M.S., Dijkstra, J. and France, J. 2005. Assessment of nutritive value of cereal and legume straws based on chemical composition and in vitro digestibility. *Journal of the Science of Food and Agriculture*, 85(9): 1550-1557.

Lulseged Gebrhiwot and Jamal Mohammed. 1989. The potential of crop residues, particularly wheat straw, as livestock feed in Ethiopia. Institute of Agri. Research, Addis Ababa, Ethiopia.

Maghomp, O., Luc, D. and Early, R.J. 2000. Effect of dietary energy density on feed intake, body weight gain and carcass chemical composition of Omoni growing lambs. *Small Ruminant Research*, 37: 35-37.

Maleda Birhan and Takele Adugna. 2014. Livestock feed resources assessment, constraints and improvement strategies in Ethiopia. *Middle East Journal of Scientific Research*, 21(4): 618-704.

Markos Tibbo, Jan Phillips son and Worknesh Ayalew. 2006. Sustainable sheep breeding programmers in the Tropics: A Framework for Ethiopia conference on International Agricultural Research for Development, University of Bonn, 11-13, October 2006. Germeny.

McDonald, P.A., Edwarda, J.F., Greenhalgh, D. and Morgan, C.A. 2002. *Animal nutrition 6th edition.* Pearson Educational Limited, Edinburg, Great Britain.

McDowell, E.R. 1988. Importance of crop residues for feeding livestock in small holder farming systems. pp. 3-28. In: J.D. Reed, B.S. Capper and P.J.H. Neate (eds.), Plant breeding and the nutritive value of crop residues. *Proceeding of a Workshop Held in Addis Ababa, Ethiopia*, 7-10 December 1987, International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Meaza Abebe. 2012. Effect of supplementation with graded levels of mixtures of sesame seed *(Sesame indicum)* cake and wheat bran on feed intake, digestibility, live weight change and carcass characteristics of Tigray highland rams fed grass hay basal diet. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Melese Gashu. 2008. Effect of supplementation with noug seed cake, wheat bran and their mixture on feed intake, digestibility and live weight change of Washera sheep fed urea treated finger millet straw. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Menke, K. H., Raab, L., Salewski, A., Steingass, H., Fritz, D. and Schneider, W., 1979. The estimation of the digestibility and metabolizable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor. J. Agri. Sci., 93: 217–222.

Mesfin Tadesse. 2007. The influence of age and feeding regimen on the carcass traits of Arsi-Bale goats. *Livestock Research for Rural Development.* 19(4).

Mesganaw Addis. 2014. Effect of different proportions of field pea *(Pisum sativum L.)* hull and concentrate mixture supplementation on feed intake, digestibility, body weight change and carcass parameters of Washera sheep fed a basal diet of grass hay. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Metayer, N. 2004. *Vicia faba breeding for sustainable agriculture in Europe*. In: Gie Feverole (ed.).

Morrison, F.B. 1984. *Feed and feeding, 2nd edition.* A hand book for the student and stockman. CBS Publisher and Distributors, New Delhi, India.

Mulu Moges, Berhan Tamir and Alemu Yami. 2008. The effects of Supplementation of grass hay with different levels of Brewery dried grain on feed intake, digestibility and body weight gain in intact Wogera lambs. *East African Journal of Sciences*, 2(2) 105-110.

Niguse Gebru, 2011. Effects of supplementing *Euphorbia tirucalli*, *Acacia albida* pods and their mixtures on feed intake, body weight gain, digestibility and carcass characteristics of Abergelle goats fed on native hay basal diet. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Owen, E. and Jayasuriya, M.C.N. 1989. Use of crop residues as animal feeds in developing countries: a review. *Research and Development in Agriculture*, 6(3): 129-138.

Payne, W.J.A. 1990. *An introduction to animal husbandary in the tropics*. Long man scientific and technical. New York.

Perry, T.W., Cullison, A.E. and Lowrey, R. 2003. *Feeds and feeding, 6th edition*. Upper Saddler River, New Jersey.

Pinkerton, F. 2009. Factors affecting goat carcass yield and quality.

Pond, K.R., Church, C.D. and Pond, G. W. 1995. *Basic Animal Nutrition and Feeding, 4th edition.* Jornhn Wiley and Sons. New York.

Purchas, R. W. 1978. Some effects of nutrition and castration on meat production from sufflok cross lambs (Border licester-Romney cross). *New Zealand Journal of Agricultural Research*, 21(3): 367-376.

Rahman, Md. F. 2007a. Prediction of carcass weight from the body characteristics of Black Bengal Goats. *International journal of agriculture and biology,* 09(3): 431-434.

Rahman, Md. F. 2007b. Estimation of relationship between hot carcass weight and rib eye muscle area which effects on meat production of Black Bengal goats. *Pakistan Journal of Nutrition,* 6(1): 33-34.

Randall, D., Burggren, W. and Flench, K. 2002. *Animal physiology*. W.H. Freeman and Company, USA.

Ranjhan, S.K. 1999. *Animal Nutrition in the Tropics. 4th revised edition*, New Delhi, India.

Ranjhan, S.K. 2001. *Animal nutrition in the tropics, 5th revised edition.* Vikas Publishing House PLtd. New Delhi, India.

Reddy, D.V. 1997. The effect of supplementation of legume straw on utilization of rice straw-poultry droppings-rice bran-fish meal based diet in Buffaloes. *Animal Feed Science and Technology,* 69(4): 305-314.

Reed, J.D., Yilma Kebede and Fossel, L.K. 1986. Factors affecting the nutritive value of sorghum and millet crop residues. pp. 233-251. In: J.D. Reed, B.S. Capper and P.J.M. Neate (eds.), Plant breeding and the nutritive value of crop residues. Proceedings of ILCA, workshop held at Addis Ababa, Ethiopia.

Reharhie Mesfin, Yohannes Gojjam and Agajie Tesfaye. 2003. Milk yield and economic evaluation of two concentrate feed to crossbred Boran X Friesian (BF) and Boran Jersey (BJ) dairy cows at Holetta Research Center. pp: 347-354. *In:* Yilma Jobre and Getachew Gebru (eds.), *proceeding of the 10th Annual Conference of Ethiopian Society of Animal Production (ESAP)*. 21-23 August 2003. Ethiopian Society of Animal Production, Addis Ababa, Ethiopia.

Riley, R.R., Savell, J.W., Shelton, M. and Smith, G.C. 1989. Carcass and offal yields of sheep and goats as influenced by market class and breed. *Small Ruminant Research, 2(3): 265-272.*

Ryan, S.M., Unruh, J.A., Corrigen, M.E., Drouillard, J.S. and Seyfert, M. 2007. Effects of concentrate level on carcass traits of Boer crossbred goats. *Small Ruminant Research,* 73(1-3): 67-76.

SARC (Sinana Agricultural Research Center). 2014. Information bulletin on major achievements. Bale, Ethiopia.

Savadogo M., Zemmelinkb, G. and Nianogo, A.J. 2000. Effect of selective consumption on voluntary intake and digestibility of sorghum (*Sorghum bicolor L.* Moench) stover, cowpea (*Vigna unguiculata L*. Walp.) and groundnut (*Arachis hypogaea L*.) haulms by sheep. *Animal Feed Science and Technology, 84: 265-277.*

Sayed, A.B.N. 2009. Effect of different dietary energy levels on the performance and nutrient digestibility of lambs. *Veterinary World*, 2(11): 418-420.

Seyoum Bedeye, Getenet Assefa, Abate Tedla and Dereje Fikadu. 2001. Present status and future direction in feed resources and nutrition research targeted for wheat based crop livestock production system in Ethiopia: pp: 207-226. In P.C. Wall (ed.). Wheat and weed: food and feed. *Proceeding of two –stockholder workshop.* CIMMYT, Mexico City.

Seyoum Bediye, Zinash Sileshi and Dereje Fekadu. 2007. Composition and nutritive value of Ethiopian feedstuff, research report no.73. pp. 9-19. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia.

SAS (Stastical Analysis System), 2002. Statistical Analysis System, version 9, Institute, Inc., Cary, NC, USA.

Silva, A. and Ørskov, E.R. 1985. Effect of unmolassed sugar beet pulp on the rate of straw degradation in the rumen of sheep given barley straw. *Journal of Animal Production*, 48: 99-108.

Simachew Gashu. 2008. Effects of supplementation with maize bran, "*noug*" seed (*Guizotia abyssinica*) cake and their mixtures on feed utilization and carcass characteristics of Washera sheep fed hay. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Singh, G.P. and Oosting, S.J. 1992. A Model for Describing the Energy Value of Straws. Indian Dairyman XLIV, 44: 322-327.

Sisay Tilahun, Pravee Vijchulata, Pornsri Chairatanoyuth and Suwapong Swasdiphanich. 2007. Effects of natural mineral soils on body weight and liver minerals of Black head Somali sheep in Ethiopia. Kasetsart J., 41:288-299.

Solomon Bogale, Solomon Melaku and Alemu Yami. 2008. Potential use of crop residues as livestock feed resources under conditions of smallholder farmers in Bale highlands of Ethiopia. *Tropical and sub-tropical Agro-ecosystems,* 8(1): 107-114.

Solomon Bogale, Solomon Melaku and AlemuYami. 2009. The Interdependence of Crop Livestock Production Sectors: The Case of Sinana Dinsho District in Bale Highlands of Ethiopia. *Tropical and Subtropical Agro ecosystems*, 42(2): 65-71.

Solomon Bogale. 2004. Assessment of livestock production system and feed resource base in Sinana-Dinsho district of Bale highlands Southeast Oromia. MSc Thesis, Alemaya University, Alemaya, Ethiopia.

Solomon Gizaw, Alemu Yami, Kassahun Awgichew, Gipson, T.A. and Merkel, R.C. 2009. Sheep breeds of Ethiopia: A guide for identification and utilization. Technical Bulletin No. 28. Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP).

Solomon Gizaw, Azage Tegene, Birhanu Gebremedhin and Hockstra, D. 2010. Sheep and goat production and marketing system in Ethiopia; characteristics and strategies for improvement. IPMS/ILRI, Addid Ababa, Ethiopia.

Stanton, T.L. and LeValley, S.B. 2008. *Feed composition for cattle and sheep*. Colorado State University, U.S. Department of Agriculture and Colorado counties cooperating. Extension program.

Susan Schoenian. 2003. *Introduction to feeding small ruminants.* Area Agent, sheep and goats. Western Maryland Research and Education Center. Maryland Cooprative Extension.

Takele Feyera. 2010. Growth performance and carcass characteristics of Horro lambs fed vetch (*Lathyrus sativus*) haulm supplemented with *Acacia albida* leaf meal, wheat bran and their mixtures. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Takele Kumsa, Gemeda Duguma, Fikru Terefe, Ulfina Galmessa and Yohannes Gojjam. 2006. Study on sexual and fattening performance of partially castrated Horro rams. *Ethiopian Journal of Animal Production, 6(2): 29-36.*

Teferawork Beyene. 1989. Performance of Arsi and crossbred sheep in the highland of Arsi Oromia Region, Ethiopia. MSc Thesis, Swedish University, Sweden.

Tembely, S. 1998. Small ruminant production in Ethiopia: prospects for improving productivity. In: *Proceedings of the 5th National Conference of the Ethiopian Society of Animal Production (ESAP),* 15-17 May 1997. Ethiopian Society of Animal Production, Addis Ababa, Ethiopia.

Tesfaye Hagos and Solomon Melaku. 2008. Feed intake, digestibility, body Wight and carcass parameter of Afar rams fed *tef* (*Eragrostics tef*) straw supplemented with graded levels of concentrate mixtures. *Tropical Animals Health and Production*, Springer Netherlands, 41(4): 599-606.

Tesfaye Kebede, Tesfaye Lemma, Estifanos Tadesse and Mieso Gurmu. 2008. Effect of level of substitution of sweat potato (*Ipomoea batata L*.) vines for concentrate on body weight gain and carcass characteristics of browsing Arsi Bale goats. *Journal of Cell and Animal Biology*, 2(2): 36-42.

Tesfaye Getachew, Aynalem Haile, Markos Tibbo, Sharma, A.K., Sölkner, J. and Wurzinger, M. 2010. Herd management and breeding practices of sheep owners in a mixed crop-livestock and a pastoral system of Ethiopia. *Afr. J. Agric. Res.,* 5(8): 685-691.

Tesfaye Kebede, Tesfaye Lemma, Hunduma Dinka, Mieso Guru and Amsalu Sisay. 2008. Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages. *Journal of Cell and Animal Biology*, 2(11): 187-194.

Tesfaye Negewo. 2008. Effect of supplementation with graded levels of wheat bran and *"noug"* seed cake mixtures on feed utilization of Arsi-Bale sheep fed urea treated maize cob basal diet. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Topps, J.H. 1995. Forage legumes as protein supplements to poor quality diets in the semiarid tropics. pp: 183-190. In: Wallace R.J. and Lahlou-Kassi A. (eds), *Rumen Ecology Research Planning*, International Livestock Research Institute (ILRI), Nairobi, Kenya.

Van Soest, P.J. 1994. *Nutritional Ecology of Ruminants, 2nd ed*ition. Cornell University press. London.

Van Soest, P.J. and Robertson, B.J. 1985. Analysis of Forage and Fibrous Feeds. A laboratory manual for animal science 613. Cornell University, Ithaca, New York, USA.

Warriss, P.D. 2000. *Meat Science*. *An Introductory Text.* CABI Publishing. Biddles ltd, King's Lynn. UK.

Wondesn Alemu. 2008. Effects of supplementing hay from natural pasture with oil seed cakes on feed intake, digestibility and body weight change of Sidama goats. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Yenesew Abebe. 2010. Assessment of small ruminant production systems and on farm evaluations of urea treated wheat straws and concentrate feeding on sheep body weight change in Burie Woreda, West Gojam. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Yetimwork Gebrmeskel. 2005. Effect of varietal differences on dry matter yield, chemical composition and quality of field pea (*Pisum sativum)* and faba bean (*Vicia faba L.)* straw. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

7. APPENDIX

Appendix Table 1. Summary of analysis of variance for grain and straw yield, straws to grain ratio and harvest index for the five varieties of faba bean used for the trial

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
Grain yield	145	0.877	10.9	12.44	0.0001	***
Straw yield	145	0.794	14.19	17.88	0.0001	***
Crop residue to grain ratio	145	0.084	0.543	6.44	0.0001	***
Harvest index	145	27.375	242.864	8.87	0.0001	***

DF= degree of freedom; EMS=error mean square; P= probability; SL=significance level; TMS=treatment mean square.

Appendix Table 2. Summary of analysis of variance for dry matter and nutrient intake of Arsi Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
DM intake	28	1796.2	11336.3	6.31	0.0009	***
DM intake (%BW)	28	0.024	0.064	2.67	0.0545	*
DM intake (g/kgW$^{0.75}$)	28	10.7	39	3.64	0.0162	**
OM intake	28	1556	8876.2	5.7	0.0017	***
CP intake	28	5.1	103.6	20.31	0.0001	***
ME intake	28	0.11	2.18	19.81	0.0001	***
Ash intake	28	8.9	312.1	35.1	0.0001	***
NDF intake	28	1159.7	3978.1	3.43	0.0211	*
ADF intake	28	812.6	1985.4	2.44	0.0699	*
ADL intake	28	33.3	109.9	3.30	0.0244	*

ADF=acid detergent fiber; ADL=acid detergent lignin; CP=crude protein; DF= degree of freedom; EMS=error mean square; ME=metabolizable energy; NDF=neutral detergent fiber; OM=organic matter; SL=significance level; TMS=treatment mean square.

Appendix Table 3. Summary of analysis of variance for percent of dry matter and nutrient digestibility for Arsi Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	DF	EMS	TMS	F-value	P	SL
DM	28	27.2	61	2.25	0.0893	*
OM	28	55.6	94.3	1.7	0.0789	*
CP	28	48.8	261.4	5.35	0.00025	***
NDF	28	15.2	10.9	0.27	0.5863	ns
ADF	28	54.1	69.6	1.29	0.2986	ns

ADF=acid detergent fiber; CP=crude protein; DF=degree of freedom; DM=dry matter; EMS=error mean square; NDF=neutral detergent fiber; ns=non-significant; OM=organic matter; SL=significance level; TMS=treatment mean square.

Appendix Table 4. Summary of analysis of variance for body weight measurements for Arsi Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	DF	EMS	TMS	F-value	P	SL
IBW	28	0.08	0.018	2.09	0.1085	ns
FBW	28	1.56	6.59	4.23	0.0084	***
BWC	28	1.6	6.8	4.22	0.0085	***
ADG	28	198.9	838.9	4.22	0.0085	***
ADG(g/kg$W^{0.75}$)	28	1.35	5.2	3.86	0.0127	**
FCE	28	0.0003	0.001	3.34	0.0235	*

ADG=average daily gain; BWC=body weight change; DF=degree of freedom; EMS=error mean square; FBW=final body weight; FCE=feed conversion efficiency; IBW=initial body weight; ns=non-significant; SL=significance level; TMS=treatment mean square.

Appendix Table 5. Summary of analysis of variance for carcass characteristics for Arsi Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
SBW	12	1.25	3.32	2.65	0.0858	*
HCW	12	0.22	0.16	0.72	0.602	ns
CCW	12	0.21	0.21	0.98	0.4566	ns
EBW	12	1.36	3.16	2.32	0.0167	*
Dressing percentage on	12					
SBW	12	4.59	4.4	0.96	0.4641	ns
EBW	12	7.71	11.81	1.53	0.255	ns
FT	12	0.009	0.024	2.45	0.0633	*
REA	12	1.6	0.57	0.36	0.834	ns

CCW=chilled carcass weight; DF=degree of freedom; EBW=empty body weight; EMS=error mean square; FT=fat thickness; HCW=hot carcass weight; ns=non-significant; REA=rib eye area; SBW=slaughter body weight; SL=significance level; TMS=treatment mean square.

Appendix Table 6. Summary of analysis of variance for edible offal components for Arsi-Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
Blood	12	7324.7	9845.2	1.34	0.3098	ns
Liver	12	427.4	565.6	1.32	0.3167	ns
Kidney	12	30.3	61.9	2.04	0.0522	*
Heart	12	61	65.9	1.08	0.4088	ns
Tongue	12	105.1	98.7	0.94	0.4742	ns
Ret-rum	12	12659.4	6909.7	0.55	0.7056	ns
Om-ab	12	281820.9	151707	0.54	0.7106	ns
Empty gut	12	2802	20387.1	7.28	0.0032	ns
SI	12	37116.7	24218.3	0.65	0.6361	ns
LI	12	17677.2	24395.5	1.38	0.0984	*
Testicles	12	6221.6	10370.5	1.67	0.0218	*
Tail	12	22038.4	10163.2	0.46	0.763	ns
Kidney fat	12	706.8	148.8	0.21	0.9276	ns
Heart fat	12	97.4	123.3	1.27	0.3363	ns
Omental fat	12	630.4	150.6	0.24	0.9109	ns
Scrotal fat	12	85.9	66	0.77	0.5658	ns
Pelvic fat	12	54.9	93.6	1.71	0.2133	ns
TEOC	12	0.56	0.2	0.36	0.8298	ns

DF=degree of freedom; EMS=error mean square; LI=large intestine; ns=non-significant; Om-ab=omasum-abomasum; Ret-rum=retculo rumen; SI=small intestine; SL=significance level; TEOC=total edible offal component; TMS=treatment mean square.

Appendix Table 7. Summary of analysis of variance for non-edible offal components for Arsi-Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
HCW	12	25103.4	5604.5	0.22	0.9202	ns
Skin	12	68896.1	82046.7	1.19	0.364	ns
Lung with trachea	12	3699.6	7159.7	1.94	0.0691	*
Pancreas	12	14.2	10.1	0.71	0.5994	ns
Spleen	12	30.1	140.7	4.68	0.0166	**
Bladder	12	33.9	9	0.27	0.8942	ns
Gall bladder	12	44.3	8.5	0.19	0.9383	ns
Full gut	12	376426.4	188036.8	0.5	0.7368	ns
Penis	12	62.5	62.3	1.00	0.4464	ns
FWH	12	1345.7	19.36.8	1.44	0.2805	ns
TNEOC	12	0.67	0.5	0.76	0.5706	ns

DF=degree of freedom; EMS=error mean square; FWH=feet with hooves; HCW=head without tongue; ns=non-significant; SL=significance level; TMS=treatment mean square; TNEOC=total non-edible offal component.

Appendix Table 8. Summary of analysis of variance for the five primal cuts of carcass components for Arsi Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
Leg total	12	9281.5	13361.6	1.44	0.2804	ns
Bone	12	2054.1	2012.1	0.98	0.4546	ns
Muscle	12	3893	3876.6	1.00	0.4469	ns
Fat	12	1381.8	1243.9	0.90	0.4939	ns
Loin total	12	4171.6	3101.4	0.74	0.5806	ns
Bone	12	1802.7	4423.4	2.45	0.0625	*
Muscle	12	5259.8	4345.2	0.83	0.5334	ns
Fat	12	690.2	507.8	0.74	0.5851	ns
Rack total	12	5603.8	2091.6	0.37	0.8233	ns
Bone	12	1352.9	673.1	0.5	0.7382	ns
Muscle	12	2272.1	1271.6	0.56	0.6964	ns
Fat	12	862.2	604.3	0.7	0.6061	ns
Breast and shoulder total	12	2517.2	3075.1	1.22	0.3524	ns
Bone	12	259.8	581	2.24	0.026	*
Muscle	12	1414.4	1512.4	1.07	0.4137	ns
Fat	12	362.6	428.3	1.18	0.3677	ns
Shoulder and neck total	12	20734.6	11759.6	0.57	0.6914	ns
Bone	12	2499.4	2016.9	0.81	0.544	ns
Muscle	12	11975.9	6739.3	0.56	0.6943	ns
Fat	12	632	356.1	0.56	0.6939	ns

DF=degree of freedom; EMS=error mean square; ns=non-significant; SL=significance level. TMS=treatment mean square.

Appendix Table 9. Summary of analysis of variance for mean tissue and proportions of the five primal cut carcass components for Arsi Bale sheep fed different faba bean straws with concentrate mixture.

Parameters	**DF**	**EMS**	**TMS**	**F-value**	**P**	**SL**
Muscle, kg	12	0.048	0.013	0.28	0.8869	ns
%	12	11.5	7.1	0.61	0.6602	ns
Bone, kg	12	0.009	0.005	0.55	0.7005	ns
%	12	12.2	6.1	0.5	0.7364	ns
Fat, kg	12	0.007	0.009	1.26	0.3401	ns
%	12	4.6	6.8	1.49	0.2669	ns

DF=degree of freedom; EMS=error mean square; ns=non-significant; SL=significance level. TMS=treatment mean square.