EFFECTS OF SUBSTITUTION OF NOUG SEED CAKE with *Brugmansia suaveolens* Brecht LEAF ON GROWTH PERFORMANCE, HEMATOLOGICAL AND SERUM BIOCHEMICAL PROFILES OF BONGA SHEEP UNDER COOPERATIVE MANAGEMENT

MSc THESIS

BY

SEKETA WOYESSA

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JIMMA, ETHIOPIA

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MSc. Thesis

Submitted to the Department of Animal Science, College of Agriculture and Veterinary Medicine, In Partial Fulfillment for the Degree of Master of Science in Animal Production

Major Advisor: Aregaw Abera

Co-advisor: Dr. Jane Wamatu (PhD, ICARDA)

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DEDICATION

I dedicate this thesis to my wife, Damoze Eshetu, who has taken on the role of everything in the family to help me achieve my dream, and to all my children, who have given their time and resources to help me succeed in life.

STATEMENT OF THE AUTHOR

I hereby declare that this Thesis is the result of my genuine work, and I have duly acknowledged all sources used writing it. This Thesis has been submitted in partial Fulfillment of MSc. degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to users in accordance with the library's regulations. I solemnly declare that this Thesis is not submitted to any other institution for the award of any academic degree, diploma or certificate. Brief quotations from this thesis may be used without special permission, as long as proper acknowledgement is given to the source. Permission to quote extensively from or reproduce any part of this thesis, either partially or in its entirety can be granted by the head of the major department or the dean of the graduate school, provided they deem the intended use of the material to be for scholarly purposes. For all other purposes, authorization must be obtained directly from the author.

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BIOGRAPHICAL SKETCH

The author was born to his mother, Workinesh Debelo and father, Woyessa Akasa, in Gida Ayana east Wallega of Oromia Regional State, Ethiopia, on April 10, 1989. He attended his elementary and junior school education in Tosse and completed his high school studies at Limu Genet High School. After successfully passing the Ethiopian Higher Education Entrance Examination, he joined Asosa ATVET Collage in 2003 and graduated with a Diploma in Animal Science. In July 2003, he was employed at the Limu Kosa District of Agriculture office and served as Developmental Agent and joined Jimma University, College of Agriculture and Veterinary Medicine BSc on 2012 and graduated in 2016 with BSc. Animal Science. Later, in September 2021, he enrolled at Jimma University, College of Agriculture and Veterinary Medicine, Department of Animal Science for the MSc study in Animal Production.

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
AOAC	Association of Analytical Chemist
Ca	Calcium
CF	Crude Fiber
CP	Crude Protein
CSA	Central Statistical Agency
DM	Dry Matter
EARO	Ethiopian Agricultural Research Organization
EIAR	Ethiopia Institute of Agricultural Research
EE	Ether Extract
FAO	Food and Agricultural Organization
FCR	Feed Conversion Efficiency
GHG	Greenhouse gas
GLM	General Linear Model
JUCAVM	Jimma University College of Agriculture and Veterinary Medicine
ME	Metabolizable Energy
MFED	Ministry of Finance and Economic Development
NDF	Neutral Detergent Fiber
P	Phosphorus
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System

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ABSTRACT

This experiment aimed to investigate the effects of substitution of noug seed cake (NSC) with Brugmansia suaveolens Brecht *(BSB) on growth performance, hematological and serum biochemical profiles of Bonga sheep under cooperative management. Twenty-five yearling Bonga Lambs with average initial body weight of 30.34±0.16 kg were assigned to treatments in a randomized complete block design. Animals were fed natural pasture ad libitum and wheat bran with different proportions of noug seed cake and (BSB): T1 = 100% (BSB); T2 = 75%BSB + 25%NSC; T3 = 50%BSB + 50%NSC; T4 = 25%BSB + 75% NSC and T5 = 100%NSC. A 10-day digestibility and 90-day growth experiment was conducted. Data were recorded and subjected to analysis of variance (ANOVA) following the GLM procedures in SAS version 9.3. Final body weight, average daily weight gain and average daily feed intake were significantly ($p<0.05$) higher in rams fed on T3 compared to other treatment groups. Except acid detergent fiber (ADF), daily dry matter (DM) and nutrient intake were significantly ($p<0.05$) affected by different treatment level. Rams fed T3 diet showed significantly higher ($p<0.05$) values in terms of crude protein (CP) and organic matter (OM) intake. The apparent digestibility of DM, OM, CP and NDF were significantly ($p<0.05$) different among treatments. The CP, OM and DM digestibility for T3 and T4 diets were higher ($p<0.05$) compared to other treatment groups. Substitution of NSC by BSB does not have a significant ($p>0.05$) effect on hematological and serum clinical biochemistry except red blood cell (RBC). Significantly ($p<0.05$) higher RBC was recorded from T3 compared to other treatment groups. Substitution of NSC by BSB up to 50 % resulted in increased nutrient intake and growth performance. Furthermore, partial budget analysis indicated positive economic importance while substitution of BSB with NSC. Therefore, BSB can be used to replace NSC up to 50% to improve feed intake and productivity of Bonga sheep without posing negative effect on hematological parameters and serum biochemistry.*

Key Words: Bonga sheep; *Brugmansia suaveolens* Brecht; Growth; Hematology; Serum Biochemistry; Noug Seed Cake.

1. INTRODUCTION

1.1 Background

Ethiopia boasts one of the largest small ruminant populations in Africa (Mekuriaw & Harris-Coble, 2021). Recent estimates indicate a national sheep population of approximately 42.9 million, with females constituting roughly 70% and males 30% (CSA, 2020). These diverse sheep breeds are found across various agro-ecological zones and are primarily kept by smallholder farmers. While sheep are present throughout Ethiopia's diverse landscapes, around 75% of the population is concentrated in the relatively moist and sub-humid highlands (elevations exceeding 1500 meters and annual rainfall exceeding 700 mm) (Markos, 2006). The remaining 25% reside in the lowlands. Among these breeds, the Bonga sheep is a recognized Ethiopian type found in the humid and mid-highland agro-ecological zones. Geographically, they are distributed across the Keffa, Sheka, and Bench zones of the Southwestern Nations, Nationalities, and Peoples' Regional State.

Sheep production in Ethiopia, and across East Africa, faces significant challenges. Productivity, measured by growth and meat output, remains low (Gebretsadik & Anal, 2014). While the national sheep population is substantial, per-animal production lags, hindering efforts to meet the demands of a growing human population and export markets. Annual off-take rates hover around 33%, with an average lamb carcass weight of only 10 kg. This is considerably lower than the global average of 15.8 kg and far behind the 21 kg carcass weight observed in Oceania (B Skapetas & M Kalaitzidou, 2017). Inadequate feed availability is a major constraint. Ethiopian sheep rely heavily on natural pastures and crop residues, which often lack sufficient nutrients, particularly protein, during dry periods (Alemu *et al.,* 2019). Smallholder farmers often lack the resources to supplement these poor-quality feeds with expensive grain concentrates. The inherent genetic potential of local sheep breeds may also contribute to lower productivity. Prevalent diseases and parasites further hinder animal health and growth (Tibbo, 2006).

Brugmansia suaveolens, a member of the Solanaceae family, offers a promising avenue for improving sheep nutrition in Ethiopia. Native to South America, it has become naturalized in various parts of the world, including Ethiopia (Pundir *et al*., 2022; Petricevich *et al*., 2020).

This multipurpose tree, known locally as "Yemogn Ababa**,"** can grow up to 4.5 meters tall and the plant grows at areas with high humidity and heavy rainfall. This bush has been used in traditional medicine in different cultures as a hallucinatory, analgesic, aphrodisiac, nematicide, sleep inducer, and muscle relaxant, as well as a treatment for rheumatism, asthma, and inflammation. The flowers, fruits, stems, and roots of the plant are used, and different chemical combinations have been identified, such as alkaloids, volatile compounds (mainly terpenes), coumarins, flavonoids, steroids, and hydrocarbons. The meditation of the different compounds varies according to the biotic and abiotic factors to which the plant is exposed.

The toxic effect of the plant is mainly attributed to atropine and scopolamine; their averages in the flowers are 0.79 _ 0.03 and 0.72 _ 0.05 mg/g of dry plant, respectively (Vera L. *et al* 2020). The first qualitative on groups of compounds, where they were identified as amines, carbohydrates (Sakunthala, P.; 2013) alkaloids Phenolic compounds, flavonoids, steroids, terpenoids, tannins, anthraquinone glycosides, saponins, and triterpenes. The quantification of the alkaloids (5.903 _ 0.01333 mg/g), phenolic compounds (3.435 _ 0.0110 mg/g), and flavonoids (9.945 _ 0.0256 mg/g) was also carried out from the ethanolic extract of the flowers (Marvin, 2018). The concentrations of such compounds can fluctuate (vary), as in living flowers, they show a continuous change in the profile of their volatile compounds, which depend on intrinsic (genetic) and external factors (light, temperature, and water stress). In the case of the cut flowers, they suffer faster decline (deteriorate) and a loss of volatile compounds (Stashenko, 2008). Other factors that also affect it are attacks from pathogens (viruses, bacteria, fungi, and nematodes) and herbivores. The Marvin program was used to draw the structures of organic chemical compounds (Marvin, 2018). *Brugmansia suaveolens*is reported in traditional medicine in many Latin American countries; However, the first studies are from 22 years ago (Encarnación *et al* 1998). There are several factors (climatic and seasonal) that can increase or decrease the concentration of the alkaloids associated with the toxicity of the bush. It has been documented that it has been involved in poisoning in many parts of the world, and other species, such as B. candida, B. sanguinea, and B. _ candida, are considered toxic in some places like Mexico, especially their seeds (Monroy,.et al 2006).

*Brugmansia suaveolens*forage was rich in CP which 34.5% and20.8% Kibrahab Yosef. (2017; Tilahun G. (2021), respectively relatively beyond or equal CP found in NSC. Previous research (Kibrahab Yosef., 2017) shown that yearling Bonga sheep fed roasted *Brugmansia suaveolens*exhibited improved nutrient consumption, daily weight gain, and feed conversion ratio. This aligns with the dominant presence of Brugmansia browse plants in the agro-ecology where these sheep are raised. Despite the potential benefits of Brugmansia suaveolens, there's a lack of information regarding its use in market-oriented sheep fattening systems. Studies are needed to explore the effectiveness of locally available Brugmansia leaves in improving nutrient availability and promoting efficient utilization for sustainable sheep production. This research aims to bridge this gap by investigating the potential of *Brugmansia suaveolens*as a protein supplement for Bonga sheep in a market-oriented fattening system. By examining the impact of Brugmansia supplementation on nutrient intake, growth performance, and economic viability, we hope to provide valuable insights for smallholder farmers and contribute to the improvement of Ethiopian sheep production.

1.2 Objective

1.2.1 General Objective

To evaluate effects of substitution of *Brugmansia suaveolens* Brecht for noug seed cake on growth performance, hematological and serum biochemical profiles of Bonga sheep under cooperative management

1.2.2 Specific Objectives

- To evaluate the effect of substitution of *Brugmansia suaveolens* Brecht for noug seed cake on feed intake, digestibility and growth performance of Bonga sheep under cooperative management
- To evaluate the effect of substitution of *Brugmansia suaveolens* Brecht for noug seed cake on hematological and serum biochemical profile of Bonga sheep under cooperative management
- To analyze partial budget analysis of the feeding experiment

2. LITERATURE REVIEW

2.1. Socio-Economic Importance of Sheep in Ethiopia

Sheep and goat in Ethiopia contribute considerably to the economy and food security of the country small holder and jobless youth. Nevertheless, small ruminants in Ethiopia and most developing regions are kept in traditional extensive systems (Legesse *et al.*, 2008). In addition to their ability to resist and reproduce in harsh environments, small ruminants for many of the small farm holders are the only source of income and fortune. Nevertheless of the under harsh environmental conditions, small ruminants are important in feeding the rapidly expanding population of the developing world (TibboM, 2006). In addition to their alteration to the harsh environment, they need low initial capital for investment costs and are able to use unsuitable land for crop and crop residues, to produce milk and meat in freely usable quantities, and are easily cared by most family members by women and children. Sheep and goat provide wholesome (meat and milk) to the smallholders and are considered as insurance mainly against crop letdown, as saving, socio-cultural and ritual purpose (Tibbo M, 2006; Gebretsadik and Anal, 2014; B Skapetas and M Kalaitzidou, 2017). Therefore, small ruminants are important to the livelihood of smallholder farmers, jobless youth and to the economy of the country.

Small ruminants are comparatively cheap and often the first asset acquired by a young family or by a poor family recovering from adversity (disaster). In the nourishment sector, farmers depend on small ruminants for much of their livelihood, often to a greater extent than on cattle, because small ruminants are generally owned by the poorer sectors of the community (B Skapetas and M Kalaitzidou, 2017). Actually small sized animals, (sheep) require small initial investment. Their small size, together with early growth, makes them more flexible and suitable for meeting sustenance needs of the rural family for meat and milk (Gizaw *et al.,* 2007). The short generation interval of sheep and goats together with high frequency of multiple births allow for quick increases in animal numbers. This builds financial capital and allows the sale of extra animals for cash that can be used for other agricultural enterprises, school fees, medical bills, etc. (Gebre *et al*., 2012; Mengesha and Tsega, 2012). Very often, there are no finance facilities in rural areas and an easy way to store cash for future needs is through the purchase of small ruminants and in some areas small ruminants have been described as the “village bank”. The sheep enterprise in the Ethiopian highland where crop and livestock production are integrated, is the most important form of investment and cash income and provides social security in bad crop years. Despite the economic importance of small ruminants to the farming household and overall economic development of a country, efforts to improve the productivity and production systems of sheep and goat are lacking. Hence forward, given these multifaceted advantages, small ruminants have to be researched and opportunities for enhancing their productivity explored.

2.2. Sheep Production System in Ethiopia

Small ruminant production system and the relative importance and potential for increased production by livestock species in varied areas differ markedly due to differences in resource available, climate, population density, and disease incidence, level of economic development, research provision and government economic policies (Kumar and Roy, 2013). In Ethiopia, sheep are categorized under two broad production systems (EARO, 2000).

2.2.1 Mixed crop-livestock farming system

In a mixed crop–livestock rating system, which is prevalent in humid, sub-humid and highland agro ecological zones, sheep are kept by smallholders and graze together with goats and/or other livestock such as cattle (Gobena, 2016). Productivity is low and is under feed shortage for much of the year due to cropping intensity. Sheep carry heavy internal and external parasite problems (EARO, 2000). According to Peacock (2005) in highland agro–ecology, as in central Ethiopia, increased human population has led to declined farm size and a gradual shift from keeping large to small ruminants, mainly sheep.

2.2.2 Agro pastoral and pastoral system

Sheep production is related with the purely livestock based nomadic and transhumance pastoral production systems based largely on range, primarily using natural vegetation. Sheep are mostly produced in pastoral and agro pastoral systems. Moderately larger flocks are maintained in the lowland (agro) pastoral systems. The major feed resources for sheep include grazing on public natural pasture, crop stubble, fallow grazing, road side grazing, crop residues, browses, and non-conventional feeds (household food leftovers, weeds, crop tillers and fillers). Production of good quality forages, used for improvement of low quality feed available such as crop residues and supplementary feeding (except fattening) is almost non-existent (Legesse *et al.*, 2008)

2.3 Characteristics of Bonga Sheep Breed

In Ethiopia, sheep types could be categorized into four groups (sub-alpine short-fat-tailed, highland long-fat-tailed, lowland fat-ramped and lowland thin-tailed) based on their ecological distribution, tail types (fat-tail versus thin-tail), tail form/shape, and fiber type (Abegaz *et al*., 2008). Within these categories, the most commonly identified indigenous sheep breed types found in south west parts of the country were Bonga sheep types (Lemma, 2002). For a long time, the Bonga sheep breed was thought to be comparable to Horro sheep breeds. The breed is distinct from Horro, according to a recent molecular characterization, and it is found in humid and mid high land (1200-2500 masl) ecological zones and it is widely distributed in Kaffa, sheka and Bench-Maji zones of the Southern Nations, Nationalities and Peoples Regional State / SNNPR (Gizaw *et al*., 2007).

Morphologically, Bonga sheep is classified as long-fat-tailed, with short hair fiber type, larger body size and better reproductive performance are the distinguishing feature that characterize the breed (Gizaw *et al., 2013).* According to Edea (2008) the coat pattern of Bonga sheep breed were plain, patchy and spotted. But, dominantly observed color was brown and brown with white. The ages to reach puberty were 8.5±2.5 and 7.2±2.4 months for male and female respectively. When it was compared to other sheep breeds of Ethiopia, Bonga sheep breed is recognized as good for growth rate, meat quality, twining rate, temperament and fattening potential (Edea, 2008). Male Bonga ram attains live body weight of 27.2 ± 0.77 and 32.19 ± 2.21 kg for one and two/more pairs of permanent incisors, respectively, which indicates that the body weight might be increased as the dentition varied through their age increased.

Breeding rams of Bonga sheep are produced by the community-based Bonga sheep breed improvement cooperatives and selected by the committee identified from the members of cooperative and the staff of Bonga Agricultural Research Center (BARC), since it started from 2012. The improved rams are distributed to other areas by the role of cooperatives after they are certified by BARC (Tarekegn *et al.,* 2016). Lambs gained from the cross breeding of Bonga ram have better performance and rapid growth rate than others obtained from cross breed of local sires. Though, the fast growth rate of Bonga crosses over local sheep attracts farmers to use Bonga rams as a breeding ram. Lambs obtained from cross of Bonga sheep with ewes have heavier body weight of 0.56, 1.92 and 4.4 kg at their birth, three and six months than local lambs under the same management practice of farmers (Ambecho, 2020).

2.4 Feed Resources in Ethiopia

The feed resources available for livestock in Ethiopia are natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products (Mengistu, 2005; Mengistu *et al.*, 2017; Tonamo, 2016). The contribution of these feed resources in the country is about 54.54%, 31.13%, 7.35%, 2.03%, 0.57% and 4.37% for green fodder grazing, crop residue, hay, by-products, improved feed and other feed resources respectively (CSA, 2020). Agro-ecology, the type of crop produced, accessibility and livestock production system are the factors which govern the contribution of feed resources. Likewise, in the highland and mid altitude areas of country cereal and pulse crop residues, and limited oil crops are providing considerable quantity of dry season feed supply for livestock.

However, the most important use of crop residues and cultivated forages are restricted to cattle (especially draught oxen) and small ruminants have low chance of being fed on these feeds (Bhandari, 2019). Grazing on corporate natural pasture, private pastures, fallow grazing, road sides, crop stubble and residues, browses, improved forages, and non-conventional feeds including (household food leftovers, weeds from crop fields, tillers from dense crop fields, fillers) crops purposely planted on part of crop lands or around farmstead to be used as feed) and traditional brewers grains (locally known as Atella) serves as feed resources for sheep and goats in Ethiopia (Duguma and Janssens, 2021; Mengistu *et al.*, 2017).

There is problem of seasonality in supply and quality of feeds. Grazing areas have constantly declined due to increased areas of cultivation. Concentrate feeds are little used due to shortage of surplus over requirements for human consumption, since feed shortage is a critical issue and there is inadequate feeding and poor feed quality, the available feed only satisfies about 58% of the requirements.

High prices of commercial feed products along with the low scale of the activity do not allow the feeding scheme based on the highly nutrition concentrate feed products rather it was based on the free grazing feeding scheme with a limited quantity of supplementary feed. In line with this Misra *et al.*, (2007) private Sheep farmers obtain forage from a combination of crop residues, private land and common gazing land. Thus, a sheep get their feed from both common land and framers' field. Based on the study by shigdaf, *et al*. (2012), in different part of country major problem to sheep production were feed shortage (44%), disease (28%), labor shortage (15%) and drought (13%).Back yard fodder development (Oats, Rhodes, Virus free Napier and desho grasses and some legumes cow pea, pigeon peas, vetch and lablab), for fattening was also introduced. Use of crop left over was encouraged together with chopping of Stover and treatment of the straw with urea. Use of locally available by-products from agro- processing (wheat bran, rice bran, *Atella*) and commercially available concentrate (cotton meal, noug cake) was stimulated. To stimulate production of fodder (for fattening), from sloping grazing areas and bottomlands, grasses and leguminous fodder species and more controlled management of such areas, was encouraged. In some areas, these supplement roughage was introduced in as a survival or an emergency feed and as a strategic feed reserve.

2.4.1 Major Feed Resources

The major our country livestock feed resources are mainly natural grazing and browse, crop residues, improved pasture and agro-industrial byproducts (Dasta *et al* 2023). The feeding systems include public or private natural grazing and browsing, cut- and-carry feeding, hay and crop remains. Today in the country sheep are fed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and crop land after harvest. The availability and quality of forage are not satisfactory year round. As a result, the gains made in the wet season are totally or moderately lost in the dry season. Shortage of feed during the dry season is a major problem that causes decline in the productivity of small ruminants.

2.4.1.1 Natural Pasture

Natural pastures are grasses, legumes, herbs, trees and shrubs that are naturally occur so used as animal feedstuff (Gurmessa, 2021). They include the largest feed resources, but estimates of the contribution of feed resource vary greatly. Mekonnen, (2016) Estimated that 75-80% of the livestock feed in Ethiopia is obtained from natural pasture. Grazing land is available on permanent grazing areas such as follow land, crop side and farm land after crop harvest. The total area grazing and browsing in the country is 62,280 million hectare out of pastoral area. Communal grazing is normal and succeeded as a common property resource. The carrying capacity of the grazing land, if calculated on plant availability, should allow a plant use of 30–

50%. Hay is the most commonly deposited fodder on the farmer and is one oldest system used to level out the feed supply through out of the year. It is generally the most covenant process of forage conservation. The aim of hay making is to conserve the maximum of dry matter and nutrient at the lowest cost. Hay should be made at the optimum date to maximize yield and still have the percentage of digestible dry matter necessary to meet the nutrient need of sheep.

Table 1: Nutritional composition natural grass hay

Diets	DM	OM	CP	NDF	ADF
Hay	91.28	84.32	7.39	61.38	41.15

Source (NRC 2001)

2.4.1.2 Crop Residues

Crop residues are the parts of a harvested crop that remain after the grain has been taken. It is one of main feed in animal production in Ethiopia, especially those areas which practice livestock and crop production. Stems, leaves, and chaff are the main components of agricultural crop residue (Feyissa *et al*., 2015). In mixed crop-livestock farming systems, crop leftovers are the primary source of ruminant fodder. Due to the growth of agricultural land, grazing spaces are limited, natural grass is accessible seasonally, and ruminants graze on marginal land and/or roadside to acquire green feed during the wet season. The contributions of crop residues reach up to 80% during the dry seasons of the year as noted by Tolera (2007) and they are abundantly available at the beginning of the dry season following the harvest and threshing of cereal and pulse crops.

This is animals thrive on high-fiber diets (straw, stover, and native pasture hay), which are low in nutrients (nitrogen, sulfur, minerals, phosphorus, and so on) that are required for microbial fermentation. Crop residue types available in the country vary depending on the agro-ecology or agricultural practices used in different places. The mid and lowland agro-ecologies are dominated by maize, sorghum, and millet crop leftovers. Small cereal crop residues such as teff straw, wheat straw, barley straw and oats straw, on the other hand, predominate in the country's medium and highland regions (Feyissa *et al*., 2013). But, the quality and digestibility is very low with less than 50% digestibility, high fiber content (more than 70% NDF) and low crude protein (< 5% CP) (Gizachew and Smit, 2005). These deficiencies can partly be mitigated by supplementing roughage diets with feeds containing sufficient nutrients. The number of fibrous crop residues in each country and region was observed in light of grass eaters (cattle, buffaloes, camels, sheep, goats, horses, mules, asses) since these animals have greater potential for the use of crop residues than grain eaters (pigs and poultry).

2.4.1.3 Improved Forage

Over the past three decades a number of introduced forages are tested on-station in different agro-ecological zones, and considerable efforts were made to test the adaptability of different species of pasture and forage crops under varying agro-ecological situation (Alemayehu, 1997). As a result, quite a number of useful forages have been select for different zones. Improved pasture and forages have been cultivate and used in government ranches, state farms, farmer's demonstration plots and dairy and fattening areas. Forage crops are commonly grown for feeding animals with oats and vetch mixtures, fodder beet, elephant grass mixed with dismodium species. More recently, about 32 government and non-governmental organizations in the Ethiopian highlands are involved in promoting multipurpose fodder trees in an integrated rural development program (Mengstu, 2008). These fodder tree species were extensively distributed in most parts of the country because of their adaptation for a wide range of soils, moisture regimens and ease for establishment and rapid growth rate. There are a number of improved forage varieties of both grass and legume species appropriate for various agro ecologies (ESGPIP, 2008). Among these, desho grass, oat and vetch forage species are widely known and distributed.

2.5 Feeding behaviour of Sheep

Sheep’s are selective in their feeding behavior if they have a choice of feed resource. A given select to sheep is preter grass. Therefore: grazer in which the animal obtains natural or cultivated forage directly from the field by partially restricting the sheep's freedom. However man can influence the way forage is used and the amount consume.

2.6 Nutrient Requirement of Sheep for Growth

Different energy and protein level is needed for maintenance specially; for growth full nutrient is needed. . The nutrient requirements are the values considered necessary for upkeep, optimum production, and prevention of any signs of nutritional shortage

2.6.1 Protein and Energy requirement of Sheep

There are three major factors such as; nutrition, genetic make-up and management which decide the productivity of animal (Sethumadhavan, 2004). The contribution of improving genetic make-up for production does not exceed 30%, but nutrition and management accounts 70% share on the production of livestock (Bureau of Finance and Economic Development (BoFED), 2006). A constant supply of feed is required for small ruminant animal production throughout the year. Energy, protein, minerals, vitamins, and water are the nutrients that sheep require. These nutrients are required for proper maintenance, optimal production, and the prevention of nutritional deficiency symptoms. Sheep nutritional needs vary depending on their physiological stage; breed type, age, and daily body weight gain (Mike, 2007).

The nutritional intake increases with animal size (growth) increase to fill the requirements of the rumen stomach. To put it another way, larger animals consume more feed to maintain their body functions and productivity (ESGPIP, 2008). In sheep nutrition, proteins are required for the maintenance, growth, and synthesis of new tissues in growing sheep, particularly in reproductive animals. That is, it is determined by growth, age-appropriate weight, body condition, the pace of gain, and protein-to-energy ratio. In most sections of the country, green pastures and legume hay (alfalfa, clover, soybeans, and others) are great sources of protein for sheep (Asmare, 2016). High quality legume hays can contain 12 to 20% protein and supply adequate protein for most classes of sheep. But, grains generally contain 8 to 11% protein (NRC, 1985). In DM, a minimum protein level of 8% is essential for maintenance (McDonald *et al*., 2010). These amounts are significantly greater than crop residue's average crude protein values.

When the protein-rich feeds are added to balance low protein roughage, there will be an increased population of the microorganism which increased the rate of fermentation of the crude fiber component (ARC, 1980). Fodder trees and bushes with a CP of more than 22 percent and up to 30 percent fed as complete ration can provide enough protein for most classes of sheep fed. The Supplemental feed may be utilized to sustain a greater rate of growth or to raise lambs to a market finish faster, depending on the amount and quality of forage available. The CP requirements of growing and fattening sheep with a 20 kg body weight, according to Ranjhan (2001), are 85 and 127 g/day, respectively. The same author has noted that the requirements for growing and fattening animals are relatively higher than the requirements for adult animals. A protein deficiency is characterized by reduced appetite, lower feed intake, and poor feed efficiency. Under extreme conditions, there are digestive disturbances, nutritional anemia, and edema. The protein produced by ruminal synthesis does not supply all of the amino acids required by animals in the quality and quantity needed (McDonald *et al*., 2010).

The major sources of energy for sheep are pasture, hays, silage, by-product feeds, and grains. These energy requirements of sheep are affected by body weight (BW) extent of growth (gain), breed type, age, the environment, and protein content of the ration. Large animals require higher energy to attain their maintenance requirement than smaller animals. This is because of the increased rate of metabolism for energy in large animals. Moreover, a fast rate of growth demands energy-rich feeds or the consumption of large amounts feed. The energy status of sheep is dependent on how much feed they are consuming, what the energy content of the feed is, and what the digestibility of the feed is. The energy content of feeds is often described by the TDN content of the feed. TDN stands for total digestible nutrients. Grains have TDN values ranged from 70 to 80%, while, forages range from 50 to 60% TDN. For example, sheep can have access to all the corn cobs that they want and still be in an energy deficient situation. This is because they have a limited capacity to consume a bulky, poorly digested feed that lacks usable energy content. Conversely, lambs are often fed high grain diets to finish them for the market. They are eating similar amounts of feed daily as those eating cobs; however, they would be growing quite rapidly. The difference is being the digestibility and energy content of the two feed-stuffs (Neary, 1997).

Supplementing urea-treated crop residues with feed containing a greater energy source is more helpful than those with high protein content (Gashu *et al*., 2014). Sheep often lack nutrients, due to poor-quality pastures and roughage or inadequate amounts of feed. Because of this, energy is the most common limiting factor in small ruminant nutrition. Lower growth or weight loss, reduced reproductive efficiency, reduced milk, meat, or fiber production, increased susceptibility to infectious disease and parasites, and increased mortality are all symptoms of energy deficiency (Ensminger, 2002). The percentage of TDN is the most widely used method of evaluating feed for energy. As a rule, the greater the TDN is in a ration, the greater the rate of gain will be in the animal (Robert Spencer, 2018). Furthermore, sheep energy status is influenced by their feed consumption, energy content, and digestibility of the feed (Mike, 2007).

Table 2: Daily nutrient Requirement of Sheep

Body Weight (lb)	Gain (lb/day)	% of Body Weight	Dry Matter Intake**1** (lb)	Total Digestible Nutrients**2** (TDN; lb)	Crude Protein**3** (CP; lb)	Calcium (Ca; grams)	Phosphorus (P; grams)
112	0.55	3.20	3.60	2.39	0.36	4.7	3.9
112*	0.66	3.72	4.19	3.13	0.47	6.5	5.5
112*	1.10	4.25	4.77	3.80	0.56	8.0	6.8

Source: NRC (2007)

2.7. Sheep Production Opportunities

Great demand of sheep in the local market as a result of population increase, urbanization, and increase in income (even within a district) can be considered as an opportunity for the sheep producers. Nowadays, many abattoirs flourish in the country; so agents and assemblers purchase small ruminant even at farm gate. Importantly, because of their small body sizes, sheep have lower feed requirements that allow integration of them into different enterprises. Moreover, in addition to requiring a small initial investment, flock numbers can be restored more rapidly because of their fast reproductive rates, and they are also suitable for meeting subsistence needs (meat and milk) of the smallholders(Gebrezgiher and Zelealem, 2013).

2.7.**1. Opportunities to solve feed shortage**

Around urban and per urban farmers address the problem by buying commercial concentrates. However, this is expensive, and farmers sometimes find these feeds to be inconsistent in availability. They may not be an economically viable option for the small holder farmers, especially in areas where live animals and their products are low. As a result, fodder trees and shrubs gained great attention for improving livestock productivity in developing countries, as well as Ethiopia(Mengistu *et al.*, 2017). Fodder shrubs take up little land; this means that they can be managed as hedges on places where food and cash crops are not established, such as: external and internal farm boundaries, along farm paths, across slopes as soil conservation structures. And also there are so many resources those cannot get attention and but if we supplement to animals they have multipurpose importance by reducing greenhouse gas reduction from environment and reducing livestock and human feed computation. Among them vegetables leaves and their left over are the most predominant and easily available in all agro ecology of the country.

2.7.2. Fodder trees and browse species

In the context of ruminant livestock production, improved forage and pasture species offer a variety of benefits, including high biomass yield and optimum quality. I many places of the world, fodder trees and bushes have a high potential value as a source of feed for domestic cattle and animals (Dida *et al.*, 2019). They are well-liked by animals, and, owing to their extensive root systems, they continue to produce far into the dry season.

The vital need of the farmers for high quality feed for ruminants in developing countries can be achievable through intensive utilization of multipurpose trees and shrubs as they have better nutritional quality nearly equal to that of grain-based concentrates (Mekoya, 2008). Browse tree and shrub fruits from successfully constructed enclosures could be used as important dry season protein supplements thereby increasing the economic benefits of enclosures (Yayneshet *et al.*, 2008). Recognition of the potential of tree foliage to produce considerable amounts of high protein biomass has led to the development of animal farming system that integrate the use of tree foliage's with local bulky feed resources. Moreover, browse species provide fodder for ruminants in many parts of the globe because most of them maintain their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate both in quality as well in quantity.

The role of fodder trees in ruminant diets can be seen as a source of post ruminant protein for digestion, nitrogen and mineral supplement to improve fermentative digestion and microbial growth effectiveness in the rumen on poor quality forage and a total feed supplying almost all the biomass and other needed nutrients to support high levels of animal products. Foliage's of browse species are generally rich in CP and minerals and they are used as a dry season supplement to poor quality pasture and fibrous crop residue. In general, legumes are higher in Ca, K, Mg, Cu, Zn, Fe and Co than grass. It is also indicated that at least 75% of the shrubs and trees of Africa serve as browse plants and many of them are leguminous.

2.7.3 Non-conventional feed

Non-conventional feed resources refers to all those feeds that are not commonly used traditionally used for feeding livestock and are not commercially used in the ration formulation of livestock feeds (Negesse *et al.*, 2009). Non- conventional feeds such as vegetable refusals, sugar cane leaves, and Enset leaves and fish offal used as animal feed. On other area non-conventional feeds type like kitchen waste and coffee hull and its Atella used as animal feed in Jimma Zone, South-Western Ethiopia (Duguma and Janssens, 2016). Categories of non-conventional feed vary according to the feeding habit of the community (Amata, 2014). House wastes and local alcohol by-products known as ‘areke’, ‘tela’ and ‘atela’ were normally used in central rift valley of Ethiopia. Likewise, (Zewdie and Yoseph, 2014) was reported that farmers were utilizing non-conventional feeds such as vegetable refusals and local alcohol waste for their animal. Non- conventional feeds like abish (Trigonela foenum gracium), tobacco, and mineral soils were used for feeding animals in south west Shewa zone. However, non-conventional feeds are not available at large and seasonal because their contribution to livestock feed as a cooping strategy was small (Zewdie and Yoseph, 2014). The competition between human and livestock for food supplies has progressively increasing; resulted in a decline in food security and increased cost of conventional animal feeds and feed ingredients. Therefore, it has become face to source unconventional, available, cheaper and nutritive feed materials as alternative livestock feed ingredients.

2.8 Constraints of sheep production

In mixed crop-livestock systems, sheep and goat productivity is forced by complex and interlinked technical, institutional and socioeconomic factors. Feed shortage, limited land, water shortage, diseases/parasites, shelter, drought, predators, labor unavailability, inadequate extension provision, inadequate veterinary service and limited market right of entry are some of the constraints obstacle small ruminant production. Among those problems feed shortage is bottle neck for cash crop areas were coffee plantation and crop livestock production are practiced.

2.8.1. Feed shortage

A major constraint to livestock production in developing countries including Ethiopia is the scarcity and changeable quantity and quality of the year round feed supply (Dejene *et al.*, 2014;

Mengistu *et al.*, 2017; Salo, 2017). The reasons for shortage of feed vary depending on the agro-ecology and production system. In densely populated areas land resources are limited. Lack of adequate feed resources as the main constraint to animal production was more prominent in the mixed crop-livestock systems, where most of the cultivated areas and high human population are located. Many authors described the seasonal feed shortages, both in quality and quantity, and the associated reduction in livestock productivity in different parts of the country (Duguma and Janssens, 2021).

Feed shortage problem was comparable all over the country, being serious in high human population areas where land size is shrinking due to intensive crop cultivation and soil degradation. On the other hand shortage of feed at the end of dry season when all crop residues have been consumed and pasture growth is deprived, which is the major constraint for livestock production in the area. The feed shortage also gives the impression even in the rainy seasons since more of the lands are covered by crops. The feed scarcity is further aggravated by seasonality of forage availability and crop residues in the highlands and by inconsistent rainfall in the lowlands. There is also inefficient collection, conservation and utilization of available feeds which is mainly expressed in the lack of adopting feeding technologies to improve the wholesomeness value and palatability of crop residues and grazing lands which are the most important feed resources in most production systems and agro-ecologies (Salo, 2017).

2.9. Role of Supplementation for Sheep

In feeding systems where straws and hay are the introductory diet for ruminants, the low input of these roughages requires supplementation to meet the demand for product (Gulliver *et al.*, 2012). The rate of growth and meat product by ruminants grazing tropical ranges, crop residue or grass hay. Alone are generally low and about 10 of the creatures inheritable implicit. Thus, it implies that strategic supplementation of energy; protein and minerals are important means of icing better living being performance. The end of supplementation for ruminants feeding system is to minimize nutritive scarcities in the rudimentary diet to maintain or increase input of the rudimentary diet (Iñiguez, 2011). When ruminants are accessible supplemented low quality roughage, they lose weight because of their powerlessness to meet both energy and protein conditions. Thus, supplementation with nitrogen either as protein or non-protein nitrogen and energy has been shown to improve animal performance, substantially over and done with adding DM insipidity, inputs and balances of nutrients. Rates of turmoil of stringy crop remainders can frequently be bettered by supplementing small quantum of largely digestible protein and energy nutrients. According to (FAO 1997), the ideal of supplementation is to insure fresh force of nutritive rudiments to the creatures to allow it to develop target performance situations and to increase their feed input. The purpose of supplementation is to give rumen microorganism optimum easily degradable energy, nitrogen and or minerals that will enhance effort of microorganisms and rumen function. Supplementation of low quality feeds with concentrates or probe legume enhances the application of the rudimentary diet, thereby perfecting the performance of ruminants.

2.10 *Bragmansia suevealeons* as animal feed

This forage Mogne Abeba" Solanaceae" *Brugmansia suaveolens*Bercht is for around south western Ethiopian people its well-known and they use as a sheep feed whenever time of every season. According to farmers these forage have high nutritive value, productivity, adaptability, tolerance and palatability. Farmers used these forages for a long period of time for fattening, milk production and calf growth (Muluken Z *et al* 2017). Animal feed from *Nophoo* and *Mogne Abeba* have high DM intake, scrotal circumference, semen quality and creamy. This might be related with increment in body weight gain and associated increase in intake to satisfy nutrient requirement of the animal. Farmers in the study area also say that *Mogne Abeba* is highly palatable to animals (Zelek M. *et al* 2017). Forage (Mogne Abeba" Solanaceae" *Brugmansia suaveolens*Bercht) is the king of forage for its high CP value 34.5 and 20.8 Yosefe,.*et al* (2017) and Tilahu G.(2021). Higher total protein values suggest a potential improvement in dietary protein and immunity of the animals due to the inclusion of *Brugmansia suaveolens*Bercht (BSB) in the diet. Previous research has shown that B. suaveolens possesses medicinal, antioxidant, pharmacological, and immunity-boosting properties (Costa *et al*., 2023).

Figure 1. Mogni abeba (*Brugmansia suaveolens*Bercht on fence)

This multipurpose tree, known locally as "Yemogn Ababa**,"** can grow up to 4.5 meters tall and the plant grows at areas with high humidity and heavy rainfall. This bush has been used in traditional medicine in different cultures as a hallucinatory, analgesic, aphrodisiac, nematicide, sleep inducer, and muscle relaxant, as well as a treatment for rheumatism, asthma, and inflammation. The flowers, fruits, stems, and roots of the plant are used, and different chemical combinations have been identified, such as alkaloids, volatile compounds (mainly terpenes), coumarins, flavonoids, steroids, and hydrocarbons. The meditation of the different compounds varies according to the biotic and abiotic factors to which the plant is exposed. The toxic effect of the plant is mainly attributed to atropine and scopolamine; their averages in the flowers are 0.79 _ 0.03 and 0.72 _ 0.05 mg/g of dry plant, respectively (Vera L. *et al* 2020). The first qualitative on groups of compounds, where they were identified as amines, carbohydrates (Sakunthala, P.; 2013) alkaloids Phenolic compounds, flavonoids, steroids, terpenoids, tannins, anthraquinone glycosides, saponins, and triterpenes. The quantification of the alkaloids (5.903 _ 0.01333 mg/g), phenolic compounds (3.435 _ 0.0110 mg/g), and flavonoids (9.945 _ 0.0256 mg/g) was also carried out from the ethanolic extract of the flowers (Marvin, 2018). The concentrations of such compounds can fluctuate (vary), as in living flowers, they show a continuous change in the profile of their volatile compounds, which depend on intrinsic (genetic) and external factors (light, temperature, and water stress). In the case of the cut flowers, they suffer faster decline (deteriorate) and a loss of volatile compounds (Stashenko, 2008). Other factors that also affect it are attacks from pathogens (viruses, bacteria, fungi, and nematodes) and herbivores. The Marvin program was used to draw the structures of organic chemical compounds (Marvin, 2018). *Brugmansia suaveolens*is reported in traditional medicine in many Latin American countries; However, the first studies are from 22 years ago (Encarnación *et al* 1998). There are several factors (climatic and seasonal) that can increase or decrease the concentration of the alkaloids associated with the toxicity of the bush. It has been documented that it has been involved in poisoning in many parts of the world, and other species, such as B. candida, B. sanguinea, and B. _ candida, are considered toxic in some places like Mexico, especially their seeds (Monroy,.et al 2006)

3. MATERIALS AND METHODS

3.1 Experimental site

The study was conducted from June 2023 up to October 2023 in Boka Kebele Adiyo (Menjiwo) woreda and it is 473 km away from Addis Ababa Ethiopia and 28 km from Bonga; 48km from Adiyo woreda. Inhabitants: 1.1million. Geographical location: 06024-8003'N of latitude and 35048-36078'E of longitude. Total land area: 10602.7sq/k/m. Annual average Temperature**:** 14 to 17 ^{0}c. Annual average rain fall: 1600-2200mm. Altitude variation: stretched from 500-3500.

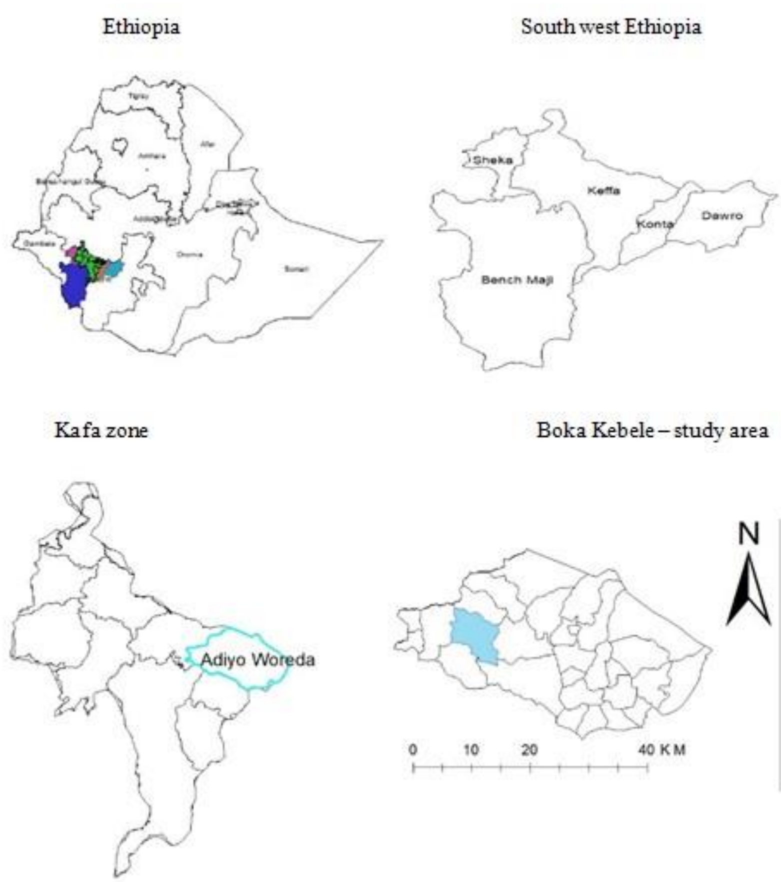

Figure 2. Map of study area (from GIS Google map)

3.2. Experimental feed preparation

Leaves of *brugmansia suvaleoun Brecht* were collected from the farmers around the study area. Fresh leaves were harvested by manual leave peaking during the months of late May to June. The harvested leaves were manually chopped to the size of approximately 2 – 5 cm and dried under the shade for four days through turning to uniform drying and maintained its green color. Dried leaves stored under shade when it was used for the feeding trial. Enough amounts of feeds for the entire experimental period was prepared before the actual experiment commences.

3.3 Experimental Animals and their Management

Intact yearlings of 25 male Bonga sheep were brought from community based Bonga sheep breed improvement and multiplication cooperatives located at 42 km from Bonga town. The age of lambs was estimated based on the data obtained from cooperative database and complemented with dentition. The experimental lambs were ear tagged for identification and quarantined for 15 days at a standard sheep barn with feeding and watering troughs in the study area till they adapted the environment, pen management, and diets before actual data collection. Meanwhile, during the quarantine period, lambs were vaccinated against ovine pasteurellosis and injected with multi-vitamins based on the prescription of veterinarians from employers of Bonga Research Center. The lambs were also dewormed against internal parasites using albendazole and ivermectin for ecto-parasites.

Lambs were arranged in a block based on their initial body weight into 5 blocks of 5 lambs each and placed in a well-ventilated experimental barn with feeding trough for desho grass hay and plastic buckets for watering and dried *brugmansia suvaleeouns* leaves with concentrate mix. The experimental lambs were carefully observed for the occurrence of any illness and records were taken for any physiological disorder during the whole experimental period

3.4 Experimental Design and Treatments

The experiment was conducted in a randomized complete block design (RCBD) with five treatments of five replications. The lambs were divided into five blocks based on their initial body weight and each lamb within each block was randomly assigned to one of the six dietary treatments by using the lottery method. The initial body weights of ram were determined as a mean of two consecutive days weighing after overnight fasting prior beginning of feeding trial.

The dietary treatment was replacement of the protein in the noug seed cake of the concentrate mix by dried leave of brugmansia at different level. The dietary treatments used in the growth trial were presented in (Table 2).

Table 3. Experimental treatments used in a growth trial

Treatments	Natural grass	Experimental Feed				Total Feed DM/day (g)	N
		WB (gr)	NSC (%)	DBSBL (%)	Salt (gr)		
T1(control)	ad libtum	180	0%	100%(120 gr)	5.5	300	5
T2	ad libtum	180	25%(30gr)	75%(90gr)	5.5	300	5
T3	ad libtum	180	50%(60gr)	50%(60gr)	5.5	300	5
T4	ad libtum	180	75%(90gr)	25%(30gr)	5.5	300	5
T5	ad libtum	180	100%(120gr)	0%	5.5	300	5

WB = wheat bran, NSC = noug seed cake, DBSBL =Dried Brugmansia suvaleoen bretch leaves, DM = Dry matter, N = number of experimental animals, gr = gram T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5: treatment five

3.5 Measurements and Observations

3.5.1 Analysis of the chemical composition of feed and faeces

The chemical analysis of experimental feeds and faeces were carried out for their chemical composition using representative samples at International Livestock Research Institute (ILRI) nutrition laboratory. The samples of experimental feeds were analyzed for DM, CP and ME content before the commencement of the experiment to determine the proportion of each ingredient in the ration. The sub-samples of experimental feed offered were dried at 65^0C in a forced draft oven for 72 hours. The dried sub-samples of feed were ground to pass through 1 mm sieve mesh and kept in an airtight plastic bags pending analysis. Offered samples of feed were dried at 105^0C overnight in forced draft oven for DM determination, while the ash content was determined by burning/igniting the feed samples in a muffle furnace at 550^0C for 5h in the oven according to the procedures of (AOAC, 2005). Nitrogen content of the samples were determined according to Keldjhal method, and the crude protein (CP) was calculated as nitrogen by multiplying the nitrogen (N) content of the sample with a conversion factor of N×6.25.

Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) was analyzed according to the procedures of (Van Soest and Robertson, 1985). The organic matter (OM) content was calculated as the difference of ash from 100. The energy value of feed was estimated according to McDonald *et al*. (2010) as metabolizable energy (ME, MJ/kg DM) = 0.016*DOMI; where DOMI is digestible OM intake per kg DM.

3.5.2 Feeding trial

After an acclimatization or quarantine period of 15 days to the experimental pens and diets, the feeding trial was conducted for 90 days. The lambs were offered the experimental feeds in to equal portions at 08:00 am and 6:00 pm and provided with free access to clean water throughout the feeding trial. The basal and experimental diets were offered separately. Experimental feeds were weighted and recorded daily for each lambs throughout the experimental period (90 days) to determine amount of feed consumed per day. Daily dry matter intake was calculated as difference between amount of feed offered and refused on dry matter basis.

3.5.3 Body weight change

The live body weight of each lamb was measured during the feeding period of 90 days within ten days' interval after overnight fasting before offering the daily ration using a 100 kg movable weighing scale with a sensitivity of 50 grams. The initial body weight of lambs was determined by taking the weights at the beginning of feeding trial, and the final body weight was taken at the end of the experiment. The initial and final body weight of the experimental lambs was used to determine the weight change during the 90 days feeding period. Average daily body weight gains (ADG) were calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Body weight gain and average daily body weight gain were calculated as follows:

Weight gain = final body weights - initial body weights

$$\text{Average daily body gain (ADG)} = \frac{\text{weight gain}}{\text{Feeding Days}}$$

3.5.4 Feed conversion efficiency and protein conversion efficiency

Feed conversion efficiency (FCE) is the measure of feed utilization how efficiently the lambs were converting the feed they consumed in to meat throughout the experimental period. According to Koksal *et al.* (2000) the feed conversion efficiency (FCE) of experimental animals was determined by dividing the average daily body weight gain to the amount of feed consumed.

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

3.5.5 Digestibility trial

The digestibility trial of the treatment diets was conducted at the end of the feeding trial using all experimental lambs for ten days. The experimental lambs were allowed to adapt harnessing of fecal collection bags for three days before data collection. The actual data collection was continued for seven consecutive days. The daily feed offered and refused, and fecal outputs were calculated for each lambs based on DM basis. Fresh feces were collected into a fecal collection bag harnessed to the lambs and recorded for each lambs throughout the digestibility trial. The total fecal output was collected by emptying the bag daily per lamb in the morning prior to offering feeds and water. The feces were weighed fresh, thoroughly mixed and 10% of the feces was sampled for each sheep and stored in a deep freezer at -18°C. The samples were pooled per animal over the collection period and representative fecal samples (10% of composite samples) were taken, weighted and dried at 65°C for 72 hours to constant weight in a forced draft oven for DM determination. The sub-samples of dried feces were ground to pass through a 1mm sieve and stored in an airtight polyethylene bag pending analysis. The chemical analysis was conducted at the animal nutrition laboratory of ILRI. Apparent digestibility of DM, OM, CP, NDF, and ADF was determined as a percentage of the nutrient intake not recovered in the feces using the following equation:

$$\text{Apparent nutrient digestibility coefficient (\%)} = \frac{(\text{Nutrient intake} - \text{Faecal nutrient output})}{(\text{Nutrient intake})} * 100$$

$$\text{Apparent DM digestibility coefficient (\%)} = \frac{(\text{DMI} - \text{Faecal DM output})}{(\text{DMI})} * 100$$

Where: DM = dry matter; DMI = dry matter intake

3.6. Haematological and Serum biochemical measurements

Blood samples were collected from the jugular vein of apparently two sheep representative each treatment. The sheep were bled through jugular vein and 10ml of blood collected. 3ml of the blood samples were collected into plastic tube containing EDTA for hematological analysis. The remaining 7ml of blood samples were deposited in anti-coagulant free plastic tube and allowed to clot at room temperature within 3hrs of collection. The serum samples were stored at -20 ^{0}C for biochemical studies. Total erythrocyte counts and total leucocyte counts were determined with the aid of Haemocytometer (Nebular counting chamber) and Hb concentration was determined by Sahl's (acid haematin) method (Benjamin, 1978). Mean corpuscular Hemoglobin concentration (MCHC), mean corpuscular Hemoglobin (MCH), Mean Corpuscular volume values were calculated (Patterson *et al.*, 1960). Serum Aspartate aminotransferase, serum aslanine aminotransferase and alkaline phosphatase were analyzed by spectriphotometrc linked reaction method (Cheesbrough, 2004). Other biochemical analysis was done using the method described by Ogunsani *et al.,* (2002). Blood chemisty part were done at Jimma specialized Hospital of human laboratory and hematology part at Jimma veterinary medicine laboratory.

3.7. Partial Budget Analysis

The partial budget analysis was carried out for determination of potential profitability and feasibility of the feeding regime of *brugmansia suvaleouns* leaves and concentrate mixture (NSC and WB) for growing lambs. It has considered the major calculation of the variable cost of purchasing sheep, feeds, and benefits gained from the selling price of lambs without considering other costs like labor, housing, and veterinary service which were common for all treatments. The market price of lambs was assessed in the local animal market and also the price of experimental lamb was estimated by experienced sheep dealers in the area.

The partial budget analysis was performed using the procedure of (Upton, 1979). Total return (TR) was determined by the difference between the selling and purchasing price of sheep. The Total Variable Costs (TVC) includes feed, animal, and transport cost. The net income (NI) was calculated as the amount of money left when total variable costs (TVC) subtracted from the total returns (TR) of the purchasing and selling price of sheep in each treatment before and after the experiment carried on:

$$NI = TR - TVC.$$

The change in net income (ΔNI) was calculated as the difference between changes in total return (ΔTR) and the change in total variable costs (ΔTVC), and the most important a reference criterion in decision making whether or not to adopt a new technology.

$$\Delta NI = \Delta TR - \Delta TVC$$

The marginal rate of return (MRR) that measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) was calculated as MRR = ΔNR/ΔTVC. All the cost was calculated by Ethiopian Birr (ETB) at the time of the experiment.

3.8. Statistical Analysis

Data on feed intake, body weight change and digestibility were subjected to analysis of variance (ANOVA) using general linear model procedure of SAS, version 9.3 (2014). The treatment means was separated by least significant difference (LSD). The model used for data analysis was:

Model $Yijk = \mu + Ti + Bj + Eijk$

Where, Yijk is the response variable (the observation in jth block and i^{th} treatment)

Yijk= Response variables

μ=Overall mean

Ti= Effect of the i^{th} treatments,

Bj=Effect of the j^{th} block and

Eijk=random error of i^{th} treatment in the j^{th} block

4. RESULT AND DISCUSSION

4.1 Composition and Nutritive Value of Experimental Feed

The chemical compositions of the experimental feeds used in the current study are presented in Table 4. This study investigated the chemical composition of various experimental feeds. The dry matter content (DM) of noug seed cake (NSC), *Brugmansia suaveolens*(BSB), and wheat bran (WB) were 93.31%, 94.02%, and 91.21%, respectively. These findings are consistent with previous research by Mamo (2021) who reported DM content of 91.09% for NSC and 91.41% for WB. Similarly, Dufera (2023) found that noug seed cake supplemented for sheep had a DM content of 93.22%. The CP content of NSC, BSB, and WB in this study was 27.99%, 31.08%, and 15.43%, respectively. Interestingly, the CP content showed a slight decrease across treatment groups (T1 to T5) from 24.74% to 18.11%. This decrease coincides with the declining level of BSB substitution across the treatments. The CP content of NSC in this study was lower than the values reported by Desta Tekle Gebru et al. (2017) and Mamo (2021), who found 34.27% and 33.4%, respectively. These variations in CP content for NSC likely stem from differences in factors like production practices, geographical location (agro-ecology), soil conditions, and the efficiency of processing methods, as suggested by Mamo (2021). The CP content of WB (15.43%) in this study was also lower than the 17.94% reported by Mamo (2021). However, the CP content of BSB (31.08%) was comparable to the findings of Yosefe *et al.,* (2017) who reported 34.51% crude protein for roasted B. suaveolens. In contrast, Tilahun (2021) reported a lower CP content of 20.1% for *Brugmansia suaveolens*bercht. These discrepancies in CP content between studies likely arise from variations in the specific protein sources used as feed. The promising CP content of BSB observed in this study suggests its potential as a viable protein supplement for the diets of small ruminants. This could be particularly beneficial for smallholder farmers who lack access to conventional protein sources and rely on low-quality roughage as their primary feed source.

The NDF (%) content obtained for NSC, BSB and WB in the current study was 35.34, 18.67 and 48.24, respectively. The NDF content obtained for NSC in this study was comparable with the values 36.5%, reported by Gebru *et al.,* (2017), and lower than 39.4% that reported by Dida *et al.,* (2019). Furthermore, the NDF content of WB in the present study was higher than the value (36.74%) reported by (Mamo, 2021). Neutral detergent fiber content of BSB of the current study (18.67%) was lower than the value reported by 36.33% Yosefe *et al.*, (2017) and 41.5% Gebre , (2021) for Roasted and raw Bercht suaveolens, respectively. This variation may be come from processing technique, stage of forage or season of harvesting.

The NDF content of 70% in a feed was thought to be enough to limit DM intake and digestibility. The NDF values ranging from 35 to 42% noted to have a relatively little impact on intake and digestibility of DM. Thus, the level of NDF observed in the present study is expected to have little negative impact on consumption and/or digestibility of the diets by the animals. Ruminants require sufficient NDF in their diets to maintain rumen function and maximize production. The NDF content of forage however varies widely, depending on species, maturity, and growing environment (Lee, 2018). The ADF content of experimental feed in treatment combination (17.49, 19.2519.46, 21.31 and21.35) were NSC found to have higher ADF content (33.63%) compared to BSB (19.15%) and WB (16.94%). ADF contents was relatively lower than the values 41.33% reported by (Tesema *et al.*, 2013). The ADL content of NSC, BSB and WB in the present study was 14.42, 3.59 and 3.61, respectively. The current study result indicated that NSC has higher ADL, whereas BSB and WB contain lower ADL. Generally, The ADL content of WB and BSB of the current study was comparable with the value reported by (Gebremariam, 2019; Yigzaw *et al.*, 2019).

The mean IVOMD of NSC, BSB and WB were 53.93, 75.43 and 68.60, respectively. The overall mean IVOMD of experimental feed from the current study were higher than the value reported by Andualem and Hundessa, (2022) who reported the mean IVOMD of grass was 48.0%. The variation could be due to the difference in types of feed used for laboratory analysis. The result of the Metabolizable energy (ME) value of 7.07, 9.48 and 10.11 MJ/Kg of dry matter (DM) was calculated for NSC, BSB and WB, respectively. The result obtained from the current study was higher than the value reported by Mohammadi *et al.*, (2023) who reported 14.60 MJ/Kg of ME energy from energy source feedstuff. The lower value of ME energy recorded from the current study might be due to the feedstuff used was protein source feed rather than energy sourced. However, the mean ME of the current study (8.15MJ/Kg) was above ME of 7 MJ/kg DM might be better to supply energy to sheep.

Table 4. Chemical composition of experimental feeds

Nutrient composition (%)	Treatment Feed					NSC	BSB	WB
	T1	T2	T3	T4	T5			
Dry matter	92.98	92.64	92.28	92.20	92.26	93.31	94.02	91.21
Ash	13.36	13.11	11.59	11.59	8.73	11.47	18.24	5.99
Crude protein	24.74	23.39	20.98	20.17	18.11	27.99	31.08	15.43
Neutral Detergent Fiber	31.96	34.55	39.19	41.19	47.22	35.34	18.67	48.24
Acid Detergent Fiber	17.49	19.25	19.46	21.31	21.35	33.63	19.15	16.94
Acid Detergent Lignin	4.33	5.16	5.54	6.22	6.82	14.42	3.59	3.61
IVOMD	71.98	68.02	66.08	64.93	62.47	53.93	75.43	68.60
Metabolizable energy (MJ/Kg)	9.71	9.18	9.12	9.05	8.95	7.07	9.48	10.11

IVOMD: Invitro-organic matter digestibility; NSC: Noug seed cake; BSB: *Brugmansia suaveolens* Brecht; WB: Wheat bran

T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5: treatment five

4.2. Dry Matter and Nutrient Intake

Table 5 presents the average daily DMI and nutrient intake of Bonga sheep. The study found significant differences ($P < 0.01$) in daily hay DMI between treatment groups. This contradicts Nurfeta *et al.* (2013) who reported no significant effect on DMI when substituting pigeon pea leaf for noug seed cake in sheep diets. This variation likely stems from the different feed types used for substitution in the sheep's diet. Sheep fed on T2 had the highest total DMI (dry matter intake) compared to other groups ($P < 0.01$). Conversely, sheep fed on T5 had the lowest total DMI ($P < 0.05$). The statistically significant difference ($P < 0.01$) in DMI across treatments can be summarized as T2 > T3 > T1 > T4 > T5. The higher DMI in the T2 group compared to others could be due to the feed's lower digestible crude protein content. This may have caused the sheep to consume more feed to meet their nutrient requirements. Conversely, the lower DMI in T5 compared to other groups might be attributed to the higher digestible crude protein content of NSC in this treatment, potentially satisfying the sheep's nutrient needs with less feed intake. The DMI progressively high BSB substitution levels T2. Additionally, BSB might contain anti-nutritional factors and plant secondary metabolites that could hinder feed intake, even if it has reasonable crude protein content.

Table 5. Mean daily dry matter and nutrient intake of Bonga sheep fed on experimental diet

Intake (g/day/head)	Treatments					p-value
	T1	T2	T3	T4	T5	
Total DM	843.3 ± 4.4^{b}	875.3 ± 3.2^{a}	862.7 ± 1.7^{a}	827.3 ± 0.0^{c}	806.7 ± 1.8^{d}	
Nutrient Intake						
CP	189.52^{b}	182.50^{bc}	213.01^{a}	167.04^{c}	146.22^{d}	0.00
OM	729.24^{b}	759.69^{a}	762.68^{a}	733.02^{b}	736.35^{b}	0.00
NDF	269.33^{d}	302.37^{c}	338.22^{b}	340.92^{b}	381.01^{a}	0.00
ADF	147.50	168.49	196.93	204.08	172.33	0.25

$^{a\text{-}b}$means within a row with the same superscript are not significantly different at $p<0.005$; SEM: Standard Error of Mean; DM: Dry Matter; CP: Crude Protein; OM: Organic Matter; NDF; Neutral Detergent Fiber; ADF; Acid Detergent Fiber
T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5: treatment five

This study observed an increase in total dry matter intake (DMI) as the feeding period progressed. This likely corresponds to the increasing live weight of the animals, leading to a higher feed intake to meet their growing nutrient requirements. As animals mature, their nutrient needs change to support the development of different organs and systems (Adem & Misbah, 2021). This explains the observed rise in daily feed intake across all treatment groups throughout the experiment.

Sheep fed diets in T2 and T3 (containing NSC) had significantly higher organic matter intake compared to the other treatments. Additionally, as Reyes-Olavarría et al. (2020) point out, the physical and chemical characteristics of the feed can significantly impact intake levels. The DMI values in this study ranged from 744-810 g/day, exceeding the 642.8–771.4 g/day reported by Mengistu *et al*. (2020) for Bonga sheep fed a replacement diet with dried mulberry and Vernonia mixed leaves instead of NSC. The observed variations in DMI could be attributed to factors such as animal weight, environmental conditions, diet composition, and feed quality (So-In & Sunthamala, 2022).

The CP intake of sheep in T3 was significantly higher ($P < 0.01$) compared to the other groups. The total CP intake ranged from 146-213 g/day in this study, exceeding the values reported by Yigzaw *et al*. (2019) who found an average CP intake of 59.1-153.8 g/day for sheep supplemented with a lentil hull and NSC mixture. However, Mamo (2021) reported a range of 59.44-301.83 g/day for sheep fed a mixture of wheat bran and NSC, which aligns with the findings of this study. Protein supplementation, as explained by Arelovich *et al*. (2014), increases the supply of nitrogen to rumen microbes, enhancing the rate of feed fermentation. This aligns with the observed rise in feed intake in the current study. Notably, the average daily CP intake of the T5 group (146.22 g/day) exceeded the minimum CP requirement (38g) for maintenance in a 19.1 kg sheep (NRC, 1981). The variations in CP intake among the supplemented groups could also be linked to the differences in CP content of the supplemental feeds. Fadiyimu *et al.* (2010) further suggest that higher CP intake is associated with better CP digestibility.

Significantly highest (P < 0.01) NDF intake was observed in the T5 group compared to the other groups. The statistically significant difference (P < 0.05) in NDF intake across treatments can be summarized as T5 > T4 = T3 > T2 > T1. This finding is consistent with Yigzaw *et al.* (2019) who reported higher NDF intake for sheep fed a lentil and NSC cake mixture compared to the control group. Replacing 50% of NSC with BSB in T3 might have led to a better balance of nutrients, consequently promoting higher DMI and overall nutrient intake. These findings highlight the importance of supplementing roughage-based diets with appropriate concentrates.

4.3 Apparent Dry Matter and Nutrient Digestibility

Table 6 presents the apparent digestibility percentages of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) in the experimental feeds. Sheep fed on T1 had a significantly lower (P < 0.05) apparent DM digestibility compared to other groups. This finding contradicts Nurfeta et al. (2013) who reported similar digestibility of DM, OM, NDF, and ADF in sheep fed diets with pigeon pea leaf replacing NSC. The lower DM digestibility observed in T1 could be attributed to the poor digestibility of its crude protein content. This aligns with Mamo et al. (2021) who suggested that lower DM digestibility is associated with both a lower digestible CP content and a higher fiber content in the feed. Kelln et al. (2021) point out that the presence of condensed tannins in tropical tree legumes can cause variations in digestibility values among legume supplements. The apparent DM digestibility in this study was comparable to the value (50.2%) reported by Nurfeta et al. (2013) for sheep fed a diet with NSC replaced by pigeon pea leaf as a protein supplement.

Table 6. Apparent dry matter and nutrients digestibility of Bonga sheep fed experimental diet.

Apparent digestibility (%)	Treatments					SEM	p-value
	T1	T2	T3	T4	T5		
DM	49.87^{b}	53.87^{a}	56.28^{a}	53.78^{a}	54.42^{a}	0.62	0.01
OM	47.42^{bc}	42.82^{c}	50.14^{ab}	53.31^{a}	49.81^{ab}	1.02	0.00
CP	29.62^{b}	35.25^{b}	49.35^{a}	49.05^{a}	49.32^{a}	2.36	0.00
NDF	45.53^{a}	41.76^{ab}	43.09^{ab}	37.71^{b}	46.91^{a}	0.96	0.00
ADF	55.74	51.29	61.24	56.01	56.02	1.50	0.35

[a-b]means within a row with the same superscript are not significantly different at p<0.005; Standard Error of Mean; DM: Dry Matter; CP: Crude Protein; OM: Organic Matter; NDF; Neutral Detergent Fiber; ADF; Acid Detergent Fiber.
T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5: treatment five

Significantly (p<0.00) higher apparent OM digestibility percentage in sheep fed on T4, whereas significantly lower apparent OM digestibility percentage was observed in T2. The lower apparent DM and OM digestibility for sheep in T1 might be attributed to the NDF and ADF content in BSB and WB. The result of the present study indicated that substitution of NSC protein with the BSB up to 100% and substitution of NSC with BSB up to 75% will affect the apparent digestibility of DM and OM. The level of apparent digestibility of diets in this study is an indication of improvement of digestibility of DM and nutrients of fibrous feed achieved due to protein source experimental diet. This is for the result of secondary plant metabolites found in the experimental forage.

The apparent CP digestibility percent value of T3. T4 and T5 are the highest (49.35%) was the highest, whereas T1 (29.62%) showed the lowest. The higher CP digestibility in T3 followed by T5 and T4 could be due to higher digestible CP content of NSC since high CP intake is usually associated with better DM digestibility. On the other hand, the CP digestibility decreased with increasing levels of BSB beyond 50% supplementation. Digestibility of CP generally increases as CP intake increases because metabolic fecal nitrogen is inversely related to CP intake and is higher at lower intake than at higher intake (Katongole and Yan, 2020). Thanh *et al.*, (2021) partially replaced concentrate at three different levels of jackfruit and observed decreased CP digestibility with increased levels of jackfruit leaves. In concur with this study, Mamo, (2021) reported that protein source feed supplementation in sheep diet will increase crude protein digestibility. According to Jooste, (2012), the high fiber and low CP contents of low quality forages are expected to result in low apparent digestibility of nitrogen.

The CP digestibility percent values observed in this study ranged from 29-49% which were lower than the digestibility values (68.2–71.9%, 73.8%), respectively reported by Mengistu *et al.,* (2020) and Melesse e*t al.*, (2018) for substitution of concentrate mix (noug seed cake and wheat bran) with dried mulberry leaf meal for Tigray lambs. The variation in CP digestibility might be due to the nutritional composition of the feed and animal type.

The digestibility of NDF was significantly ($p < 0.05$) different among the experimental diets where T1 and T5 showed the highest digestibility. In line with this study, Yigzaw *et al.,* (2019) reported that the apparent digestibility of NDF was increased by supplementation of protein source feed (lentil hull and NSC) compared to control group. In contrary with this study, Abebe, (2012) reported absence of significance difference on digestibility of NDF between the supplemented and non-supplemented group in Farta and Tigray highland sheep, respectively

4.4 Effect of Experimental Feed on Growth Performance of Sheep

Mean values of initial body weight, final body weight, body weight change, average daily gain, and feed conversion efficiencies of experimental animals are shown in Table 7. There was significance difference ($p<0.01$) among treatments on all evaluated growth performance of sheep. Significantly ($p<0.01$) higher body weight gain was recorded from group of sheep fed on T3 followed by T5 compared to other treatment groups. Similarly, significantly ($p<0.05$) higher body weight change was recorded from sheep fed on T3 compared to the rest of treatment groups. This indicated that replacement of NSC up to 75% with BSB would improve final body weight of sheep. Similarly, higher body weight change was recorded from sheep fed on T3 diet. The average final body weight ranging from 35-42 kg observed in the current study higher to the values of 18-21 kg for sheep fed on different Proportions of Ficus spur Fruits and Oats (Avena sativa) grain supplementation observed by Diriba and Mengistu Urge, (2018). The differences in body weight change and daily body weight gain among treatments in the current study could be due to the differences in the amount of daily DM intake and digestibility of the feed intake. Sheep which received T1 (100% BSB and 0% NSC) had lower total body weight change (4.8 kg), and this value was slightly lower than 6 kg as reported by Yirga *et al.*, (2017) that body weight change for local sheep fed with dried mulberry leaves at 1.5 and 2.5% body weight, respectively.

Significantly, higher ($p<0.01$) average daily feed intake was recorded from sheep fed on T2 compared to others. On the other hand, significantly lower average daily feed intake was observed in sheep fed on T5 followed by T4. The improved average daily feed intake recorded from T3 could be due to the equal proportion of NSC, and BSB in sheep diet compared to other treatments. The mean daily feed intake of sheep received experimental diet in the current study was lower than the value reported by Yosefe *et al.*, (2017) who reported the average daily feed intake (938g) of sheep fed on roasted *Brugmansia suaveolens*leaf. The variation of daily feed intake could be due to the treatment methods (roasting technique) of *Brugmansia suaveolens*leaf to improve feed intake.

Table 7. Effect of experimental feed on growth performance and Feed conversion efficiency of Bonga Sheep under intensive management system

Variables	Treatments					p-value
	T1	T2	T3	T4	T5	
Initial body weight (kg)	30.8±0.2	30.0±0.0	31.0±0.6	31.6±0.3	29.0±0.6	0.01
Final body weight (kg)	35.7±0.4^{c}	38.9±0.4^{b}	41.5±0.6^{a}	38.2±0.5^{a}	37.4±0.3^{bc}	0.00
Body weight change (kg)	4.8±0.3^{c}	8.9±0.4^{b}	10.5±0.0^{a}	8.4±0.2^{b}	8.4±0.4^{b}	0.00
Average daily weight gain (g)	52.0±0.8^{c}	98.8±0.5^{b}	106.3±0.9^{a}	100.3±1.2^{b}	101.3±1.7^{ab}	0.01
Average daily feed intake (g)	843.3±4.4^{b}	875.3±3.2^{a}	862.7±1.7^{a}	827.3±0.0^{c}	806.7±1.8^{d}	0.00
Feed c conversion efficiency	0.06±0.0^{c}	0.11±0.0^{b}	0.12±0.0^{a}	0.12±0.0^{a}	0.12±0.00^{a}	0.00

$^{a\text{-}b}$means within a row with the same superscript are not significantly different at $p<0.005$.
T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5: treatment five

Average daily weight gain was significantly ($p<0.05$) influenced by different experiential treatment as shown in Table 7. Unlike with the current study result, Abdel Hameed *et al.*, (2013) fed different sources of protein (cotton seed cake, sesame seed cake, groundnut cake and sunflower seed cake) to sheep and observed similar weight gain among the different sources. On the other hand, Thanh et al., (2021) partially replaced concentrate at three different levels (0, 25 and 50%) with jackfruit and observed lower body weight gain at the highest level of replacement. Likewise, Saeed *et al.*, (2019) supplemented rice straw at 0.5, 1.0 and 1.5% of the body weight of sheep and observed weight loss at 0.5% whereas weight gain was observed at high levels of supplementation with no significant difference among the higher levels.

Significantly higher average daily weight gain was recorded from sheep fed on T3 compared to the rest of treatment group. On the other hand, significantly ($p<0.05$) lower ADG observed in T1 groups. The increased ADG in T3 might be explained by the higher total dry matter and crude protein intake compared to other groups. The variation in average daily weight gain might be resulted from sheep supplementation with NSC that had better DM and OM intake and nutrient digestibility Furthermore, this difference might also be resulted from the relatively higher bypass protein content in NSC than BSB. Sebsibe, (2008) in their study on evaluation of supplement feeds indicated that feeds such as oilseed cakes have large proportion of the protein bypasses to the small intestine without being solubilized in the reticulo-rumen and this improves use of dietary protein more efficiently. The above authors also agreed that crude protein from forage has intermediate rumen solubility. The level of intake and digestibility of experimental diets could determine animals' performances (Guimarães *et al.*, 2014).

The result of the current experiment agrees with many previous studies Mengistu *et al.* (2020); Yigzaw *et al.* (2019) in which supplementation of digestible crude protein source feed in sheep could improve final body weight, body weight change and average daily gain. Forage to concentrate ratio was reported to affect average daily gain where increasing the concentrate portion increased average daily gain, improved feed conversion efficiency and carcass characteristics in kids (Chaudhary *et al.*, 2015). The average daily weight gain observed in the current study ranged from 52-106g/day were higher than the value 56-87g/day reported by Mengistu *et al.*, (2020) who did substitution of noug seed cake with dried mulberry and Vernonia amygdalina leaves in the diets of Bonga sheep. On the other hand, Saro *et al.*, (2020) reported that the mean ADG of sheep fed on different proportion of protein source feed ranged from 221-297g/day which is higher than the current study result. The modest weight gain in sheep fed BSB indicates that in areas where noug seed cake is not available especially for smallholder farmers, BSB could be used as a CP supplement.

Significantly ($p<0.05$) lower mean value of feed conversion efficiency was observed from sheep fed on T1compared to the rest of treatment groups. The lower mean value of feed conversion efficiency was the indication if improved feed conversion efficiency. These results indicated that diets that have higher digestibility values result in higher final body weight gain, average daily gain and lower feed conversion efficiency value. From this study, we concluded that sheep fed on T1 (100% BSB and 0% NSC) showed improved feed conversion efficiency which could be due to the animals in T1 produced higher weight gain even their feed intake was minimal. The results of this experiment indicated that substitution of NSC with BSB up to 50% improved feed intake partly as the result of increased digestibility due to the supply of sufficient CP and/or energy that enhanced microbial multiplication and activity, with consequent increase in ADG and FCE.

4.5 The effect of Experimental diet on haematological variables of Bonga sheep

Table 8 presents the hematological variables of Bonga sheep fed diets with varying levels of BSB replacing NSC. Red Blood cell (RBC) count, White Blood Cell (WBC) count, hemoglobin concentration, and packed cell volume (PCV) were among the key hematological parameters evaluated. Substitution of NSC with BSB did not significantly affect ($P > 0.05$) most of the measured hematological parameters, with the exception of red blood cell count. The T3 group had a significantly higher ($P < 0.05$) RBC count with a mean value of 13.45 g/dL compared to other treatment groups. Additionally, the mean RBC value aligns with the 13.7 g/dL reported by Ayele *et al.* (2017) for fat-tailed sheep fed different levels of concentrate supplement. However, Io (2018) reported a lower total erythrocyte (RBC) count of 6.98 g/dL in sheep fed a diet containing 75% mango kernel meal. The mean RBC counts observed across all treatment groups fell within the normal reference range of 9-15 reported by Radostits *et al*. (2006) and Kerr (2008). These normal ranges for RBC differentials in this study suggest that the experimental sheep were not anemic.

Table 8. The effect of *Brugmansia suaveolens* Brecht on hematological variables of sheep under intensive management system

Variables	Treatments					p-value
	T1	T2	T3	T4	T5	
RBC (g/dl)	9.10±0.60[ab]	10.05±0.25[ab]	13.45±1.15[a]	6.25±2.14[b]	9.08±0.14[ab]	0.04
WBC ($X10^9$/l)	5.69±0.70	5.63±.15	4.24±1.54	5.05±1.25	5.13±0.80	0.88
Hemoglobin (g/dl)	7.68±0.82	12.50±1.00	13.95±1.65	8.20±1.59	9.60±1.00	0.06
Packed cell volume (%)	33.55±3.85	38.20±4.10	38.95±2.45	27.45±2.15	30.70±1.40	0.15

[a-m]eans within a row with the same superscript are not significantly different at p<0.005. T1: treatment one, T2: treatment two; T3 ; treatment Three ; T4 :, treatment four; T5 : treatment five

Significant difference (P > 0.05) in the white blood cell count of sheep across treatments was observed. This finding aligns with Brant *et al.* (2021) who reported minimal dietary influence on WBC count. However, Saeed *et al*. (2019) observed significant differences in WBC among sheep fed various experimental diets. The WBC count in the experimental sheep ranged from 4.24-5.69 x 10^9/L. This is lower than the values (7.30-8.45) reported by Tulu et al. (2022) for Hararghe highland lambs exposed to saline water. Additionally, Amam *et al*. (2023) reported a WBC range of 2.17-2.56 for sheep fed ensiled coffee skin as a replacement for dried water spinach. Variations in WBC count can be attributed to factors such as geographical location, nutritional status, age, and sex of the animals. Stress can also cause the release of corticosteroids or epinephrine, temporarily elevating WBC count (Oliveira *et al.*, 2014). The observed WBC range fell between 6.13-22.10 x 10^3/µL. According to Scott *et al*. (2006), the normal WBC count in sheep blood is typically between 5-11 x 10^3/µL. This suggests the sheep in this study had an active immune system, indicating good overall health.

The major functions of the white blood cell and its differentials are to fight infections, defend the body by phagocytosis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response (Zhu and Su, 2022). Thus, animals with low white blood cells are exposed to high risk of disease infection, while those with high counts are capable of generating antibodies in the process of phagocytosis and have high degree of resistance to diseases Soetan *et al.,* (2013) and enhance adaptability to local environmental and disease prevalent conditions (Isaac *et al.,* 2013).

Experimental feeds have non-significant (p>0.05) effect on hemoglobin concentration sheep. In line with this result, Jiwuba *et al.,* (2022) supplementation of Pleurotus tuber-regium treated cassava root sievate based diets had non-significant effect on hemoglobin concentration of west African dwarf goat. Numerically higher concentration of hemoglobin was recorded from T3 followed by T2. Hemoglobin concentration of experimental sheep fed on substation of different level of NSC with BSB was found between the ranges of 7.68-13.95g/dL, which is within the normal range for sheep. The hemoglobin range reported herein was within the physiological ranges of 7–15 g/dl and 8-16 g/dl for clinically healthy west Africa dwarf goats reported by Daramola *et al.,* (2005) and Olaifa and Opara, (2011), respectively. The normal references range of hemoglobin of sheep was found between 9-15g/dL. Increased level of hemoglobin concentration is attributed to ability to tolerate infection and good nutritional status as well as breed of animals (Joy *et al.,* 2020). Furthermore, the Hb concentration of Bonga sheep on the diets could indicate that the dietary proteins were of good quality.

The mean packed cell volume (PCV) observed in the current study was found within the normal reference range (27-45%) of sheep (Radostits *et al.*, 2006; Kerr, 2008). Treatment effect was found to have non-significant (p>0.05) effect on packed cell volume. In agreement with this finding, Io, (2018) reported that diet has no significant effect on PCV value of sheep. Similarly, Saeed *et al*., (2019) reported that feed supplementation had non-significant effect on PCV value of small ruminants. PCV essentially measures the ratio of the volume of RBC to that of the whole blood in a sample (Osman *et al.*, 2023). The range of PCV value recorded from the current study (27.45-38.95) was comparable with the value (30.43-32.27) reported by Tulu *et al.,* (2022). In contrary with the current study, Jiwuba *et al.,* (2022) reported the lower packed cell volume (PCV) ranged from 24.90 to 29.49% of West African dwarf goats fed Pleurotus tuber-regium treated cassava root sievate based diets. The variations in the blood profile occurred as time elapsed, which is due to changes in physiology resulting in the growth of ruminants *Daramola et al.,* (2005) where it was found that the age of farm animals affects their hematological parameters.

4.5 The effect of Experimental diet on serum profiles of Bonga sheep

Table 9 presents the serum biochemical variables of Bonga sheep fed diets with varying levels of BSB replacing NSC. The substitution of NSC with BSB at any level did not significantly affect (P > 0.05) any of the measured serum clinical biochemistry parameters. The concentrations of blood serum biochemical markers observed in this study were generally consistent with values reported in the literature, with minor variations. These differences could be attributed to factors like breed of sheep, geographical location (agro-ecology), management practices, and feeding conditions. Serum aspartate aminotransferase (AST) activity in sheep fed the experimental diets ranged from 98.44-115.80 U/L. This normal range for AST suggests a high-quality diet and no evidence of hepatocellular damage (liver cell injury) in the sheep. Although statistically non-significant, numerically higher values were observed in T4 and T3 compared to other treatments. Our findings align with Kiran *et al*. (2012) who reported AST values of 103.2-118.0 U/L in healthy sheep in Pakistan, and Rahman *et al*. (2018) who found AST levels of 99.46-120.09 U/L in indigenous sheep (Ovies aries) from Bangladesh. As a reminder, AST is an enzyme primarily found in the liver and heart muscles, playing a crucial role in amino acid metabolism (Otto-Ślusarczyk *et al*., 2016).

The average serum ALT activity observed in this study was higher than those reported by Daramola *et al*. (2005) (8.9±0.9) for West African dwarf goats and Soch et al. (2010) (10.0±1.1) for sheep. Interestingly, Mostaghni *et al*. (2005) reported a higher ALT value (29.15±3.20) in wild sheep from Iran compared to the present findings. Elevated ALT and AST levels can sometimes be attributed to increased gluconeogenesis (sugar production) from protein sources, potentially stressing the liver (Gjorgjieva *et al*., 2019). Heat stress can also have a negative impact on liver function (Rathwa et al., 2017). Stress in general can affect transaminase activity in livestock (Liu *et al*., 2022), with even strenuous exercise reported to increase ALT levels (Berzosa *et al.*, 2011). Therefore, sudden or prolonged stress could explain changes in enzyme activity due to increased stimulation by corticosteroids. Mirmiran *et al*. (2019) suggest that higher serum levels of AST or ALT in any species might be linked to a lower tolerance for heat. In conclusion, while the ALT values in this study were slightly higher than some previously reported values, they remained within the normal range, indicating healthy liver function in the sheep. Factors such as increased protein metabolism or potential heat stress during the experiment warrant further investigation.

Serum ALP activity in the current study ranged from 112-135 U/L, with an average value of 125.05 U/L. This aligns with the findings of Saeed et al. (2019) who reported no significant differences in serum ALT, ALP, and AST levels between treatment groups. While statistically non-significant, T3 sheep exhibited a numerically higher ALP value compared to other groups. However, the mean ALP level observed in this study is considerably higher than the value (151-163 U/L) reported by Saeed *et al*. (2019) for lambs fed a basal diet of urea-treated rice straw supplemented with corn as an energy source. The reasons for the discrepancy in ALP values between this study and Saeed *et al*. (2019) are unclear and require further investigation.

The maximum and minimum creatinine value observed was 0.74±0.06mg/dL and 0.58±0.13mg/dL in T1 and T4 respectively. As indicated in the Table 9, different treatment level have non-significant ($p>0.05$) effect on creatinine level of sheep. The creatinine level recorded from the current study was lower than the value reported by Persaud *et al.*, (2021) (0.76-1.45mg/dl) and Ayele *et al.*, (2017) (1.0-1.0mg/dL). However, in general the level of creatinine was found lower than the normal reference values of ovine species (1.2-1.9mg/dL (Oliveira *et al.*, 2014). Reduction of CREAT concentration in blood is an indicator of high protein and amino acid metabolism that may be due to supplementation of low energy rich feeds (low quality feeds). In animals, creatinine levels are directly related to muscle mass and kidney function (Patel *et al.,* 2013). The results also show that the Bonga sheep consume enough protein from their diet.

Total Cholesterol (mg/dl) of sheep fed on NSC substitution with BSB was ranged from 64-73 which was found within the normal reference level (52-76mg/dl) for sheep. Because a high amount of serum cholesterol is a sign of heart-related disease, the findings of the study suggest that the sheep were normal and not susceptible to heart diseases. The mean cholesterol level (mg/dL) of sheep recorded from the current study was much lower than the finding of Kiran et al., (2012) who reported (98.5±14.8) from Southern Punjab in Pakistan. Similarly high cholesterol concentration in sheep was reported by Devendran et al., (2009) in Coimbatore sheep (81.81±5.17) and K *et al.*, (2009) for Awassi sheep (87.00±3.40).

Dietary substitution of NSC with BSB did not significantly affect total protein concentration ($P > 0.05$) in the experimental sheep. While Tsheole and Mwanza (2022) reported significant changes in total protein concentration of Tswana goats with protein supplementation over time, this study did not observe a similar effect. Numerically, the highest TP value was recorded in the T1 group (0% NSC + 100% BSB) compared to other treatments. The total protein level observed in this study (7.91 g/dL) was considerably higher than the values reported by Tulu *et al*. (2022) (6.06 g/dL) and Osman *et al*. (2023) (5.89 g/dL) for Bonga sheep. Previous research has shown that B. suaveolens possesses medicinal, antioxidant, pharmacological, and immunity-boosting properties (Costa *et al*., 2023). The observed albumin levels in this study (1.70-3.18 g/dL) were comparable to those reported by Rahman *et al.* (2018) (2.4-3.2 g/dL) for indigenous sheep in Bangladesh and Amatya Gorkhali *et al.* (2017) (2.6-3.5 g/dL) for indigenous sheep in Nepal. These values fall within the normal physiological range, suggesting that the diets provided adequately for rumen microbial protein requirement.

Table 9. The effect of BSB on serum clinical biochemistry of sheep under intensive management system

Variables	Treatments					p-value
	T1	T2	T3	T4	T5	
AST (U/L)	98.74±0.35	98.44±16.05	110.65±14.35	115.80±5.20	101.75±10.64	0.74
ALT (U/L)	19.83±2.53	15.19±2.87	22.50±4.10	23.92±2.22	19.18±1.17	0.33
ALP (U/L)	203.83±11.27	145.43±32.87	218.85±16.55	205.08±2.96	202.07±16.16	0.18
CREA (mg/dl)	0.74±0.06	0.59±0.05	0.59±0.04	0.58±0.13	0.69±0.11	0.61
DBIL (mg/dl)	0.04±0.01	0.05±0.01	0.04±0.00	0.02±0.01	0.03±0.01	0.39
TBL (mg/dl)	0.15±0.03	0.14±0.02	0.11±0.03	0.13±0.01	0.11±0.00	0.77
Total Cholesterol (mg/dl)	71.72±2.52	73.95±11.65	70.45±5.15	73.92±2.62	64.38±0.13	0.77
TRIG (mg/dl)	25.49±2.05	29.84±5.51	26.00±3.30	22.75±0.74	25.78±3.45	0.71
HDL (mg/dl)	44.38±0.94	42.63±7.51	41.60±2.70	40.12±1.17	39.15±0.07	0.85
LDL (mg/dl)	23.84±3.54	20.50±0.59	22.94±3.25	24.35±0.55	20.88±3.24	0.78
Glucose (mg/dl)	41.90±3.80	29.79±3.61	35.90±2.70	37.11±4.99	41.11±0.01	0.23
Total Protein (g/dl)	9.06±0.13	7.78±0.18	8.01±0.40	7.15±0.70	7.56±0.37	0.13
Albumin (g/dl)	2.18±0.41	1.70±0.41	3.18±0.77	2.56±0.55	2.10±0.02	0.39

AST=Serum aspartate aminotransferase ALT=Alanine aminotransferase DBIL=direct bilirubin TBL =total bilirubin HDL=high density lipoprotein, LDL= low density lipoprotein. TRIGL =Triglyceride ALP; serum alanine phosphate CREA; creatinine
T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5: treatment five

4.6 Partial Budget Analysis

The partial budget analysis of Bonga sheep fed under different treatments is presented in Table 10. The difference in the net return and rate return among dietary treatment groups were due to the quality feed perform, better feed conversion efficiency, body weight gain, and difference in feed cost and selling price of the animals. Based on total variable costs, purchasing and selling price of sheep, the higher total income was gained from sheep supplemented with 50% NSC and 50% BSB. The partial budget analysis also demonstrated that T3 (50% NSC + 50% BSB) had higher net return and rate return due to higher body weight gain, body condition of sheep and the prices of experimental feeds as compared to the other treatments. Therefore, T3 was better as compared to the other feeding options. However, the use of either diet depends on the availability and cost of feed ingredients. The value of MRR in the present study is found to be positive for all the treatments except T4 and T5. As can be observed from the results of feed intake, digestibility, body weight change and feed conversion efficiency in the present study, and based on most of the parameters (net income, total rate of return and marginal rate of return) considered in partial budget analysis, combination of the two supplements in equal proportions as in T3 appeared to be recommendable.

Table 10. Partial budget analysis of sheep fed different experimental diet

Parameter	Unit	Treatment				
		T1	T2	T3	T4	T5
Purchasing price of lambs	ETB/head	3080	3000	3100	3400	2900
Total basal feed consumed	Kg/head	46	46	46	46	46
Total BSB dried leave consumed	Kg/head	19.8	14.8	9.9	4.95	0
Total NSC consumed	Kg/head	0	2.7	5.4	8.1	10.8
Total WB consumed	Kg/head	16.2	16.2	16.2	16.2	16.2
Total feed consumed	Kg/head	82	79.7	77.5	75.25	73
Cost of basal feed consumed	ETB/head	46	46	46	46	46
Cost of BSB dried leave consumed	ETB/head	148.5	111.375	74.25	37.1	0
Cost of NSC consumed	ETB/head	0	108	216	324	432
Cost of WB consumed	ETB/head	186	186	186	186	186
Total Variable cost	ETB/head	383.5	451.375	522.25	593.1	664
Gross income /Selling price of lambs/	ETB/head	3500	3890	4150	4210	3740
Total return (TR)	ETB/head	420	890	1050	910	840
Net return (NR)	ETB/head	36.5	438.625	527.75	316.9	176
Change in total return	ETB/head	0.0	470	160	-140	-70
Change in total variable cost	ETB/head	0.0	67.875	70.875	70.85	70.9
Change in net return (ΔNR)		0.00	402.125	89.125	-210.85	-140.9
Marginal rate of return (MRR)		0.0	5.92	1.257	-2.976	-1.987

ETB = Ethiopian Birr, T1 = Natural pasture hay adlib + 180g WB+ 0%NSC+100%BSB, T2 = Natural pasture hay adlib + 180g WB+ 25%NSC+75%BSB, T3 = Natural pasture hay adlib + 180g WB+ 50%NSC+50%BSB, T4 = Natural pasture adlib + 180g WB+ 75%NSC+25%BSB, T5 = Natural pasture hay adlib + 180g WB+ 100%NSC+0%BSB T1: treatment one, T2: treatment two; T3; treatment Three; T4: treatment four; T5 : treatment five

5. CONCLUSION AND RECOMMENDATION

This study investigated the effects of substituting noug seed cake (NSC) with *Brugmansia suaveolens* Bercht (BSB) on feed intake, nutrient digestibility, growth performance, and blood parameters in Bonga sheep. The results demonstrated that replacing NSC with BSB up to 50% level significantly improved dry matter intake, crude protein intake, organic matter intake, apparent dry matter digestibility, and digestibility of crude protein, organic matter, and neutral detergent fiber. Final body weight, body weight gain, average daily weight gain, and average daily feed intake were also significantly enhanced with BSB supplementation up to 75% However, increasing BSB beyond this level resulted in decreased growth performance and feed intake. Substitution of NSC with BSB did not significantly affect most hematological and serum biochemical parameters except for red blood cell count. These findings suggest that BSB can be a valuable feed resource for smallholder farmers. It can be used as an economical and locally available replacement for expensive noug seed cake, particularly at inclusion levels up to 75% or interaction both ingredient at equal proportion is satisfy animals nutrient requirement also economically viable. It was a potential protein supplement in animal feed due to its protein content and positive impact on dry matter intake and digestibility. Disseminating knowledge on the use of BSB as a sheep feed is crucial. Farmers should be advised as they use BSB for their animal feed with equal interaction of NSC and also farmers should be oriented focus to cultivate this plant at back yard for their animal feed because this plant ever green and drought tolerant plant when grasses dry up and deteriorate both in quality and also quantity. Further study should be done on carcass quality and medicinal value of forage for farm animals.

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7. APPENDIX

Appendix ANOVA Table 1: ANOVA table for daily dry matter and nutrient intake

Dependent variables	Source	SS	DF	Mean Square	F	Sig.
CP	Treatment	7504.434	4	1876.109	41.531	0.000
	Error	451.733	10	45.173		
	Total	7956.168	14			
OM	Treatment	2976.817	4	744.204	30.048	0.000
	Error	247.670	10	24.767		
	Total	3224.487	14			
NDF	Treatment	21502.220	4	5375.555	1393.458	0.000
	Error	38.577	10	3.858		
	Total	21540.797	14			
ADF	Treatment	6252.940	4	1563.235	1.536	0.265
	Error	10179.700	10	1017.970		
	Total	16432.640	14			
DM	Treatment	8446.472	4	2111.618	102.373	0.000
	Error	206.267	10	20.627		
	Total	8652.739	14			

Appendix ANOVA Table 2: ANOVA table for apparent dry matter and nutrients digestibility

Dependent variables	Sources	Sum of Squares	df	Mean Square	F	Sig.
CP	Treatment	1064.112	4	266.028	24.515	0.000
	Error	108.515	10	10.851		
	Total	1172.627	14			
OM	Treatment	182.026	4	45.507	12.101	0.001
	Error	37.606	10	3.761		
	Total	219.633	14			
NDF	Treatment	153.662	4	38.415	9.352	0.002
	Error	41.079	10	4.108		
	Total	194.740	14			
ADF	Treatment	158.947	4	39.737	1.256	0.349
	Error	316.447	10	31.645		
	Total	475.394	14			
DM	Treatment	65.524	4	16.381	10.020	0.002
	Error	16.348	10	1.635		
	Total	81.871	14			

Appendix ANOVA Table 3: ANOVA table for growth performance

Dependent variables	Sources	Sum of Squares	Df	Mean Square	F	Sig.
IBW	Treatment	36.256	4	9.064	18.676	0.000
	Error	4.853	10	.485		
	Total	41.109	14			
FBW	Treatment	87.291	4	21.823	36.574	0.000
	Error	5.967	10	.597		
	Total	93.257	14			
BWC	Treatment	52.096	4	13.024	47.303	0.000
	Error	2.753	10	.275		
	Total	54.849	14			
DWG	Treatment	6018.731	4	1504.683	403.040	0.000
	Error	37.333	10	3.733		
	Total	6056.064	14			
FCR	Treatment	.009	4	.002	298.592	0.000
	Error	.000	10	.000		
	Total	.009	14			
ADFI	Treatment	8993.600	4	2248.400	86.036	0.000
	Error	261.333	10	26.133		
	Total	9254.933	14			

Appendix ANOVA Table 4: ANOVA table for hematological variables

Dependent variables	Sources	Sum of Squares	df	Mean Square	F	Sig.
Hemoglobin	Treatment	59.736	4	14.934	4.703	0.060
	Error	15.878	5	3.176		
	Total	75.614	9			
PCV	Treatment	191.746	4	47.937	2.710	0.152
	Error	88.435	5	17.687		
	Total	280.181	9			
WBC	Treatment	2.732	4	.683	.267	0.888
	Error	12.803	5	2.561		
	Total	15.535	9			
RBC	Treatment	53.467	4	13.367	5.250	0.049
	Error	12.731	5	2.546		
	Total	66.198	9			

Appendix ANOVA Table 5: ANOVA table for serum clinical biochemistry

Dependent variables	Sources	SS	DF	Mean Square	F	Sig.
AST	Treatment	482.487	4	120.622	.499	0.740
	Error	1208.409	5	241.682		
	Total	1690.896	9			
ALT	Treatment	90.735	4	22.684	1.502	0.329
	Error	75.514	5	15.103		
	Total	166.249	9			
ALP	Treatment	6511.249	4	1627.812	2.328	0.190
	Error	3496.396	5	699.279		
	Total	10007.645	9			
CREA	Treatment	.043	4	.011	.725	0.611
	Error	.074	5	.015		
	Total	.117	9			
DBIL	Treatment	.000	4	.000	1.258	0.395
	Error	.000	5	.000		
	Total	.001	9			
TBL	Treatment	.002	4	.001	.444	0.774
	Error	.006	5	.001		
	Total	.008	9			
TOTCHOL	Treatment	123.561	4	30.890	.440	0.777
	Error	351.059	5	70.212		
	Total	474.620	9			
TRIG	Treatment	51.234	4	12.809	.552	0.708
	Error	116.000	5	23.200		
	Total	167.234	9			
HDL	Treatment	33.930	4	8.482	.322	0.853
	Error	131.918	5	26.384		
	Total	165.848	9			
LDL	Treatment	24.072	4	6.018	.438	0.778
	Error	68.708	5	13.742		
	Total	92.780	9			
GLUC	Treatment	188.033	4	47.008	1.970	0.238
	Error	119.325	5	23.865		
	Total	307.358	9			
TOTPRO	Treatment	4.102	4	1.026	3.015	0.129
	Error	1.701	5	.340		
	Total	5.803	9			
ALBUMIN	Treatment	2.510	4	.628	1.266	0.393
	Error	2.479	5	.496		
	Total	4.990	9			