EVALUATION OF NUTRIENT UTILIZATION AND ECONOMIC FEASEABILITY OF BONGA SHEEP AND KAFFA GOAT BREEDS SUPPLEMENTED WITH MIXES OF TANNIN RICH TREE LEAVES WITH OR WITHOUT POLYETHYLENE GLYCOL

MSc. Thesis

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Chairperson, DGC signature Date

DEDICATION

This Thesis Dedicated to my father **Yosefe Wodebo** and my mother **Abebech Anore** for nursing me with affection as well as to all my brothers and sister for their dedicated partnership in the success of my life.

STATEMENT OF THE AUTHOUR

First, I declare that this Thesis is my bona fide work and that all sources of materials used for this Thesis have been duly acknowledged. This Thesis has been submitted in partial fulfillment of the requirements for M.Sc degree at Jimma University and is reserved at the University library to be made available to borrowers under rules and regulations of the library. I solemnly declare that this Thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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BIOGRAPHICAL SKETCH

The author, Kibreab Yosefe Wodebo, was born on December 19, 1985 G.C in Kembata Tembaro Zone,South Nation, Nationality and Peoples Regin of Ethiopia. He attended his elementary education at Ambaricho as well as Mudula St.Geberel School. Eary Secondary School Education at Hawassa St.Daniel Comboni School and Preparatory Education at Hawassa SOS Herman Geminer until 1999 E.C. Right after completion of secondary education, successfully passing the Ethiopian School Leaving Certificate Examination(ESLCE), he joined Samara University and completed B.Sc. degree in Animal Science in 2002 E.C.

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LIST OF ABBREVATIONS

ADF	Acid detergent fiber
ADFD	Acid detergent fiber digestibility
ADFI	Acid detergent fiber intake
ADG	Average daily gain
AM	Ante meridian
AOAC	Association of analytical chemist
AS	Albizia schimperiana
BW	Body weight
C	Carbon
CIMMYT	International Maize and Wheat Improvement Centre
CP	Crude protein
CPD	Crude protein digestibility
CPI	Crude protein Intake
CT	Condensed tannin
DM	Dry matter
DMI	Dry matter intake
DNA	Deoxyribonucleic acid
EAA	Essential amino acids
EE	Ether extract
EED	Ether extract digestibility
EEI	Ether extract intake
ESGPIP	Ethiopia sheep and goat prodactivity improvement program
ETB	Ethiopian Birr
FAO	Food and agrecaltural organization
FCR	Feed conversion rate
FO	Ficus ovate
G	Goat
GIT	Gastrointestinal tract
GR	Gross return
H	Hydrogen
Ha	Hectare
HCL	Hydrochloric acid
HT	Hydrolysable tannin
IFAD	International fund for agricultural development
ILCA	International livestock center for Africa

LIST OF ABBREVATIONS(*continued*)

ILRI	International livestock reaserch inistitute
IVDMD	Invitro dry matter digestibility
LWG	Live weight gain
MEI	Metabolizable energy intake
MoA	Ministry of agriculture
MPTs	Malti purpose tree species
MRR	Marginal rate of return
MW	Molecular weight
N	Nitrogen
NDF	Neutral detergent fiber
NDFD	Neutral detergent fiber digestibility
NDFI	Neutral detergent fiber intake
NI	Net income
NRC	National research council
O	Oxygen
OM	Organic matter
OMD	Organic matter digestibility
OMI	Organic matter intake
P	Period
PBA	Partial budget analisis
PEG	Polyethylene glycol
PER	Protein efficiency ratio
PROC	Procedure
PSCs	Plant secondary compounds
PSMs	Plants secondary metabolites
S	Sheep
SAS	Statistical Analysis System
SE	Standard Error
SNNPR	Southern Nations Nationalities and Peoples Region
T	Treatment
TR	Total return
TRP	Tannin rich plants
TVC	Total variable cost
V	Volume
Wt	Weight

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ABSTRACT

The study was conducted to evaluate the effects of dietary inclusion of leaves of the condensed tannin-rich trees(Albizia schimperiana (AS)and Ficus ovata (FO)) in grass-based hay with or without polyethylene glycol (PEG (4000 & 6000)) on nutrient intake and digestibility, weight change, feed conversion and economic efficiency of 8 intact male Bonga sheep and 8 kaffa goats(12±0.46 months old, weighing initially 22.2±2.9 kg and 23.1±1.5kg (mean ±SE) respectively). Experimental animals randomly assigned to 4 dietary treatment groups sequentially in separate periods. The experiment was arranged with four treatments in a 4 × 4 randomized crossover design. A 15-day adaptation and 7-day data collection conducted for each treatment. The dietary treatments consisted of grass based hay alone (=T_4, control); AS (36%) +FO (9%) +control diet (55%)=T_3; T_3+PEG_{6000} (=T_2); T_3 +PEG_{4000} (=T_1). Animals were individually fed at 50g DM/kg live weight and had free access to clean drinking water and mineralized salt licks. Nutrient intake and Apparent digestibility coefficients were determined for dry matter (DM), crude protein (CP), crude fat (EE) acid detergent fiber (ADF) and neutral detergent fiber (NDF). Partial budget analysis was conducted after the end of each period. Condensed tannin contents of AS and FO were 110 and 191 g/kg DM, respectively. Nutrient intake was higher ($P<0.001$) in goats than sheep. Sheep and goats in the control treatment lost BW (2.2 & 2.1 g/day), while in T_2 supplemention they gained 37g/day & 41g/dayBW , respectively ($p<0.001$). The feed DM intake of sheep ranges (625-960 g/d), goats (631-976 g/d) where as apparent digestibility of sheep (46-65 %), goats(48-67%) while FCR goats were significantly higher ($P<0.01$) than sheep. The improvement in nutrient intake, digestibility, weight gain, feed conversion rate and profitability after PEG supplementation emphasizes the negative effect of CTs on feed utilization. Feeding local grass hay would be inadequate as the sole source of nutrients for Bonga sheep and Kffa goats. For each Ethiopian birr invested on test browse feeds with T_2, farmers would have to obtain additional 2.3211±0.42 and 1.7038±0.63 ETB from Kaffa goat and Bonga sheep respectively .The control treatment resulted in a negative return while high level of tannin source supplementation with PEG_{6000} (T_2) resulted in the best return (2.32 ETB/Kaffa goat & 1.7ETB/Bonga sheep). 36% AS + 9% FO + PEG_{6000} supplementation could maintain the optimum utilization of the grass based hays for sheep and goats. The overall improvement in nutrient utilization, weight gain and feed conversion was more pronounced for goats with or without PEG suggested that goats could be able to utilize tannin rich diets. Bonga sheep could only be efficiently use mixes of tannin rich diets either as maintenance or production ration with the presence of tannin binding agents such as PEG.In general Bonga sheep and Kaffa goats would need to be appropriately supplemented to achieve profitable production.

Keywords*: Albizia schimperiana; Bonga sheep; Digestibility; Economic feasibility; Ficus ovata; Kaffa goat; Polyethylene glycol; Taninnin*

1. INTRODUCTION

Inadequate feed supply (in quality, quantity and seasonality) is a major constraint of ruminant livestock production in Sub-Saharan African countries (Arigbede *et al*., 2011; IFAD, 2008). In Sub-Saharan Africa, the dominant feeding systems for sheep and goat are based on grazing pastures, after math and road sides (Alemayehu, 2006;Arigbede *et al*., 2011; Berhanu *et al*., 2013) and crop-byproducts.However, during the usually extended dry seasons, the grasses, crop residues and agro-industrial by-products are usually fibrous, low in digestibility and devoid of most essential nutrients including fermentable nitrogen, digestible by-pass protein, minerals and vitamins which are required for increased rumen microbial fermentation and improved performance of the host animal (Abate *et al.*,2001). They often contain below the minimum metabolizable energy content regarded as being useful (McDonald *et al.*, 2002). Animals resultantly suffer weight losses, lower birth weights, lower resistance to diseases, and invariably, reduced reproductive and productive performances (Bamikole and Babayemi, 2004).

One potential way for increasing the quality and availability of feeds for smallholders' ruminant animals in the dry season may be through the use of foliages of various locally available multipurpose trees and shrubs (MPTS) (Devendra and Thomas , 2002).MPTS are of paramount importance in animal production because they can provide significant protein supplements, but unfortunately the amounts of tannins that they contain vary widely and largely unpredictable (Somasiri *et al*., 2010). Tannin have an ecological function of plant protection from the attack of pathogens and consumption by herbivores(Makkar; 2003; Hagerman, 2011). In ruminant nutrition, it has been shown that the levels of tannins present in food items represent a major component of food choice (Glenn, 2005).

The inverse relation between high tannin levels in forage and palatability, voluntary intake, digestibility and nitrogen retention has long been established in several herbivores (Krebs *et* *al*., 2007). Reduced palatability, low evacuation rate of the digested material out of the rumen and toxicity are factors that were considered as an explanation for the negative effects of tannins on ruminants feed intake (Makkar, 2003; Frutos *et al*., 2004). However, several ruminant species seem to tolerate (or even prefer) considerable amounts of tannins in their diets (Clauss *et al*., 2003, 2005). However, tannin coping strategies varies among different classes of animals as well as times of exposure to tanniferous diet (Clauss *et al*., 2005; Yisehak *et al*., 2011b, 2012).

The effects of tannin on animals range from beneficial to toxicity and death (Silanikove *et al*., 2001; Hagerman *et al*.,2010; Lamy *et al*., 2011). Tannins have dose-dependent negative nutritional effects on Livestock consuming tannin rich diets (Mueller-Harvey, 2006, Garry,2008). Thus, the first step in the targeted use of shrubs and trees as feed resource is the analysis of their nutritive value, and identification of environmental factors that may affect their nutritive value (Afework, 2012; Belachew *et al*., 2013). With a better understanding of tannin properties and proper management, they could become an invaluable source of protein for strategic supplementation. As the demand for food rises, tanniferous plants must play an increasingly important part in the diet of animals, in particular for ruminants in smallholder subsistence farming in developing countries (Babayemi *et al*., 2004; Frutos *et al*.,2004;Biruk, 2012).

A variety of MPTS are growing in the Gilgel Gibe basins of Ethiopia, mainly due to the suitability of the environment and the need to use them as fuel wood, construction, mulch, traditional human and veterinary medicine, environmental conservation and shade for cash crops(Aynalem and Taye, 2008; Yisehak *et al*., 2010;Yisehak and Belay, 2011). *A. schimperiana* and *Ficus ovata* are a tropical multipurpose tree indigenous to Ethiopia (Lemmens, 2007; Hyde *et al.*,2014) and are widely abundant in the tropical Africa, containing high amount of protein(> 150 g CP/kg DM ,Yishak and Geert, 2013) and condensed tannin (>100 g CT/kg DM) which is well known to affect the efficiency of nutrient digestion in farm animals (Yisehak and Belay, 2011a).

The variations in feeding behavior, even for the same species, is not surprising and could be accounted to the high level of genetic diversity among the different breeds of goats (Pereira *et al.*, 2005) and sheep (Pereira *et al*., 2006) and the vast range of ecosystems they dwel (Yisehak *et al.,* 2011a). Whatever the classification, there is a general consensus in considering that goats eat proportionally more browsing material than sheep. Goats usually have the capacity of adapting their ingestive behavior to food items available, and select diet compounds in order to maintain the nutrients and plant secondary metabolites proportions relatively constant throughout the year (Salem A.Z.M *et al*., 2004, Kharrat and Bocquier, 2010).

Previous studies have demonstrated acute changes in nutrient utilization in response to the level of tannin rich diets in sheep (Biruk, 2012) and Zebu cattle (Yisehak *et al*., 2013). Despite the acute nature of these changes, a substantial amount of concentration and tannin type is required to achieve steady-state in relation to tannin rich diet following alterations in feed intake, digestibility,weight changes and feed conversion efficiency. Moreover, under natural grazing and browsing conditions animals are exposed to several tannin sources. Thus, offering mixed types of tannin sources with or without PEG could give clear picture for evaluating feeding value of feed sources at the time of trial. Chemicals such as Polethylene glycol known to make strong complexes with dietery CTs, alowing dietary ingredients to be digested and utilized more efficiently. It is a noon toxic,water soluble polymer widely used in nutrition, medicine and cosmetics (Makkara,2003; Frutos *et al*.,2004).

This study is the first to compare the effect of two different tannin sources in grazers (sheep) and intermediate feeders (goats) with or without PEG on economic feasibility and nutrient utilization performances.

As the inclusion rate of PEG in sheep and goats diet is too small (40 mg PEG/ kg CT on DM basis), it will mostly be appropriate for smallholder farmers to use it. For instance in sheep and goats feeding experiment, in general, the increased growth of sheep and goats fed grass-based diets after dietary inclusion of *A. schimperiana* and *F. ovata* leaves (rich in CT and CP) could motivate smallholder farmers.

The general objective of this study is to develop a feeding protocol for local sheep and goat breeds based on foliages of *Albizia schimperiana* and *F. ovata* which could also apply for other sheep and goat breeds in the tropics .The specific objectives were;-

1. To evaluate the effects of dietery inclusion of leaves of condenced tannin rich trees with or without polyethylene glycol (PEG) on nutrient intake,digestibility,weight gain change and feed conversion ratio in Bonga sheep and Kaffa goat.
2. To evaluate the economic feasibility of supplementing tannin rich feed resources in bonga sheep and kaffa goat.

2. LITERATURE REVIEW

2.1. Potential Feed Resources for Sheep and Goats in Ethiopia

2.1.1. Natural pasture

Natural pastures are composed of grasses (Poaceae), legumes (Fabaceae), sedges (Cyperaceae), and other heterogenous plants in various families, which could be herbaceous or woody forms (McIllroy, 1972). The first two plant groups; grasses and legumes, make up the bulk of the herbage that are valuable as animal feed (Pamo and Piper, 2000).

In most areas of sub-Saharan Africa, the major even the sole feed source available for large parts of the year in smallholder production systems are natural pastures (Smith, 1992; Gylswyk, 1995). However, natural pastures mostly suffer from seasonally spells of dry periods during which they drop in quality, which is characterized by high fiber content, low digestibility and very low protein and energy content (Ndlovu, 1992;Topps, 1995).

In Ethiopia, it has been estimated that more than 90 percent of livestock feed requirement is provided by natural pastures, which consist of a wide range of grasses, legumes and other herbaceous species (Lulseged, 1985). The yield as well as quality of pasture is very low due to poor management and over stocking. Natural pastures would be adequate for live weight maintenance and weight gain during wet seasons, but would not support maintenance for the rest of the year (Zinash *et al*., 1995). The productivity from grazing land is insufficient in both quantity and quality for optimal livestock growth and production. Studies indicated that poor production of grazing lands and large herd size on small farmlands caused overgrazing of natural pasturelands resulting in serious land degradation. Consequently, soil fertility declines causing lowered dry matter yields from the natural pasturelands. Moreover, prolonged harvesting time impairs the quality of native hay (Varvikko, 1991; Gashaw, 1992).

Low CP and high cell wall content of natural pasture hay is a critical nutritional limitation to its potential intake and utilization by meat goats which can be ameliorated by complementary supplementation (Kato *et al.*, 2013). Nationally, this ranges from 1 to 3 ton DM/ha, occasionally yields peak to 4 to 6 tons DM/ha (Alemayehu, 2003).

Due to a rapid increase in human population and increasing demand for food, grazing lands are steadily shrinking due to the conversion of prime grazing lands to crop lands, and are restricted to areas that have little value or farming potential such as hill tops, swampy areas and roadsides (Tsigewoini, 1997).Animals depend mainly on natural pastures for their feed requirements. Natural pastures, which provide more than 90% of the livestock feed, are generally very poorly managed (Alemu, 1998).

2.1.2. Crop residues and agro-industrial by-products

Feed resources of sheep and goats are derived from herbaceous forages, trees and shrubs, food crop residues, crop green feeds, crop roots and tubers, concentrates and agro-industrial by-products, mineral supplements, and others (Tolera *et al*., 2012). The use of crop residue is limited by its poor digestibility and low feeding value due to low nitrogen(2.5 to 6%), deficiency in some minerals and vitamins, and disproportionately high lingo-cellulose content(Khilberg, 1972).Agro-industrial by-products produced in Ethiopia include by-products from flour milling, sugar factory, oil processing factories, abattoir, and breweries. These products are mainly used for dairy, fattening and commercial poultry production and the scope for their wider use by smallholder producers is low due to availability and price (Mekasha *et al*., 2003).

Improved pasture and forages have been grown and used in government ranches, state farms, farmer's demonstration plots and dairy and fattening areas. Forage crops are commonly grown for feeding dairy cattle with oats and vetch mixtures, fodder beet, elephant grass mixed with *siratro* and *desmodium* species,*rhodes/lucerne* mixture, *phalaris/trifolium* mixture, hedgerows of sesbania, leucaena and tree-lucerne being common ones (MoA,1997; Alemayehu,2003). Due to unprecedented population increase, land scarcity and crop dominated farming, there has been limited introduction of improved pasture and forages to smallholder farming communities and the adoption of this technology by smallholder mixed farmers has been generally slow (Mekoya *et al*., 2008).

2.1.3. Multi purpose tree species (MPTS)

2.1.3.1. Availability and feeding value of MPTS

Young shoots, twigs, fruits/pods and leaves of MPTS are suitable for sheep and goats to eat. They provide protein, vitamins and mineral elements, which are lacking in grasslands pastures during the dry and/or cold season and serve as standing feed reserves to be built up, so that herds are able to survive critical periods of rainfall shortage (El-Hassan *et al*., 2000). In Ethiopia there are 179 browse species from 51 genera, which is not exhaustive, of which 51 species from 31 genera are recorded as promising browse species. Currently 185 accessions from 41 species and 18 genera are systematically collected and conserved by ILRI (Alemayehu, 2006).

Browse foliage is claimed to have a great potential as protein supplements to graminaceous fodder and crop by-products containing low protein and fermentable energy levels (El-Hassan *et al*., 2000). According to Ammar *et al*. (2011), IVDMD on browses has positively correlation with the crude protein content, where as a negative relationship with the ADF and lignin contents. Lignin and tannin seem to be the main constraints of digestibility of browse plant species (Ouédraogo, 2008; Njidda *et al*., 2010 ; Ammar *et al*, .2011).

Shortage of supply and poor quality of feed on dry season fodder as the biggest problem facing small-scale farmers, but it is often marginal in economic terms and may involve unsustainable land use practices (overall poor management) causing erosion on sub-humid hillsides so that creates a further problem of acid infertile soils in large areas of the tropics (Tuwei *et al*, .2006).

There are many factors (Plant and animal, (Isaac *et al*., 2008) that affect feed intake of small ruminants, of which smell is often the most important, according to recent concepts, voluntary feed intake of ruminants is best understood as an outcome of the interaction between taste and postingestive feedback.Research held by Isaac *et al*., 2008 on five browse species revealed that goats had higher intakes of all the browse foliages than sheep. When feed intake in response to an increase in demand for energy or protein or both is influenced by physiological state, feeding centers of the hypothalamus, Palatability and unpalatability, effects of exercise on feed intake, animal genotype, rumen distension and nutrient imbalance, fatigue , acetate clearance and feed intake control **.**

Study taken on condensed tannin concenteration measured either by vanillin-HCl or butanol-HCl method on tropical browse legumes there is poor correlation between nitrogen digestibility and total condensed tannin content(Jong *et al*.,1989) . Although the digestive tract of goats is anatomically similar to that of sheep, studies conducted under field conditions and *in vivo* revealed that goats are more efficient than sheep digesting feedstuffs with low nitrogen, high fibre or high tannin contents (Ammar *et al*., 2008).

2.1.3.2. *Albizia schimperiana*

The plant belongs to Family: *Leguminosae,* Genus: *Albizia*, species: *schimperiana,* Botanical name: *Albizia schimperiana*. *Albizia schimperiana* is a deciduous tree with a flattened or rounded, often umbrella-shaped crown; Medium sized deciduous tree up to (30-35) m tall;

bole straight and cylindrical or low-branched, up to 70 cm in diameter; bark surface gray or brown, smooth or rough; crown flattened or round, of then umbrella-shaped; young twig brown pubescent. Leaves alternate, bipinnate; stipules awl-shaped, caduceus; petiole near the base of upper side with a sessile gland, rachis densely to sparsely pubes-cent; leaflets in 6-21(-23) paires per pinna (Makonda *et al*., 2007).

A. schimperiana is found at the range of East and tropical Africa - Eritrea, Ethiopia, east DR Congo, Uganda, Kenya, Tanzania, Zambia, Malawi, Zimbabwe and Mozambique. Upland forest and evergreen bush land, at elevations from 900-2,600 meters. It is the dominant species in the upper canopy in southern Sudan and Ethiopia (Tigabu & Oden, 2003).

The tree roots develop nitrogen fixing nodules contain bradyrhizobium-fixing nodules contain bradyrhizobium bacteria. This species has a symbiotic relationship with above soil bacteria; these bacteria form nodules on the roots and fix atmospheric nitrogen. Some of this nitrogen is utilized by the growing plant but some can also be used by other plants growing nearby. Flowering occurs at the end of dry season pods take about 5 months to mature (Graham *et al*., 2000; Roe *et al*., 2002; Lemmens, 2007).

The findings by Taye *et al*.(2003) depict that the highest and stable coffee yield performances in Jimma was obtained under *Albizia schimperiana* .Generally, it is concluded by the above authors that this leguminous tree is among the most prominent coffee shade trees for sustainable coffee production under Jimma and other similar areas where it can adapt well.

The tree is planted in agroforestry systems as a shade tree and nitrogen fixation for soil conservation and improvement. The bark is a source of saponins and is used as a soap substitute and dyes. The ground seeds, mixed with water, are used as an insecticide. The ash of the bark is added to snuff tobacco to give pungency. The wood is fairly strong, works easily and is resistant to termites. It is used for construction, source of wood, jowelery, tool handles, beehives, bee fodder; monkeys too eat the flowers, stools, grain mortars, spoons, needles, timber, gum, plywood and matchboxes. The wood is used for fuel and for charcoal production (Neuwinger, 2000).

The tree is also harvested for local use as a medicine. A root infusion is added to porridge and used as a treatment against headache and other pains. The stem bark is used to treat warts. The bark is used as cough remedy. Spermine alkaloids and several triterpenes (lupeol, lupenone, oleanoic acid and hederagenin) have been isolated from the bark (Muhammad *et al*., 2010; Samoylenko *et al*., 2009; Volodymyr *et al*., 2009).There are up to 15000 seeds per kg. The species is most suited to higher, cooler sites and prefers shade when first out planted. Trees tend to find a great part of nutrients in the soil, because their roots spread more than ten meters (Kindt *et al*., 2013).

2.1.3.3. *Ficus ovata*

Ficus ovata is flowering plant belong to family, *Moraceae*; genus, *Ficus*; species, *ovata*; Botanique name, *Ficus ovata*. Derivation of specific name ovata has a meaning of egg shaped (Bingha *et al*., 2014). Tree to about 15 m tall, or a shrub, terrestrial or starting as an epiphyte or lithophytes. The bark is pale grey-brown with regularly spaced paler latitudinal stripes, and small crumb-like scales over the general surface on top of longitudinal papery scales. The leaves are discolorous, glabrous above and finely tomentose below. The figs are borne singly or in pairs in the leaf axils or on old wood. The mature figs are typically ellipsoid, green with whitish spots. The tree found at altitude range Up to 2100 m (Arbonnier., 2000). The tree is known by its high contents of condensed tannins (Yisehak and geert, 2013).

F. ovata or fig tree is the name of some shrubs or trees of the family *Moraceae* producing a milky juice and best known for their fleshy and edible fruits. Leaf shape is very variable. The shape may be whole or lobed and the edges rough or smooth. In some tropical species, leaf shape changes during growth of the tree. The flowers are minute and unisexual (male or female), they cluster on flat or hollow receptacle. Male flowers have one or two stamens, rarely more. In female flowers, the stamens are numerous and pedicellate. In fact, the shape of fruit that develops from inflorescences is varied. The seeds, embedded in the fruit are very numerous. The ovary of Ficus has a lateral style. The branches are covered with a fluffy greenish grey bark. The Ficus is found mainly in tropical forests (Tchinda *et al.,* 2010).

F. ovata, another plant of the *Ficus* species found in the savanna woodland, forest edges, river side forest and secondary forest, up to an altitude of 2100 m is distributed in the subtropical Africa (Hanelt *et al.,* 2001), *F. ovata* is use widely for street ornament in Dakar in Senegal (Kuete *et al.*, 2009)**.** In Africa, *F. ovata* is found in Senegal, southern Ethiopia, Kenya, North of Angola, Zambia, Malawi, Mozambique, and Cameroon(Louppe, 2002).

The plant uses as auxiliary plants essential oils and exudates fiber forages fruits fuels plants medicinal plants ornamentals stimulants timber (Sonibare *et al*., 2009).The crude extract and certain compounds inhibited the activity of streptococcus faecalis, staphylococcus aureus (Kuate *et al.,* 2009).Herbal extracts contain different phytochemicals with biological activity that can be of valuable therapeutic index. Much of the protective effect of fruits and vegetables has been attributed by phytochemicals, which are the non-nutrient plant compounds. Different phytochemicals have been found to possess a wide range of activities, which may help in protection against chronic diseases. For example, glycosides, saponins, flavonoids, tannins and alkaloids have hypoglycemic activities; anti-inflammatory. Reports show that saponins possess hypocholesterolemic and antidiabetic properties (Poongothai *et al.,* 2011). Plant polyphenols in this species have been known to exert anti-diabetic action and promote insulin action (Abu *et al.,* 2011).

The decoction of leaves of *Ficus ovata* is used to treat infectious diseases and facilitate childbirth. The decoction of the bark stems is used in the treatment of gastrointestinal infections, diarrhea and as antipoison. In Benin, the leaves of *F. ovata* are used against external hemorrhoids, sprains and jaundice (yellowing) (Kuete *et al*., 2009) and its leaves are used in Ivory Coast against the psychoneuroses.Fruits are used to stimulate milk production in cows and stem back use as food for mastication (Hanelt *et al.*, 2001).

2.1.3.4. Tannins in multipurpose tree species

Tannins are the most widely occurring anti-nutritional factors found in plants. These compounds are present in numerous tree and shrub foliages, seeds and agro-industrial by-products (Aregheore, 1998; Makkar and Becker, 1998, 1999).Tannins are a subset of plant polyphenols found in leaves, twigs, flowers, fruit and tree bark. Min *et al*. (2003) reported that CT concentration (>55 g CT/kg DM) generally reduces voluntary feed intake but at lower level (20–45 g CT/kg DM) voluntary intake was not affected. Wang *et al*. (1996) observed that the grazing of *L. corniculatus* (34 g CT/kg DM) reduced feed intake but increased the live weight gain in tannins fed group as compared to a group supplemented with PEG, which binds tannins and inactivates them. These authors observed a 23% improvement in live weight gain when lambs grazed *Holcus lanatus* (4.2 g CT/kg DM. There are exceptions to tannin suppression of DMI, and in some cases, there is an increase in DMI due to tannin supplementation (Puchala *et al*., 2005).

Beauchemin *et al*.(2007) reported no adverse effect on DMI and average daily gain (ADG) in cattle fed 70% forage ration supplemented with quebracho CT. Puchala *et al*.(2005) reported increased DMI and decreased methane emissions in Angora does fed *Lespedeza cuneata* (low CT containing forage) vs. a mixture of *Digitaria ischaemum* and *Festuca arundinacea*. Frutos et al. (2004) reported no effect of chestnut HT on DMI, ADG and FCR in finishing lambs consuming a high energy ration. However, tannins in low concentrations (2-4%) induce beneficial effects, which are associated with suppression of bloat in ruminants (Jones *et al*.,

1973) and protection of dietary proteins in the rumen. The nature of tannins in different fodder species and the species' stage of growth can have different effects on body weight gain **(**Sicelo Phumlani Dludla, 2010**).**

Condensed tannins from carob (*Ceratonia siliqua*) MPTS reduced lamb growth rate whilst sulla (*Hedysarum coronarium*) browse with double CT concentration did not reduce daily gain of lambs (Waghorn, 2008). Studying the nutritional effects of tannins in plants is therefore complicated because different plants contain a great diversity of tannins and other PSCs that have contrasting effects which changes with the plant age and season (Sicelo Phumlani Dludla, 2010). Livestock consuming tannin-rich diets (>5%, wt/v tannin) usually develop negative nitrogen balances, lowered feed digestibility and animal performance (Mueller-Harvey, 2006). It was expected that goats given low CT concentration browse will gain more weight than those fed high CT concentration browse (Makkar, 2003), however observations of reduced body weight gain in lambs fed feed with CT concentrations of 76-90 g/kg DM (Frutos *et al*., 2004; Huang *et al*., 2010). The resent study by Hagerman, 2011 shows higher tannin levels (CT > 100 g/kg DM) become highly detrimental.

2.2. Effect of Tannins on Animal Production

Under the finding of Abdulrazak *et al*. (2000) and Osuga *et al*. (2006, 2007), browse foliages have been reported containing tannins with varying concentrations. Mokoboki (2011) has stated on the level of nutritive value and anti-nutritional factors of browse tree leaves that there is variation between seasons among same species. Secondary Metabolites such as, lignin, tannins, and resinous compounds can reduce feed digestibility by tying up nutrients. High content of indigestible compounds, such as lignin, silica, or waxes, can also decrease the digestive benefits of a plant and reduce preference. Compounds like gossypol and tannins, that bind proteins, can decrease digestibility by deactivating digestive enzymes. Plant compounds, such as essential oils and tannins, have anti-microbial effects that kill microbes in the digestive system, thereby reducing feed digestibility (Karen Launchbaugh, 2001).

According to Makkar (2003) tannins are hydrosoluble polymers that form complexes with proteins, starch, cellulose and several minerals. Based on their structures and properties, tannins are distributed into two major classes-hydrolysable tannins (HT) and condensed tannins. Condensed tannins (CT) are hydrolytically cleaved to anthocyanidins and related compounds and are more correctly called proanthocyanidins or proflavanoids (Frutos *et al.*, 2004; Reddy *et al.*, 2008). Their role in plant metabolism is not known, although several hypotheses have been advanced, but effects on ruminant digestion are becoming increasingly clear. Condensed tannins bind to proteins in the rumen, reduce protein degradation and when dietary crude protein (CP) concentrations exceed animal requirements for CP, these effects can improve performance. However when dietary CP concentrations are low and fibre concentrations are high, CT are nearly always detrimental (Waghorn,2008; Wanapat , 2002).

Tannins are complex polyphenolic compounds with the molecular weights in range of 500-20, 000 Daltons (Nackz *et al.*, 2001). Condensed tannins, as opposed to hydrolysable tannins\ consist of covalently C-C bound flavan-3-ol units,that is not susceptible to anaerobic enzyme degradation (McSweeney *et al.*, 2001, Schofield *et al.*, 2001). Tannins owe their name to their capacity to bind and crosslink protein and their application in the tanning (is the process of treating skins of animals to produce leather, which is more durable and less susceptible to decomposition) process of hides. Tannins are hydrosoluble polymers that form complexes primarily with proteins but also with, starch, cellulose, carbohydrates, amino acids and several minerals(Makkar, 2003; Hagerman, 2011). These complexes are broken under conditions of high acidity (pH < 3.5) or high alkalinity (pH > 7.5). Hence condensed tannins may be used as organic protestant of protein from rumen degradation.

Further research (Wallace *et al.*, 2002; Barman and Rai, 2008) shows tannins are one of the most abundantly available plant secondary metabolites, with its well known adverse effects on rumen microbial population, feed digestibility and animal performance. The amount of tannin in feed is group as low (3-22 mg/g DM), moderate (42-58 mg/g DM) and high (77-152 mg/g

DM) (Osuga , 2005). At high levels of tannins in the diet, however, herbivores experience anti-nutritional effects such as lower feed intake due to decreased palatability, decreased nitrogen absorption, reduced availability of minerals and damage to the mucosal lining of the gastrointestinal tract, thus reducing the digestibility of food in the rumen (Udita Sanga, 2010). Generally tannins have dose-dependent negative nutritional effects on Livestock consuming tannin rich diets >5%, w/v tannin (Mueller-Harvey, 2006). (>55 g CT/kg DM) usually develop negative animal performance

The physiological activities of tannins result from either direct inhibition of digestive tract enzymes or from the absorption of dietary proteins (Silanikove *et al.*, 2001, Udita Sanga, 2010).Tannins either reduce the solubility of enzyme protein by forming insoluble protein-phenolic complexes or they inhibit digestive enzyme activity by forming soluble but inactive enzyme–inhibitor complex. Tannins also decrease the palatability of plants through their “astringent” nature by precipitating the salivary protein or by immobilizing enzymes in the mouth (Udita Sanga, 2010).

Beside adverse effect, tannins are plant polyphenols that can positively serve the physiological processes in ruminants and the metabolism of rumen microbial populations depending on their chemical nature and concentration in feed stuffs. Both these processes can generate useful benefits for ruminant nutrition and health (Dixon *et al.*, 2005), productivity (Grainger *et al*., 2009), and product quality (Vasta *et al*., 2010). Low concentrations of CT (20–45 g CT/kg DM) is valuable to ruminants with its positive effects such as reduce rumen feed protein degradation enable more efficient use of protein by reducing protein degradation in the rumen, greater nitrogen retention by increasing the flow of protein and essential amino acids to the intestine(Priolo *et al.* , 2001) due to reversible binding to these proteins (protein sparing action) and to reducing the populations of proteolytic rumen bacteria, as well as reducing bloat risk and reducing internal parasite burdens or anthelmintic effects(Reddy *et al.* , 2008, Belay Chufamo *et al.,* 2013); This is probably related to action of the CT in increasing essential amino acids(EAA) absorption from the small intestine (Min *et.al.*, 2003).

Condensed tannins have attracted interest as antibiotics and antioxidants (Karou *et al*., 2005; Cos *et al.,* 2004). They are important food components, for example in nuts (Mueller-Harvey, 2006) In agronomy, they have traditionally been known as digestibility reducers; however, recent experiments demonstrated beneficial impacts of condensed tannins on health and productivity in optimum percent (Mueller-Harvey, 2006). According to Waghorn *et al*. (1999) the presence of CT at dietary concentrations below approximately 100 g/kg DM in the diet may increase the performance of the ruminant, But it is approved by recent studies by deferent scholars that the above DM level is almost double fold above the expected minimum tannin negatively affecting range (Mueller-Harvey, 2006; Osuga, 2005).

Another main effects of tannins is depression of the rumen liquid and particulate content of the rumen, acceleration of the passage of liquid from the abomasums, and delay of the passage of digesta in the intestine. The overall effect was a delay in the passage of liquid and particulate matter throughout the entire GIT (Silanikove *et al*., 2000).

Decreased performance of sheep and goats, consuming diets rich in these anti-nutritional factors has been reported by many authors (Decandia *et al*., 2000a). The potential use of tanniniferous shrubs in livestock feeding was thoroughly investigated and some reviews have discussed the negative and positive effects of tannins on ruminant nutrition and performance (Makkar, 2003; Min *et al*., 2003). Although polyphenolic compounds might improve animal health, they can also decrease proteolytic activity and, thus, protein digestion (Oliveira *et al*, 2010).Their antinutritional effects include interference with the digestive processes either by binding with the enzymes or by binding to feed components like proteins or minerals (Liener, 1989). Hydrolysable tannins are easily degraded in biological systems, forming smaller compounds that can enter the blood stream and over a period of time cause toxicity to the vital organs such as liver and kidney.

2.3. Methods Used to Alleviate Deleterious Effects of Tannins in Browse Trees

According to Makkar (2003) various methods have been attempted to de-activate tannins in a wide range of browse species, grain seeds and agro-industrial by-products. These methods have included mechanical or physical techniques (e.g. wilting, processing, ensiling, etc.), inoculation with tannin resistant bacteria(FAO, 2007) and chemical techniques (treatment with alkalis, organic solvents, precipitants, etc.). The use of polyethylene glycol (PEG; MW 4 000 or 6 000), for which tannins have higher affinity than for proteins, is by far the most used reagent to neutralize these secondary compounds (Silanikove *et al*., 2001; Makkar, 2003).

PEG is water soluble polymer compound with linear formula of H $(OCH_2CH_2)_n$ OH and bond structure of H-$(O\text{-}CH_2\text{-}CH_2)_n$-OH). Commercially available over a wide range of molecular weights (Nackz *et al*. 2001).In some early trials there was no significant effect of PEG on goat total intake was reported where as other authors found an increase of DM intake in sheep and goats supplemented with PEG but relatively higher in sheep. This effect was higher in sheep than goats, probably because sheep are less adapted to digest tannin-rich plants (Kumar and Vaithiyanathan, 1990).

Polyethylene glycol (PEG) is a non-ionic detergent external marker which forms complexes with hydrolysable and condensed tannins over a wide pH range (2–8.5). According to Decandia (2000b) polyethylene glycol (PEG) is an inert and unabsorbed molecule, which binds with tannins to form a stable, insoluble complex that prevents tannins from binding to protein in the rumen. Furthermore, protein may be released from the protein–tannin complex by exchange reaction. PEG can also liberate protein from the pre-formed tannin-protein Complexes. Therefore, PEG has been used to mitigate the adverse effects of tannins on rumen fermentation as well as to improve the performance of animals on tannin–rich diets. It has also been proposed as a tool to predict adverse effects of tannins in animal nutrition (Silanikove *et al*., 2001). Polyethylene glycol has been used to counteract the adverse effects of tannins and can be added to the feed to improve digestibility, palatability and intake of tannins in ruminants (Titus *et al.*, 2001).

The theory of post-ingestive feedback holds that ruminants do not avoid or prefer food based only on flavor; rather, they form preferences and aversions by integrating the flavor of food with its post-ingestive Consequences (Udita Sanga, 2010). One prediction emerging from this theory is that herbivores supplemented with PEG should consume more tannin containing feed as the negative effects of tannins are attenuated by the presence of PEG in the gastrointestinal tract. Indeed, ruminants in pen trials supplemented with PEG markedly increase their intake and preference for fresh-cut legume with concentrations of condensed tannins of about 15% (Mantz *et al*., 2009). In other studies, lambs increase intake of PEG when the concentration of tannin in their diet is increased (Provenza *et al*., 2000, Udita Sanga, 2010). Lambs also learned to differentiate the medicinal effects of PEG from other non-medicinal foods such as wheat straw by selective intake of PEG after consumption of tannin-containing feeds (Villalba and Provenza 2001,Udita Sanga, 2010).Sheep is ruminant of self-select medicinal substances such as polyethylene glycol (PEG), a non-nutritive polymer that attenuates the aversive effects of plant secondary compounds such as tannins, as concentrations of these illness-inducing compounds increase in the diet (Provenza *et al*. 2000; Villalba and Provenza, 2001).

The effect of PEG on the digestibility was much more important than that on intake, particularly as far as protein nutrition is concerned. The digestibility of CP, either in metabolic cages or at pasture, was markedly increased by PEG supplementation, with a bigger effect in the indoor as compared with the outdoor experiment (+90% versus +30%, respectively) Decandia *et al.*, 2000b). Supplementation with PEG resulted in an increase in blood urea concentrations. Polyethylene glycol has the potential to improve the feeding value of *A. nilotica* leaf meal and can, therefore, be used in the feeding systems for ruminant animals (Motubatse *et al*., 2008).Polyethylene glycol (PEG), a tannin-binding agent, was shown to be a power-full tool for isolating the effect of tannins on various digestive functions (Silanikove *et al.,* 2000).

Different means of administering PEG have been used by different studies to assess the fodder potential of tanniniferous plant species. PEG was included either in concentrate supplement (Ben Salem *et al*., 1999; Decandia *et al*., 2000;Makkar,2003), dissolved in drinking water (Ben Salem *et al*., 1999), infused orally (Gilboa *et al*., 2000) or sprayed in solution on browse foliage (Ben Salem *et al*., 1999) given to ruminant animals. The response to PEG supply in terms of intake, digestion and production varied with the mode of PEG application. PEG is used as a tannin blocking agent to enhance the intake of tannin rich plants (TRP) and/ or to alleviate the tannin detrimental effects in ruminants (Silanikove *et al*., 2006). In general, positive results, with regard to improved intake, were found when tannin content in the diet or plant (as a sole feed) was above 50 g/kg DM (Makkar, 2003) or when a single source of tannins was offered to small ruminants (Silanikove *et al*., 2006).

2.4. Effect of PEG on Nutrient Utilization of Sheep and Goat

Silanikove *et al.* (1996) found an increase in the intake of goats dosed with PEG and fed with tannin-containing leaves. However, their goats were fed only foliage from tanniferous species, without supplementation of concentrate, (Decandia *et al.,* 2000a). As a finding of Decandia *et al*. (2000b) PEG supplement have an effect of a higher N loss in the urine, but this waste of nitrogen could be lower in lactating goats, due to their higher requirements for metabolisable protein. In this study PEG increased the proportion of tannin-rich species in the diet and crude protein digestibility, allowing a better utilization of woody species and in the mean time enhancing the efficacy of concentrates supplementation. PEG can improve the nutritive value of this feed source and hence optimizing goats' performance (Decandia *et al.,* 2000b).

PEG has been used to neutralize the negative effects of tannins on food intake and digestibility in sheep, goats, and cattle (Landau *et al.,* 2000). Sheep increase intake of PEG as increases in tannin concentrations in their diet (Provenza *et al.,* 2000), perhaps because they recognize the positive “medicinal” effects of PEG and associate PEG with recovery from the aversive effects of tannins.

Invitro Study by Getachew *et al.* (2001) shows the improvement of the nutritive value of diets resulted in increased growth rates in sheep and goat responses obtained with 18 and 24% PEG in feed blocks were similar, so the authors recommended limiting the level of PEG to 18 % inorder to obtain an optimal positive effect from feed block use. Sheep given feed blocks containing 18 percent PEG consumed approximately 23 g PEG/day. The slow release of PEG, and therefore the synchronized consumption of tannins and PEG, is probably the main explanation of the beneficial effect of PEG-containing feed blocks.

Ben Salem *et al.*(2002),on lambs confirmed the contention of inclusion of high levels of urea in PEG-containing blocks in sheep diet. Similar to this findings from *in vitro* investigations (Getachew *et al.,* 2001), findings on acacia foliage showed the levels of NH3-N and the concentration of volatile fatty acids were significantly increased with PEG supply. The extent of this increase was highest with PEG-containing concentrate, while PEG in drinking water or in feed blocks resulted in similar increases in NH_3-N in the rumen fluid of sheep on (+34 and +31 percent, respectively) (FAO, 2007).

Indeed, PEG-containing concentrate is consumed rapidly by sheep in a few minutes, in contrast the presence of salt restricts free intake of the block and obliges the animal to consume small amounts continually over the day. This results in slow release of nutrients and of PEG but It is evident that increased water consumptions .However, the increased water consumption by sheep receiving PEG-containing blocks is surprising in the absence of any variation in block and total diet intakes between groups with PEG-containing or PEG-free blocks(Moujahed *et al*.,2000) .

Irrespective of administration mode, PEG supply increase urinary excretion of allantoin and consequently microbial nitrogen supply. The response was more pronounced when PEG was included in concentrate or feed blocks than when in drinking water or sprayed as solution on browse foliage (FAO ,2007).

2.5. Comparative Aspects of Sheep and Goat Feeding Habit

2.5.1. General comparative aspects

Sheep and goats are closely related since both belong to subfamily *Caprinae* where as they are separate species. The inherent characteristics of goats such as resistance to dehydration (Devendra, 1986), wider choice of vegetation, and wide-ranging feeding habits with preference for browse species, enable them to perform better than sheep in regions of scanty rainfall. Furthermore, goats appear to digest fiber more efficiently than sheep. Studies are required to delineate differences in microbial population between sheep and goat which might be helpful in enhancing productivity of the species reared under changing climatic conditions. Sheep/goats such as resistance to dehydration, wider choice of vegetation, and wide-ranging feeding habits with preference for browse species, enable them to thrive in regions that receive less than 750 mm of rainfall. The most telling difference, though not visible, is that sheep have 54 chromosomes and goats have 60. They have similar dentition (Agrawal *et al*., 2014).

Sheep are grazing animals while goats are essentially intermidate feeders. Goats have a competitive advantage over sheep in woodland and shrub land, are generally more active, selective, walk longer distances in search of feed and relish variety of feeds (Devendra, 1990).Sheep are less selective and utilize pasture more effectively. Another feature of the feeding behavior of goats is their discerning ability to taste. Goats can distinguish between bitter, sweet, salty and sour tastes, and show a higher tolerance for bitter taste than do sheep and cattle .Goats tended to select diets with appreciably higher nitrogen content than sheep, but *in vitro* digestibility of the nitrogen was not always as high (Agrawal *et al*., 2014).

2.5.2. Comparison of sheep and goats in tanniferous feed utilization

Goats are the most selective feeders of domestic ruminants. Condensed tannins have been shown to influence worm burden in sheep under experimental conditions (Athanasiadou *et al*, 2000). Tannins enhance protein metabolism and absorption in the gut (Sykes and Coop 2001) and may also have a direct killing effect on gut parasites (Athanasiadou *et al*, 2000, Cresswell *et al*, 2004).

The natural propensity of goats to browse has resulted in the development of a tolerance to defensive chemicals such as tannins which are inherent in tanniferous forages. Some possible explanations for the tolerance of goats to tannins are the ability of the microbes in the goat's rumen to break down tannins, and the existence of secretions in the saliva that bind tannins. (Min and Hart, 2003) indicated that goats have a tolerance to tannins because they have the ability to elevate their intake rates of plants with high tannin levels for short periods of time and limit long-term intake of the plants. According to Alonso-Díaz *et al*.,2012 salivary proteins from goats had higher capacity to precipitate tannins (to form an insoluble compound).Tyrell *et al.,* 2012 states negative aspect of the use of woody plants in a commercial production system is that they usually are not as resilient to being eaten as grasses. Therefore, the plants must be incorporated into the pasture in strategic locations in order to maximize forage consumption throughout the pasture.

Goats indigenous to tropical and subtropical environments generally performed better than other ruminants (ILCA,1986) . The capacity of goats to consume high-tannin browse and to detoxify the tannin is higher than that found in sheep under comparable conditions. Some of the desert breeds goats, are able to reduce their energy requirements by as much as 65% in response to reduction in feed availability.These advantages are probably related to the ability of goats to control effectively their rumen environment. In addition, maintaining a steady pH in the rumen, and efficient recycling of key nutrients such as nitrogen and sulfur, enable goats to maintain a maximal ruminal fermentation rate at given conditions. Adaptation to high-tannin feed is a long-time process that allows goats to benefit from a steady supply of forage. Some of the physiological features of ruminants defined as intermediate feeders, such as large salivary gland, a large absorptive area of their rumen epithelium, and a capacity to change the volume of the foregut rapidly in response to environmental changes, are most likely responsible for the goat's superior digestion capacity (Silanikove *et al*.,2000).

Different groups of microbes have different tolerance to tannin. Rumen fungi, proteolytic bacteria and protozoa are more resistant to tannin as compared to other microbes (McSweeney *et al.,* 2001). Several studies have shown that goats differ from sheep in feeding behavior, level of intake, diet selection, taste discrimination, and rate of eating due to the differences in anatomy and physiology (Ngwa *et al*., 2000). Ngwa *et al*.(2000) found that forage from tree species contributed about 75% of the diet of the goats, while the reverse was true for sheep.

Goats can also attain higher bite rates than sheep, which suggests a higher chewing efficiency or willingness to swallow larger particles (Domingue *et al.*, 1991). Nitrogen (N) concentration in simulated grazed forage samples was greater for goats than for sheep, and the concentration of neutral detergent fiber (NDF) was markedly less in the samples from goats than for sheep (Animut *et al*., 2005). The greater number of total protozoa in the rumen of goats (37.94 x 10^4 ml-1 strained rumen liquor) than the sheep (32.55 x 10^4 ml-1 strained rumen liquor).Dominique *et al*. ,(1991) showed that goats produce more protein-rich saliva during eating than sheep and Gilboa (1995) found that the parotid saliva of goats was relatively rich in proline (6.5%), glutamine (16.5%) and glycine (6.1%), which are known to enhance the affinity of proteins to tannins (Mehansho *et al*., 1987).

2.6. Sheep and Goat Breeds of Ethiopia

2.6.1. Bonga sheep breeds

The sheep types in Ethiopia are classified into four major groups based on their physical characteristics: short fat-tailed, long fat-tailed, thin-tailed and fat-rumped sheep. Based on DNA differences, Ethiopian sheep types have been classified into nine genetically distinct breeds (Solomon, 2008).The sheep types named after their geographic location and/or the ethnic communities keeping them, there are about 14 traditionally recognized sheep breeds in Ethiopia (ESGPIP, 2008).

Bonga sheep belong to Long-fat-tailed, Tail type/shape = Fatty and long, Fiber type = Short hair, Geographical distribution = around south west Ethiopia. Liner measurement of adult Bonga sheep breed is: Withers height = 66.7, Body length = 69.4, Heart girth= 73.5, Sub-sternal height = 36.4, Ear Length 9.8, Tail Length 25.9, Tail Width 8.1, Hair length 2.9 .Other name = Gesha, Menit

Important physical characteristics of Bonga sheep**:** Long, fat tail with straight tapering end (98.4%); hair sheep; large size; predominantly plain brown (57.9%) or with black (9%) or white (5.3%) shade, plain white (10.5%) or with brown patches (10.5%),and black (2.6%); both sexes are polled. Reared by Keffa, Sheka, Jimma, Dawuro and Bench communities of Ethiopia.

Bonga sheep breed is best meat producing breeds in Ethiopia. Adapted to produce in good environments of wet highlands .Adaptive characteristics/special merits = Adapted to produce in good environment; good mutton producers. Body Weight (kg) = 34.2, Litter size= 1.31, Lamb survival percentage= 49 (ESGPIP, 2008).

2.6.2. Kaffa goat breeds

Goat breeds found in Ethiopia have been identified and classified based on their differences in physical characteristics and genetic make-up. Based on differences in physical characteristics and genetic differences at the DNA level, four families and 12 breeds of goats have been identified in Ethiopia (Tesfaye, 2004).

The breeds are named after their geographical location, the ethnic communities maintaining them, or based on some identifying physical features. Goats of Ethiopia grouped in to four families: Nubian family, Rift Valley family, Somali family, Small East African family.

Kaffa goat breeds belong to small East African goats family. Adult goats' measurements are: Height at withers (cm) = 66.7, Chest girth (cm) = 72.2, Ear length (cm) = 13.0, Horn length (cm) = 11.6 Value to the community/special merits=milk and blood, Twinning percentage = 22, Weight (kg) =28.2 (ESGPIP, 2009).

Key identifying features of kaffa goats breeds are**:** Small, red or black, short neck, short prick ears. Other features: straight facial profile 92%; most males (83%) have straight horns pointing backwards (80%), a small proportion (14%) have curved horns; low incidence of polledness (3%); most goats have a coarse (38%) to hairy (27%) coat type; some 16% have hair on the thighs; plain colors predominate (52%), with some patchy color patterns (45%); main colors are black (30%) or brown (31%); among males, 88% have beards, 97% have ruffs; wattles are present on 12% of all goats (ESGPIP, 2009).

2.7. Partial Budget Analysis

Partial budgeting is a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business. It is also a planning and decision-making framework used to compare the costs and benefits of alternatives faced by a farm business (Ben Salem *et al*, 2003).

Profit is the driving force for taking risk in putting time and money into a given business venture. Farmers need to make decisions about allocation of their resources on a day-to-day basis as well as on a long-term basis. This includes decisions related to the whole farm such as what crops to grow, what animals to raise, what production system and inputs to use and how to market products. Feed costs can account for 60% to 80% of sheep and goats production costs. As a result, many producers have become engrossed in reducing costs to feed a sheep/goat per day rather than optimizing their feeding efficiency. The cheapest ration is not usually the most production-efficient ration (ESGPI, 2008).

The partial budget method is often used to calculate the effect of changes in farm management, change of crops or the introduction of a new technology (Overton, 2005; Allen, 2006; Nahamya *et al*., 2006; Cox *et al*., 2009).While there are other types of budgeting (e.g. whole farm and enterprise budgeting), the partial budgeting procedure is the most useful in farming system research (Doye, 2005).

Partial budgeting is a method of organizing experimental data and information about the cost and benefits from some change in the technologies being used on the farm. The aim is to estimate the change that will occur in farm profit or loss from some change in the farm plan (Swinton and Lowenberg-DeBoer, 2013). Partial budgets do not calculate the total income and expenses for each of the alternative plan but list only those items of income and expense that change. They measure changes in income and returns to limited-resources, provide a limited assessment of risk and, through sensitivity analysis, suggest a range of prices or costs at which a technology becomes profitable (Yilin Hou, 2006).

3. MATERIALS AND METHODS

3.1. Description of the Feed Sampling Area

The leaves of *A. schimperiana* and *F.ovata* were collected from Kitimbile *Kebele* of Kersa *woreda*, Jimma zone, southwestern Ethiopia. The climate of *A. gummifera* and *F. ovata* trees grown area is characterized as semi-humid tropical with bimodal heavy rainfall, ranging from 1200 to 2800 mm per year. The twenty years mean annual minimum and maximum temperature of the area was 11°C and 30°C, respectively (GOR, 2006). According to Deckers *et al*. (2008), the most common soil types around the study area are nitisols and planosols. As reported by Deckers *et al*. (2008) report, the less common are vertisols and ferralsols.

3.2. Collection and Preparation of Experimental Diets

The basal diet, hay, was harvested from Jimma University Kito-Furdisa campus natural pasture site. The botanical composition of the natural pasture hay was assessed directly before harvest and percent biomass expressed as dry matter. The hay was composed of plant mixtures about 52% *Poaceae*, 30% *Asteraceae*, 17.5% *Fabaceae*, 0.5% *Cyperaceae* and *Juncaceae* as a control or basal diet. The hay harvests were dried and stored for use as basal feed.

Fresh leaves of *A. schimperiana* and *F.ovata* were hand plucked from 30 randomly selected farm grown trees with age of 3.5 years and dried under shade. The under shade drying was chosen because oven drying of feeds that contain CTs (proanthocyanidins), even at temperatures below 60ºC, polymerizes tannins, increased NDF, fibre bound nitrogen and lignin (Makkar, 2003).

The harvests were then pooled, put in sacs and transported to Jimma University College of Agriculture and Veterinary Medicine small ruminant research facility within 40 minutes. After arrival, the fresh leaves were spread on plastic sheet and dried under shade for about 7 days. After drying (> 85% DM), leaves were packed in sacs of polythene bags in amounts of about 15 kg per bag and stored for use.

The MPTS (*A. schimperiana* and *F.ovata*) were selected because they are rich in protein, widely distributed in the study region and many other tropical countries, have higher fodder biomass and are commonly consumed by browsers (Yisehak *et al*., 2010).

3.3. Animals, Feed Management, Data Collection and Experimental Design

Eight intact male Bonga lambs *(*mean live weight and SE, 22.2±2.9 kg) and 8 kaffa goats (mean live weight and SE 23.1±1.5kg) average 12 months of age were used in the experiment. The sheep and goats were purchased from Seka local livestock market in Jimma zone. Care was taken to avoid variation in age determined by dentition and birth history. Animals were conditioned for one month to familiarize them with the feeding and research protocol. Prior to experiment; the animals were dewarmed and vaccinated (drenched) against common diseases of small ruminants especially against gastro-intestinal parasites in Jimma area. Pens were installed in a well ventilated shed with one side open to natural light and roofing to protect animals against sun and rain. They were randomly housed in individual holding pens (1.5 x 2.5 m^2) with concrete floors on an open-air platform. They were penned individually in a well-ventilated shed with cemented floor. During the feeding trial, animals were fed their experimental allowances according to the experimental scheme. For total collection of faeces, sheep and goats were fitted with faecal collection bags using harnesses. Faeces were quantitatively collected from each animal. Animals were allowed to adjust to faecal collection bags 3 days before data collection. The daily faeces excreted for each animal were weiged and 10% was sub-sampled, pooled on animal basis and frozen pending chemical analysis. Feed leftover were removed daily morning at 8:00 AM and weighed. During the collection period, samples of test and basal feed and refusals were collected, composited by animal, ground (1 mm screen) and kept frozen (−20◦C) for laboratory analysis.

Pasture hay (55%), and test diet (45%) of which 80% (*A schimperiana*), 20 % (F. ovata) were all together estimated to 50 g DM/kg LW of feed daily (Osuji *et al*., 1993). Test feed was provided once daily at 8:00AM prior to the provision of basal diet up to 10:00 AM in a separate trough in an individual opened pen. The animals were free access to clean drinking water throughout the experiment. The offered and refused amounts of feeds were recorded to estimate the actual voluntary feed intake for each treatment. Diet digestibility was measured by total faecal collection, 21 days for each treatment, two weeks for adaptation and one week for data collection in randomized 4 ×4 crossover trial. In the beginning and last day of each of the experimental period, all animals were weighed individually following overnight fasting to avoid gut content variation and data for the next period were recalculated. Body weight was measured using platform manual weighing balance which was calibrated manually. Weight of animals was taken after the balance is set correctly and once the animals stand calmly on it. Every sheep and goat were received PEG at rate of 40 mg PEG to 1 kg of AS+FO after mixing it with water at a rate of 0.5 g PEG/ml (Getachew *et al*., 2001). In general, the daily diet (basal + supplement) were balanced to provide 8.36 MJ/kg Metabolisable energy and 70 g/kg crude protein in dry matter basis (NRC, 1994).

Table 1. List of treatment combinations used in the experiment

Treatment	Composition	Short form
T1	*Albizia schimperiana* (36%) + *Ficus ovata* (9%) + PEG_{4000} + GBhay (55%)	T3+ PEG_{4000}
T2	*Albizia schimperiana* (36%) + *Ficus ovata* (9%) + PEG_{6000} + GBhay (55%)	T3+ PEG_{6000}
T3	*Albizia schimperiana* (36%) + *Ficus ovata* (9%) + GBhay (55%)	T3
T4	Grass based hay (Control fed)	GBhay

Apparent digestibility coefficients ((nutrient intake - faecal excretions) / nutrient intake) $\times$ 100%)) were calculated for each animal (McDonald *et al*., 2002). Metabolisable energy (ME) contents were predicted from the equations of Abate and Meyer (1997); ME (MJ kg^{-1} DM) = $5.34 - 0.1365CF + 0.6926NFE - 0.0152NFE^2 + 0.0001NFE^3$. Feed conversion efficiency (FCE) was measured as proportion of average daily BW gain to daily DM intake (Ball and Pethick, 2006). Metabolizable energy intake (MEI) (kJME/kg $BW^{0.75}$) was estimated according to Luo *et al*. (2004) as:MEI = 533 + (43.2*ADG (g/kg $BW^{0.75}$)).

3. 4. Chemical Analysis of Feed and Faeces

Samples of feedstuffs and faeces were analyzed for dry matter (DM), crude protein (CP), crude ash (CA), crude fiber (CF) and ether extract (EE) according to AOAC (2005) and for neutral detergent fiber (NDF), Acid detergent fiber (ADF) according to Van Soest *et al*. (1991).Total digestible nutrients were calculated from the proximate, detergent composition and nutrient digestion data following McDonald *et al*. (2002). After thawing, the faeces of the whole collection period were pooled for each animal and thoroughly mixed. For chemical analysis (excluding N), the faeces samples were oven dried at 105 °C for 24 h. Non-oven dried but well-mixed faeces were directly used for N analyses. Determination of total extractable CT was based on oxidative depolymerization of CTs in butanol-HCl reagent using 2% ferric ammonium sulfate in 2N HCl catalyst (Porter *et al.* 1986). All chemical analyses were carried out in duplicate.

3.5. Statistical Analysis

Analysis of variance was carried out according to the repeated measures design using mixed model procedures (PROC MIXED) of statistical analysis system (SAS, 2010 version 9.3). The linear model included the fixed effects of, dietary treatment, period and the interaction of period and dietary treatment, the random effect of sheep and goat and the random residual.

Duncan's multiple range test procedure used to obtain confidence intervals for all pair-wise differences between means. Differences considered significant at $P \leq 0.05$, but trends were noted when $0.10 > P > 0.05$. The appropriate linear model is as follows:

$\mathbf{Y_{ijk} = \mu + A_i + B_j + C_k + BC_{jk} + \sum_{ijk}}$ Where, $\mathbf{Y_{ijk}}$ = the response due to the animal i; the period j ;treatment k and the interaction between jk

μ = the overall mean effect

A_i = the random effect of the i^{th} sheep or goats (subject) (i = 1, 2…8)

B_j = the fixed effect of the j^{th} period (j = 1,2… 4) excluding the pre-experimental period

C_k = the fixed effect of the k^{th} treatment (k = 1, 2…4)

BC_{jk} = the fixed interaction effect between period j and treatment k

$\sum_{ijk}$ = the random error

3.6. Economic Analysis

Partial budget analysis was performed by considering variable costs (sheep and goats purchase price, price of T_1,T_2,T_3 and T_4 intake, water intake) and total revenue (income) from sales of sheep. Net income obtained from the experiment was calculated as the difference of total revenue (total returns) and total variable costs according to the formula developed by CIMMT (1988); Ehui and Rey (1992) and Ibrahim and Olaloku (2000).

NI = TR –TVC

ΔNI = ΔGR – ΔTVC

MRR = ΔNI/ΔTVC

Where, NI = net income, TR = Total return, TVC = Total variable cost, ΔNI = change in net income, ΔGR = change in gross return, ΔTVC = change in total variable cost, MRR = marginal rate of return.

Marginal rate of return (MRR) is another way of taking the cost factor into account. It measures the ΔNI which is generated by each additional unit of expenditure (ΔVC):

MRR is also a measure of additional capital invested in a new technology and its effect on net return.

Experimental animals sell estimate at experimental periods was the source of income calculation but manure that was used as fertilizer was not included in total revenue calculation because sheep and goat manure selling was not carried out.

All the cost is calculated by Ethiopian Birr (ETB) at the time of the study. Live animal pricing, at each period, carried out using six local livestock merchants. Partial budget analysis was calculated to assess the economical profitability and feasibility of the different feeding treatments compared to control feed (test feed). We assume that the experimental animal performance during the early one month adaptation period was constant for all.

4. RESULTS AND DISCUSSION

4.1. Chemical Composition of Experimental Feedstuffs

Table 2 presents the chemical composition of the basal and test diets. Despite its high amount of CT (110 g CT/kg DM), *A. schimperiana* leaves which can interfere with the utilization of nutrients, its CP content was higher by 459 %, than that of basal feed (hay). *F. ovata* had 313% higher CP than that of CP content of hay. Yet, no traces of CTs were determined for the hay.

Table 2.The chemical composition (g/kg DM) and Metabolisable energy(MJME/kg DM)of experimental feedstuffs

Diet sources	DM	CA	OM	EE	CP	NDF	ADF	ADL	CT	ME
Hay	914	117	883	39	63	653	511	129	BDL	9.74
A. schimperiana	910	77	923	31	289	417	309	110	110	8.50
F. ovata	906	111	889	29	197	445	314	103	191	9.15

DM, dry matter; CA, crude ash; OM, organic matter; EE, ether extract; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin; CT, condensed tannin;ME,metabolisable energy; BDL, below determination limit

The CP content of test feeds is by far above the recommended level of 60 g CP/kg DM (NRC, 1984) and 70-80 g CP/kg DM (NRC,1994;Norton, 2003; McDonald *et al*., 2002) which is a minimum daily requirement of ruminant animals from tropical feeds that in sequence can provide ammonia required by rumen microorganism to support optimum microbial activity. The high CP content of browse species is one of the main distinctive characteristic of browses compared to most grasses (Njidda, 2010).

As shown in Table 2 the CP contain of both *A. shimperiana* and *F. ovata* is greater than that reported for foliages of other browse species grown in the same locality such as *Maesa lanceolata*, 170.6 g CP kg–1DM, *Rhus glutinosa*, 160.4 g CP kg–1DM (Belachew *et al*., 2013), *Ficus vasta*, 186 g CP kg–1 (Yisehak and Janssens, 2013), and *Prunus africana* 148 g CP kg–1DM (Yisehak *et al.*, 2013). This might be associated with differences in genetic make up of browse species Mokoboki (2011); Boufennara *et al*., 2012. The intake of forage is limited when their CP contain is less than 100g kg$–^{1}$DM (Ranjhan, 2001).Voluntary feed intake also rapidly falls if CP contain of forage is below 62 g kg$–^{1}$DM (Nasrullah *et al*., 2003).The high CP Content in the leaves of *A. shimperiana* could be due to its nitrogen fixing ability. The high value of CP in the two browses test diet is an indication that various browse plants could serve as potential protein supplements to enhance the intake and digestion of low quality basal diets such as natural pasture hay and fibrous crop residues.

The CP content observed for the test browses were above the nutritional requirements for various production status of sheep and goats as stated by NRC (2007). The difference in CP content among browse species and hay can be explained by the inherent characteristics of browse species related to the ability to extract and accumulate nutrients from soil (Yusuf and Muritala, 2013).

The EE content of browse species in the present study is less than values recommended by Preston (1995) in that total diets do contain EE; more than 100g/kg DM is acceptable. On the contrary, in the reports of Campbell *et al*. (2006) fats and oils are extremely rich sources of energy, although because they impede microbial fermentation, ruminant diets should be limited to about 40 g EE/kg DM.

The three feeds had higher fiber (NDF & ADF) content that reduce spacing 12 % is minimum requirement in goats' diet (Mammon, 2008). The threshold level of NDF in tropical grass beyond which DM intake of ruminants is affected is 600 g NDF/kg (Meissner *et al*., 1991) suggesting that both the test diets (MPTS leaves) in the present study have acceptable NDF values (below 600 g NDF/kg DM) indicating that the MPTS are very high in feeding value in terms of NDF content. Tree forages with a low NDF content (200–350 g/kg) are usually of high digestibility (Norton, 1994). The digestibility of plant material in the rumen is related to the proportion and lignifications of cell walls (Van Soest, 1994). In general, the browse species included in the study and in the reported investigations had lower levels of NDF than a large variety of grass species quoted by Meissner and Paulsmeier (1995). However, although the detergent extraction techniques are used regularly when analyzing foliage from trees and other browse plants (Balogun *et al*., 1998; Kallah *et al*., 2000, Makkar *et al*. (1995) pointed out that these techniques are not suitable for tannin-rich forages.

Tannins are prevalent, however, among dicotyledonous forbs, shrubs and trees leaves (Haslam, 1979) above the concentration (>50 g/kg DM) consider toxic to ruminant micro-organism (Albrecht and Muck, 1991). The effect of tannins can be either adverse or beneficial for animals, depending on the concentration and chemical structure (Makkar, 2003; Min *et al*., 2003). Higher tannin levels (CT > 100 g/kg DM) become highly detrimental (Hagerman, 2011) as they reduce digestibility of fiber in the rumen by inhibiting the activity of bacteria (Chesson *et al*., 1982) and anaerobic fungi (Akin and Rigsby, 1985), high levels also lead to reduced intake (Leng, 1997). Brooker *et al*. (1999) also reported that livestock animals consuming tannin-rich diets usually develop a negative nitrogen and energy balance and lose weight and body condition unless supplemented with non-protein nitrogen, carbohydrate and minerals.

4.2. Nuterent Intake

Average intakes (g/kg DM) of nutrients per day by sheep and goats are presented in Table 3. The highest DMI (P<0.001) was recorded for lambs when they fed with T_2 (hay,55% + *A. shimperiana*,39% + *F. ovata*, 9% + PEG_{6000}) compared to T_4 (control diet). The highest DMI in goats was also recorded for T_2 compared to T_4 (Appendix Table 1). DMI of goats fed T_2 found to be significantly (P<0.001) higher than sheep fed the same treatment (Table 3). In the current trial feeding grass based hay + *A. shimperiana* and *F. ovata* with PEG_{6000} improved DMI of sheep and goats compared to other treatment (P<0.001). Treatments combined with PEG_{4000} had also significantly improved the DMI of sheep and goats though the tendency is greater in goats (P<0.001). Differences in DMI were very significant among periods and period×treatment interaction (P<0.001). The improved capacity of goats to consume high-tannin browses and to detoxify the tannins as compared to sheep under comparable conditions might be associated with evolution and/or adaptation of goat breeds to tannin rich browses in tropical environments through secretion of special tannin binding proteins which is in agreement with Alonso-Díaz *et al*.,2012 that salivary proteins from goats had higher capacity to precipitate (to form an insoluble compound) tannins. Yisehak *et al.* (2012) investigated the largest concentration of tannin defending proteins in saliva of intermediate feeders which have longer exposure to tannins.

The improvement of DMI after PEG inclusion in tannin containing treatments could be associated with tannin deactivating capacity of PEG types. This is in agreement with results of Gilboa *et al.* (2000) and, Decandia *et al.* (2000) that PEG_{4000} has the potential to increase productivity in goats feeding in tannin-rich browses in different environments.In this particular study DMI due to PEG_{6000} was higher (P<0.001) than PEG_{4000} in both species (Appendix Table 1).Afework (2012) also reported the improved performance of PEG_{6000} treated groups in deactivating tannins from tannin rich browses compared to PEG_{4000} in relation to kinetics of *in vitro* fermentation. The possible reason that PEG_{6000} combined treatments compared to PEG_{4000} might be associated to high affinity of tannins to PEG. Makkar(2003) also reported higher affinity of PEG_{6000} for tannins. This higher DM intake through roughage was responsible for higher CPI which is in agreement with the finding of (Silanikove, 1996).

Table 3.Least square means compared for daily nutrient and energy intake (g/day DM &MJME/kgDM) by Bonga sheep and Kaffa goat (mean ± se) fed hay and supplemented with leaves of condensed tannin-rich trees with or without polyethylene glycol (4000 & 6000) with their interaction effects

Nutrients	Species	Treatment, mean			
		T_1	T_2	T_3	T_4
DMI	S	960^{b}	989^{b}	916^{b}	625^{b}
	G	976^{a}	993^{a}	924^{a}	631^{a}
CPI	S	161^{b}	176^{b}	94^{b}	62^{b}
	G	164^{a}	180^{a}	98^{a}	65^{a}
EEI	S	24^{b}	24^{b}	20^{b}	14^{b}
	G	25^{a}	25^{a}	22^{a}	14^{a}
OMI	S	809^{b}	812^{b}	731^{b}	583^{b}
	G	814^{a}	817^{a}	735^{a}	586^{a}
ADFI	S	397^{b}	438^{b}	359^{b}	244^{b}
	G	412^{a}	471^{a}	380^{a}	263^{a}
NDFI	S	410^{b}	460^{b}	370^{b}	260^{b}
	G	430^{a}	490^{a}	390^{a}	280^{a}
MEI	S	943^{b}	949^{b}	876^{b}	691^{b}
	G	947^{a}	953^{a}	881^{a}	673^{a}
	SEM	0.39	0.48	0.43	0.42
	P-value(T×P)	***	***	***	***

Sheep

	DF	DMI	CPI	EEI	OMI	NDFI	ADFI	MEI
Treatment(T)	3	***	***	*	***	***	***	***
Period(P)	3	***	***	**	***	**	***	***
T×P	9	***	***	***	***	***	***	***

Goats

	DF	DMI	CPI	EEI	OMI	NDFI	ADFI	MEI
Treatment(T)	3	***	***	*	***	***	***	***
Period(P)	3	***	***	*	***	***	***	***
T×P	9	***	***	***	***	***	***	***

DMI, dry matter intake; CPI, crude protein intake ;EEI, ether extract intake; OMI, organic matter intake ADFI,Acid detergent fiber intake; NDFI,neutral detergent fiber intake;MEI, metabolisable energy intake; SEM, standard error of mean;DF,degeree of freedom;T,treatment; p, period;S,sheep; G,goats;T×P,interaction effect of treatment and period. ^{a,b} *Means with different superscripts in the same column are significantly different at (P < 0.01);*P<0.05;**P<0.01; ***P<0.001*

Similar to DMI and CPI, significantly (*P*<0.001) higher NDFI (g/animal/day) was observed in goats received T_2 compared to other dietary treatments. Goats had significantly ($p<0.001$) a higher ADFcompared to sheep. The higher NDFI intake of goats compared to sheep might be associated to CP utilization ability of goats from tannin rich diets compared to sheep. Efficient protein utilization in goats can motivate multiplication of fibre (ADF & NDF) digesting bacteria in the digestive tract of goats. Goats have been considered more efficient in the digestion of crude fibre and the utilization of poor roughages than sheep (Malechek & Provenza, 1983; Squires, 1984). Possible physiological and behavioral factors for this ability of goats have also been indicated (Louca *et al*., 1982). However, with medium and good quality forage and adequate feed availability goats apparently are similar to sheep (Malechek and Provenza, 1983).

4.3. Apparent Digestibility Coefficients and Digestible Nutrients

Apparent digestibility coefficients (the weights of nutrients digested as proportions of the weight consumed) of the test and basal diets is presented in Table (4). In sheep, apparent DMD was higher for T_2 ($P<0.001$) compared to other dietary treatments. Acording to Table 4 goats, DMD due to T_2 was also found to be highest value compared to other dietary treatments ($P<0.001$). Goats showed superior digestion capacity of DMD than sheep fed same treatment particularly T_2 and the lowest values were recorded at T_4 ($P<0.001$). This might be due to the inclusion of PEG_{6000} for efficient utilization of protein rather than escaping as bypass because of tannin. The higher apparent digestion coefficients of nutrients for goats received tannin rich diets with or without PEG compared to sheep across all periods could be associated with the physiological feature of goats defined as intermediate feeders, such as large salivary gland, a large absorptive area of their rumen epithelium, and a capacity to change the volume of the foregut rapidly in response to environmental changes (Agrawal *et al*., 2014).

CPD digestibility was also significantly improved in both animal species after feeding *A. shimperiana* and *F. ovata* with PEG_{6000} (T_2 and T_1) than browse species alone (T_3). The best CPD is associated with tannin neutralizing ability of PEG. The low CPD in non-PEG treated diets might be associated with protein binding effects of CTs. This result is in line with the result of Perevolotsky *et al.(* 1993); decandia *et al*.(1999); Decandia *et al.* (2004) that low protein digestibility caused by the high level of tannins . The daily administration of PEG_{4000} to goats grazing on woodlands resulted in increased digestibility and intake (Silanikove *et al.*, 1996). It has been found that Sarda goats fed with fresh branches of *Pistacia lentiscus* and supplemented with PEG_{4000} showed an increase of *in vivo* CP digestibility (Decandia *et al.*, 1999). Several researchers have reported a reduction in protein digestibility in ruminants fed diets containing high levels of condensed tannins (McSweeney *et al.*, 2000; Reed, 1995). In addition to complexion with dietary proteins, CTs combine with, and hinder digestibility of cellulose, hemicelluloses and pectin either by preventing microbial digestion or by directly inhibiting cellulolytic micro organisms (McSweeney *et al*., 2000). CTs were reported to form combination with proteins in the rumen rendering them unavailable for digestion and consequently increase their output in faces (Robins and Brooker, 2005).

Table 4. Least square means for apparent digestibility of nutrients (%) compared between Bonga sheep and Kaffa goat fed hay and supplemented with mixes of leaves of condensed tannin-rich trees with or without PEG (4000/6000)

Nutrients	Species	Treatment, percentage			
		T_1	T_2	T_3	T_4
DMD	S	63^b	66^b	59^b	50^b
	G	65^a	67^a	61^a	52^a
CPD	S	65^b	67^b	53^b	46^b
	G	67^a	68^a	65^a	48^a
EED	S	63^b	63^b	56^b	48^b
	G	64^a	64^a	58^a	51^a
OMD	S	65^b	67^b	61^b	53^b
	G	66^a	69^a	63^a	54^a
NDFD	S	52^b	56^b	50^b	46^b
	G	55^a	58^a	51^a	48^a
ADFD	S	42^b	45^b	40^b	37^b
	G	43^a	47^a	41^a	38^a
	SEM	0.03	0.1	0.02	0.04
	P-value(T×P)	***	***	***	**

Sheep

	DF	DMD	CPD	EED	OMD	NDFD	ADFD
Treatment(T)	3	***	***	*	***	***	***
Period(P)	3	***	***	*	***	***	***
T×P	9	***	***	**	***	***	***

Goats

	DF	DMD	CPD	EED	OMD	NDFD	ADFD
Treatment(T)	3	***	***	*	***	***	***
Period(P)	3	***	***	*	***	***	***
T×P	9	***	***	**	***	***	***

*DMD, dry matter digestibility; CPD, crude protein digestibility; EED, ether extract digestibility; OMD, organic matter digestibility;NDFD, neutral detergent fiber digestibility;ADFD, Acid detergent fiber digestbility; SEM, standard error of mean;DF,degeree of freedom; T, treatment; P, period; T × P, interaction between treatment and period; [a,b] Means with different superscripts in the same column are significantly different at (P < 0.01);*P<0.05;**P<0.01; ***P<0.001*

It seems that the protein in acacia is poorly digested by sheep and goats due to the presence of tannins (4-11%) on DM basis (Degen *et al*., 1995; Abou EL-Naser *et al*., 1996). In non-tanniferous feeds, the true digestibility of N is approximately 93% (Van Soest, 1982). For browses used in ILCA's experiments, the true digestibility of nitrogen ranged from 52 to 94%. Browses with high contents of CTs typically had low nitrogen digestibility, reflecting the ability of these chemicals to bind protein, thereby reducing its availability to the animal (ILCA, 1989). Nunez-Hernandez *et al* (1989), Kaitho *et al* (1998), Dawson *et al* (1999), Komolong *et al*. (2001), Mbata (2001) all pointed out that condensed tannins from foliage or of exogenous origin undoubtedly reduced apparent nitrogen digestibility, increased faecal nitrogen and reduced urinary nitrogen excretion.

Similar to DMD, sheep had significantly higher OMD (67%) (P<0.001) when fed on T_2 compared to other dietary treatments. Goats showed the same trend when feed T_2 with , i.e., higher OMD (69%) was recorded with T_2 compared to other treatments (P <0.001). There were also highly significant (P<0.001) differences in sheep and goats (Table 4). The interaction effect between treatment and period was also found to be significant for ADFD and NDFD (P <0.001).

ADFD and NDFD varied significantly among treatments and animal species (P<0.001. When fed with $T_{2,}$sheep was performed higher NDFD (56%) compared to T_4 which showed the lowest NDFD (46%). Goats also performed better NDFD (58%, P<0.001) when fed in with T_2. Goats showed a better performance over sheep in relation to ADFD and NDFD which reflected a better adaptation of the species to particular environmental tannin load. These results are in agreement with investigators such as Devendra (1990) and Tisserand *et al*.(1991) that goats fed with high-fiber, low-quality forages, have better digestive efficiency than other ruminants. This might be attributed to their longer retention time of digesta in the rumen.Although goats are considered as opportunistic feeders with a very flexible foraging behavior, they are the most appropriate animals to utilize the high-fibre, low nitrogen forage produced on shrub lands and woodlands (Papanastasis, 2006).

About 25% Flemingia (*Flemingia macrophylla*) perennials browse in the feed with polyethylene glycol (PEG) used to neutralize CT which were present at 105 g/kg DM, negatively influenced apparent digestibility and intake of hemicelluloses, dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF) and total carbohydrate digestibility, but this was neutralized when PEG_{4000} was added (Fagundes *et al.*, 2013). It has been suggested that CTs may have a detrimental effect on animal's appetite when present in the diet at concentrations more than 3% (Provenza, 1995). In contrast, Mbatha (2001) observed reduced voluntary intake when goat diets contained more than 5% of WTE (wattle tannin extract on intake). In contrast, ruminants can still make use of CT concentration more that 100 g/kg DM. Tannins may reduce cell-wall digestibility by binding bacterial enzymes and/or forming indigestible complexes with cell-wall carbohydrates (Barry and Manley, 1984; Barry *et al*, 1986; Reed, 1986). The leaves of *A. schimperiana* and *F. ovata* ameliorates digestibility and performance in hay-fed Bonga sheep and Kaffa goats and the addition of PEG further improves this effect, likely due to the binding of tannins on it rather than with protein. The result of the present study is in contrast with Van Soest (1982) and Demment and Van Soest (1985) that, goats have smaller gut in proportion to body weight than other ruminants, resulting in rapid movement of digesta from the rumen and along the entire gastro-intestinal tract so that goats are not true utilizers of cellulosic matter and their success in tropical areas relates to their ability to exploit forages which have differentiated leaves of less lignified material and stems.

4.4. Live Weight Gain, Feed Conversion Efficiency and Protein Efficiency Ratio

The highest average daily weight gain of lambs was recorded for T2 (37 g/day). Sheep supplemented T2 showed the highest ADG followed by T1 where as sheep fed control diet(T4) loses 2.2g/day significantly (P<0.001). As shown in appendix Table 3 Goats fed on T2 showed the highest (41 g/day) average daily weight gain as compared to other treatments very significantly (P <0.001), while goats fed control meal (T4) loses 2.1g/day. Similar trend (P <0.001) was followed for sheep (appendix Table 3). Following T2 the higher ADG of sheep and goats was recorded in T1 through T3 is associated with increased nutrient intake and utilization (when compare with others) .

Table 5. Least square means for ADG (g/day), FCR (g/ g) and PER compared between Bonga sheep and kaffa goats fed hay supplemented with leaves of condensed tannin-rich trees with or without PEG

Nutrients	Species	Treatment, mean			
		T_1	T_2	T_3	T_4
ADG, g/day	S	31b	37b	16b	-2.2b
	G	36a	41a	19a	-2.1a
FCR, DMI / ADG	S	34b	29b	57b	-284d
	G	30a	26a	49a	-316a
PER, g ADG/g CPI	S	0.19b	0.21b	0.17b	-0.035b
	G	0.22a	0.23a	0.19a	-0.032a
	SEM	0.03	0.1	0.02	0.04
	P-value(T×P)	***	***	***	***

Sheep	DF	ADG	FCR	PER
Treatment(T)	3	***	***	***
Period(P)	3	***	***	***
T×P	9	***	***	***

Goats	DF	ADG	FCR	PER
Treatment(T)	3	***	***	***
Period(P)	3	***	***	***
T×P	9	***	***	***

*ADG, average daily weight gain; FCR, feed conversion ratio (DMI /ADG); PER, protein efficiency ratio SEM, standard error of means, T, treatment; P, period; T x P, interaction between treatment and period . [a,b] Means with different superscripts in the same column are significantly different at(P< 0.01). *P<0.05; **P<0.01; ***P<0.001*

Daily weight changes as shown in Table 5 were highest in Kaffa goats compared to bonga sheep for all dietary treatments ($P<0.001$). PEG inclusion in fed improved weight gain and feed conversion ratio in sheep and goats, yet the values were significantly ($P<0.001$) higher for goats. Although goats can make use of tannins in comparison to sheep, PEG inclusion further improved their daily weight gain and feed conversion efficiency very significantly ($P<0.001$). It is likely that, the improved productivity of PEG_{6000} supplemented sheep and goats is due to the binding ablity of condensed tannins by PEG resulting in greater availability, digestion and absorption of protein contributed for the best average daily weight gain of experimental animals. The result goes in line with the finding of Decandia *et al.* (2000a, b) that anglo-nubian and sarda goats' weight gains because of receiving PEG as a supplement.In adition to the above reason it might be the ruminants adaptive capacity to the browse feed of study area which agrees with the result of Biruk(2012) and reduction of feed intake but increase in live weight gain of sheep given tannin-rich feed has been observed (Frutos *et al*., *2004*).

Feed conversion ratio (FCR) is a gross measure of feed utilization efficiency and is most often used as a tool to evaluate groups of growing and finishing animals to determine costs of production and prices in production operations. Animals that will convert at a high rate (lower FCR) are more preferred to those with higher ratio which is low rate of feed conversion (Koech, 2010). As shown in appendix Table 3 of this study, sheep fed T2 exhibited the highest feed conversion rate (FCR=29) while T4 had the lowest conversion rate (FCR = -284) significantly ($p<0.001$).The result is in accordance with Koech, 2010 that diets with a low FCR (Feed conversion ratio) which means highest conversion rate are considered to be more productive and economical in animal production.

The best performance of goats ($p<0.001$) in ADG, FCR and PER compared to sheep across treatments might be associated with better nutrients utilization efficiency of goats to tanniferous and fiberous feed sources. Goats have developed coping sterategy against taninnin rich diet sources through production of taninnin neuteralizing proteins such as proline rich protein and mucins (Lami *et al*., 2011).

4.5. Economical Evaluation of Treatments Using Partial Budget Analysis

Table 6 presents the Partial budget analisis of the experiment with the four treatments of this study. Based on the total variable costs, purchasing and selling prices of experimental animals , T_2 had the highest MRR followed by T_1 and T_3, respectively. MRR in the present study is found to be positive for all the treatments except control feed and highest for T2 followed by T3.Treatment T_4 had the lowest NI; this is because it had the lowest returns in terms of weight gains which is uneconomical and does not give return to supplementation trial. From this study, T_2 was the most cost effective treatment followed by T_1.

Table 6. Overall economic analysis of Bonga Sheep and Kafa goats fed tannin rich mixes of MPTs with or without PEG (4000/6000) on station management condition

	Species	Treatments				
		T_1	T_2	T_3	T_4	
TVC	S	1084.15^{a}	852.73^{b}	1480.9^{b}	756.99^{b}	
	G	1004.67^{b}	913.96^{a}	1225.09^{a}	833.16^{a}	
TR(GR)	S	1202.45^{b}	1030.79^{b}	1596.11^{a}	772.3^{b}	
	G	1151.02^{a}	1130.03^{a}	1367.84^{b}	859.35^{a}	
NI(NR)	S	118.3^{b}	178.06^{b}	115.21^{b}	15.31^{b}	
	G	146.35^{a}	216.07^{a}	142.75^{a}	26.19^{a}	
NROC (ETB/head)	S	102.99^{b}	162.75^{b}	99.9^{b}	0	
	G	120.16^{a}	189.88^{a}	116.55^{a}	0	
MRR	S	31.48^{b}	170^{b}	13.8^{b}	-	
	G	70.06^{a}	232.11^{a}	29.74^{a}	-	
	SEM	3.11	2.97	3.56	3.44	
	P-value (T×P)	***	***	***	***	
		Sheep				
		TVC	TR (GR)	NI (NR)	NROC	MRR
Treatment (T)	3	***	**	***	***	***
Period (P)	3	***	**	***	***	***
T×P	9	***	**	***	***	***
		Goats				
		TVC	TR (GR)	NI (NR)	NROC	MRR
Treatment (T)	3	***	**	***	***	***
Period (P)	3	***	**	***	***	***
T×P	9	***	**	***	***	***

TVC-total variable coast; TR-total return=GR- gross return; NI-net income=NR= net return (GR-TVC); NROC = net return over control; ETB = Ethiopian birr; MRR= marginal rate of return (MRR = ΔNI/ΔTVC); T = Treatment, S=sheep, G=goat. ^{a,b} *Means with different superscripts in the same column are significantly different at (P < 0.01);*P<0.05;**P<0.01; ***P<0.001*

According to Tabele 6 MRR ranges from 31.48 up to 170 in Bonga sheep and from 70.06 up to 232.11 in Kaffa goats($p<0.001$), which implies that in 1 Birr investment in T_2, there will be from 0.3148 up to 1.70 birr profit in Bonga sheep and from 0.70 up to 2.32 Birr profit in kaffa goats .If more birr invested there will be more benefit as well.

There is change in costs, returns and value added because of differences in treatments. For the return, only the weight gain (selling price estimate) during each experimental phase (period) is used in the calculations. As indicated in table 6 , Bonga Sheep fed with T_2 was able to record net income of 178.06 while goat feed the same treatment (T_2) in this study significantly ($p<0.001$), performed the best net return of 216.07 birr per head of goat. These values are directly related with the live weight gain and the prices of experimental feeds.The result is in line with the findings of Birhanu *et al*.,2013 sugesting that, blackhead ogaden sheep feed *Prosopis juliflora* browse scored economically profitable result.

The resalt of the present study is in accordance with Silanikove, 1996, that in ecosystems dominated by varieties of oak browse plant (100g/kgDM condensed tannins), providing goats with a daily dose of 10 g PEG yielded the best cost-beneficial response in terms of improvements in intake and organic matter digestibility. From this study, experimental animals performance results shows there were tangible differences between MPTs with PEG supplemented sheep and goats and the un-supplemented. This gives the reason for PBA analysis of the different levels of supplementation that aids in making appropriate decision for supplementation intervention.

According to Dalsted and Gutierrez, 1992, Partial budgeting is based on the principle that a small change in the organization of a farm business will have one or more of the following effects: eliminate or reduce some costs; eliminate or reduce some returns, cause additional costs to be incurred, cause additional returns to be received. Verspecht *et al.(* 2011) explained the net effect will be the sum of positive economic effects minus the sum of negative economic effects and the final outcome of this technique is a net effect, i.e. it gives a measure for the possible change in farm profit. The result is therefore always compared to a reference situation.

4. SUMMARY AND CONCLUSION

The present study consisted of 8 Bonga sheep and 8 Kaffa goats evaluated at Jimma University College of Agriculture and Veterinary Medicine campus during the 2013 dry season with the objectives of evaluating the performance of above breeds on feed intake, digestibility, weight gain and economic feasibility of studying feeding tannin rich mixes with $PEG_{4000}\&_{6000}$.

Nutrient intake and digestibility, feed conversion efficiency, weight gain and protein efficiency ratio of bonga sheep fed *A. schimperiana (36%) +F. ovata (9%)* + grass based hay (55%) +PEG_{6000} is very significantly higher than same species feed the rest tree treatments (T1, T3 and T4). The trend is similar for Kaffa goats even though Kaffa goats performed best over Bonga sheep significantly in all above parameters.Feeding mixes of tannin rich foliage of browse like *A. schimperiana* and *F. ovata* along with PEG ($_{6000\&4000}$) especially PEG_{6000} to Bonga sheep and kaffa goat, particularly for kaffa goat led to increases feed intake, apparent nutrient digestibility and live weight gain as compared with control fed of grass based hay. MRR result shows each Ethiopian birr invested on Kafa goats feeding T2 (*A. schimperiana (36%) +Ficus ovata (9%)* + grass based hay (55%) +PEG_{6000}) could make to earn additional 2.3211 as compared to 1.7038 Ethiopian birr on Bonga sheep. Maximum performance achieved by Kaffa goats fed mixes of tannin rich foliage with PEG_{6000} is more economically attractive to adopt.

The appreciable nutrient constituents of the browse species in this study compare with that of grass based hay shows that test feeds can be used as supplement in sheep and goats nutrition and subsequently improve performance. A. *schimperiana* and F. *ovata* had a significant effect on chemical composition and estimated parameters of the leaves fed quality tests. From the feeding trail and chemical analyses it was indicated that A. *schimperiana* leaves and F. *ovata* are a source of good quality protein, indicating that it has potential as a browse source for ruminants fed low quality roughages, since high protein content in browse improves digestibility of low quality fed and lead to an overall increase in intake of digestible dry matter, suggesting that CT of test feds had adverse effect on feeding value. Intake of browse over critical periods like dry season result in increased survival and productivity of livestock thus based on analysis of chemical parameters and DMD, the foliage of A. *schimperiana* and F. *ovata* have potential to be used as source of fodder with a proper feeding management system.

The beneficial effect of feeding Sheep with 36% of *A. schimperiana* and 9% *F. ovata* with PEG_{6000} to bonga sheep and kaffa goats improved nutrient intake such as CP and ME intake, as well as fed digestibility and resulted better growth performance and feed conversion efficiency, However, unsupplemented and fed control one decreased the protein intake and increased the faecal protein loss of experimental animals in this trial. This can direct to agree the theory that CT influences feed utilization. Furthermore, gradual adaptation and dilution of *A. schimperiana* and *F. ovata* with PEG has contributed to the strategic utilization of the plant material. Supplementation PEG_{6000} at rate of 40 mg PEG to 1 kg of A. *schimperiana* +F. *ovata* after mixing it with water at a rate of 0.5 g PEG/ml increased diet OM and CP digestibilities by experimental animals.

The improvement in feeding value of *A. schimperiana* and *F. ovata* leave due to PEG supplementation seems to be higher than expected and feasible. Livestock farmers should be advised to supplement their sheep and goats with a low cost feed of A. schimperiana and F. ovata with PEG meal particularly during the dry season and inclusion of A. schimperiana and F. ovata in grass based hay feed as supplements to be used to improve productivity of sheep and goat in the country and reduce competition between humans and livestock in food resource allocation. Moreover the issue of anti-nutritive factors other than tannins has not been addressed in this study thus in view of the tendency for *Albizia* and *Ficus* species to contain highly biologically active secondary compounds, which is an area that would merit further investigation on the species at the study area. It is also important that studies to be done to determine the effects of PEG $_{6000}$ supplementation on productivity of ruminants fed *Albizia* and *Ficus* browse during different productive status.

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7. APPENDICES

Appendix Table 1.Least square means compared for daily nutrient intake (g/day DM) by Bonga sheep and Kaffa goat (mean ± standard error) fed hay and supplemented with leaves of condensed tannin-rich trees with or without polyethylene glycol (4000 & 6000)

	Species	Treatment, Mean					
		T_1	T_2	T_3	T_4	SEM	*P-value*
DMI	S	960^{b}	989^{a}	916c	625^{d}	0.445	<0.001
	G	976^{b}	993^{a}	924^{c}	631^{d}	0.022	<0.001
CPI	S	161^{b}	176^{a}	94^{c}	62^{d}	0.014	<0.013
	G	164^{b}	180^{a}	98^{c}	65^{d}	0.012	<0.001
EEI	S	24^{ab}	24^{ab}	20^{c}	14^{d}	0.081	<0.001
	G	25^{ab}	25^{ab}	22^{c}	14^{b}	0.022	<0.002
OMI	S	809^{b}	812^{a}	731^{c}	583^{d}	0.334	<0 .002
	G	814^{b}	817^{a}	735^{c}	586^{d}	0.413	<0.001
MEI	S	943^{b}	949^{a}	876^{c}	691^{d}	0.032	<0.001
	G	947^{b}	953^{a}	881^{c}	673^{d}	0.031	<0.001
ADFI	S	397^{b}	438^{a}	359^{c}	244^{d}	0.016	<0.001
	G	412^{b}	471^{a}	380^{c}	263^{d}	0.091	<0.01
NDFI	S	410^{b}	460^{a}	370^{c}	260^{d}	0.011	<0.01
	G	430^{b}	490^{a}	390^{c}	280^{d}	0.021	<0.001

^{a,b,c,d} Means with different superscripts in the same rows are significantly different at (P < 0.01); DMI, dry matter intake; CPI, crude protein intake EEI, ether extract intake; OMI, organic matter intake; MEI,metabolizable energy intake; ADFI, Acid detergent fiber intake; NDFI, neutral detergent fiber intake;SEM, standard error of mean; T, treatment; S, sheep; G, goats.

Appendix Table 2.Least square means for apparent digestibility of nutrients (%) compared between Bonga sheep and Kaffa goat fed hay and supplemented with mixes of leaves of condensed tannin-rich trees with or without PEG (4000/6000)

	Species	Treatment, Mean					
		T_1	T_2	T_3	T_4	SEM	*P-value*
DMD	S	63^{b}	66^{a}	59^{c}	50^{d}	0.02	<0.001
	G	65^{b}	67^{a}	61^{c}	52^{d}	0.03	<0.001
CPD	S	65^{b}	67^{a}	53^{c}	46^{d}	0.02	<0.001
	G	67^{b}	68^{a}	65^{c}	48^{d}	0.01	<0.001
EED	S	63^{ab}	63^{ab}	56^{c}	48^{d}	0.01	<0.01
	G	64^{ab}	64^{ab}	58^{c}	51^{d}	0.03	<0.01
OMD	S	65^{b}	67^{a}	61^{c}	53^{d}	0.02	<0.001
	G	66^{b}	69^{a}	63^{c}	54^{d}	0.01	<0.001
NDFD	S	52^{b}	56^{a}	50^{c}	46^{d}	0.01	<0.001
	G	55^{b}	58^{a}	51^{c}	48^{d}	0.02	<0.001
ADFD	S	42^{b}	45^{a}	40^{c}	37^{d}	0.92	<0.001
	G	43^{b}	47^{a}	41^{c}	38^{d}	0.97	<0.001

DMD, dry matter digestibility; CPD, crude protein digestibility; EED, ether extract digestibility; OMD, organic matter digestibility; NDFD, neutral detergent fiber digestibility; SEM, standard error of mean; T, treatment; S, sheep, G, goats. [a,b,c,d] *Means with different superscripts in the same rows are significantly different at (P < 0.01)*

Appendix Table 3.Least square means for ADG (g/day), FCR (g/ g) and PER compared between Bonga sheep and kaffa goats fed hay supplemented with leaves of condensed tannin-rich trees with or without PEG

	Species	Treatment, Mean				SEM	*P-value*
		T_1	T_2	T_3	T_4		
ADG, g/day	S	31b	37a	16c	-2.2d	0.03	<0.001
	G	36b	41a	19c	-2.1d	2.52	<.001
FCR, DMI/ADG	S	34b	29a	57c	-284d	2.34	<0.01
	G	30b	26a	49c	-316d	0.02	<.001
PER, g ADG/g	S	0.19b	0.21a	0.17c	-0.035d	0.02	<0.001
CPI	G	0.22b	0.23a	0.19c	-0.032d	0.02	<.001

ADG, average daily body weight gain; FCR, feed conversion ratio (DMI/ADG); PER, protein efficiency ratio (ADG/CPI);SEM, standard error of means; T, treatment, S, sheep, G, goats; [a,b,c,d] *Means with different superscripts in the same rows are significantly different at (P < 0.01)*

Appendix Table 4.Overall economic analysis of Bonga Sheep and Kafa goats fed tannin rich mixes of MPTs with or without PEG (4000/6000) on station management condition

	Species	Treatments					
		T_1	T_2	T_3	T_4	SE	*P*-value
TVC	S	1084.15[b]	852.73[c]	1480.9[a]	756.99[d]	1.73	***
	G	1004.67[b]	913.96[c]	1225.09[a]	833.16[d]	1.42	***
TR(GR)	S	1202.45[b]	1030.79[c]	1596.11[a]	772.3[d]	1.56	**
	G	1151.02[b]	1130.03[c]	1367.84[a]	859.35[d]	1.73	***
NI(NR)	S	118.3[b]	178.06[a]	115.21[c]	15.31[d]	1,61	***
	G	146.35[b]	216.07[a]	142.75[c]	26.19[d]	1.52	***
NROC(ETB/head)	S	102.99[b]	162.75[a]	99.9[c]	0	1.14	***
	G	120.16[b]	189.88[a]	116.55[c]	0	1.16	***
MRR	S	31.48[b]	170[a]	13.8[c]	-	1.45	***
	G	70.06[b]	232.11[a]	29.74[c]	-	1.52	***

TVC-total variable coast; TR-total return=GR- gross return; NI-net income=NR= net return (GR-TVC)); NROC = net return over control; ETB = Ethiopian birr; MRR= marginal rate of return (MRR = ΔNI/ΔTVC); T = Treatment, S=sheep, G=goat. [a,b,c,d] *Means with different superscripts in the same colomn are significantly different at (P < 0.01);*P<0.05;**P<0.01; ***P<0.001*