Volume 2 Issue 1
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ES Veterinary Medicine and Animal Science

Replacement Effect of Noug-Cake with *Lablab Purpureus* Seed on Biological Performance of Woyito-Guji Goat Fed a Basal Diet of Haricot Bean Haulms

Research Article

DOI: 10.59152/ESVMAS/1004

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Received: May 20, 2023; **Accepted:** May 29, 2023; **Published:** May 31, 2023

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Abstract

Objective: This study aimed to investigate the replacement effect of noug-cake (NC) with lablab purpureus seed (LPS) on biological performance of Woyito-Guji goat.

Material and Methods: About 24 intact male Woyito-Guji bucks having a preliminary weight of 17.34kg were allocated to one of the 4 investigational treatments in a randomized complete block design (RCBD). The investigational treatments used were; haricot bean haulms (HBH) *ad-libitum*+ 18% of wheat bran (WB)+23% of maize (MG)+24% of sorghum (SG)+20% of NC+12% of sunflower seed (SFS) +1.5% of common salt and+1.5% of limestone (T_1), HBH *ad-libitum*+18% of WB+22% of MG + 20% of SG+15% of NC+12% of SFS + 10% of LPS+1.5% of common salt + 1.5% of limestone(T_2), HBH *ad-libitum*+20% of WB +23% of MG + 22% of SG+ 5% of NC+12% of SFS + 15% of LPS +1.5% of common salt and+ 1.5% of limestone (T_3), and HBH *ad-libitum*+18% of WB + 23% of MG + 24% of SG +12% of SFS+ 20% of LPS+1.5% of common salt + 1.5% of limestone (T_4).

Results: The total-dry-matter and crude protein consumption, and nutrient digestibility were higher (p<0.001) for bucks consumed the T_1 and T_4 over the bucks consumed the T_2 and T_3. Similarly, goats consumed T_1 and T_4 gained more (p<0.001) average-daily-gain (ADG), hot carcass weight (HCW), and rib eye muscle area (REMA) than bucks that given T_2 and T_3.

Conclusion: The findings from this investigation pointed-out that replacing NC with roasted LPS at a 20% inclusion level in goat rations improved biological performance of goat.

Keywords: Carcass, Digestibility, Feed Intake, Weight Gain, Woyito-Guji Bucks.

Introduction

Small ruminants, particularly goats, have played an important role in the livelihoods of smallholder rural communities in Ethiopia, providing meat, milk, income, and foreign exchange [1,2]. However, goat husbandry practice is solely based on rangeland forages, which have insufficient in nutrient supply to meet nutritional requirements of goats particularly during dry periods for high level of production [3,4]. Likewise, the Woyito-Guji goats, one of Ethiopia's genetically defined goat breeds, have impacted by poor nutrition, which is exacerbated by climate changeability events [3,5]. As a result, goat growth performance is slow and takes a long time to attain marketable weight [6]. It has been evidenced that by using a scientifically proven goat feeding system, goats reach maturity early, which has a significant impact on goat producers' income and profitability and goat producers can sell their goats as early as six to eight months of age [6]. In this context, one suggested strategy for overcoming poor nutrition and feeding system and maximizing the use of roughage-based diets is use protein-rich diets [7]. Noug-cake (NC) is one of an industrial waste product that is widely used in Ethiopia in goats' diets as a protein supplement to maximize usage of roughage-based diet [8]. However, the use of NC as a protein supplement in goat ration in marginalized area of Ethiopia like South Omo is debatable because the NC processing industry is concentrated in the central part of Ethiopia, which makes NC inaccessible to goat producers [8].

Moreover, the transportation costs of NC from the production site to pastoral areas are comparable to the selling price of NC at the production site [9]. In this concern, the finding the low-cost and locally available protein supplements, as well as their appropriate substitution level with NC is ideal for solving nutritional impediments and thus, improved productivity of goats. The *Lablab purpureus* (LP) is annual legume forage with seed yields ranging from 500 to 1000 kg/ha and has a crude protein (CP) content ranged from 20%~28%, with dry-matter-degradability ranging from 55~76.6% [7,10]. It was conveyed that using LP seed and leaf instead of industrial-cakes as a protein supplement in the goat rations improved biological performance of goats [7,11]. Additionally, the research report, communicated by [7] from the study area, suggests that including 35% LP hay meal in the Woyito-Guji goat ration enhances the biological performance and carcass yield of goats. However, the effect of varying amounts of LPS replacement with NC on the biological performances of Woyito-Guji goats have not been investigated for future usage by pastoralists and agro-pastoral communities as local alternative protein supplements to boost goat output. Therefore, the aim of current investigation is to evaluate the effect of replacing different levels of NC with LPS on the biological performances of intact male Woyito-Guji bucks.

Materials and Methods

Description of trial site

The goat feeding trial was conducted at Bena-Tsemay district (Key-Afer) Goat Research Sub-center from September to November 2021. The sub-center is located at $5^0$01'0'' and $5^0$73'0'' North and $36^0$38'0'' & $37^0$07'0'' East direction. The site's microclimate ranges from arid to hot semi-arid, with an elevation of 1500m above sea level [12]. Site experiences bimodal rainfall, by which a substantial rain begins from March to May and a light rain period from September to October with average rainfall 1400mm and average annual temperature ranged from 15.60C to 260C. The rangeland is dominated by acacia species in varying densities, as well as over 35 herbaceous grasses and legumes [12].

Experimental diet preparation

Maize (MG), sorghum (SG), sunflower (SF), wheat bran (WB), LPS, and NSC were used to make the experimental diet. The NSC and WB were obtained from the Aribaminch town, the LPS and SFG from the JARC, and the MG and SF purchased from the Jinka local market. LPS was roasted in water that boiled at 100°C for 15 minutes to reduce anti-nutritional factors and increase nutrient bioavailability to goats [13]. The experimental ingredients were then milled and mixed at the JARC on-station using a livestock feed processing machine to meet the tropical nutrient requirements of goats [14]. HBH was collected from JARC and sliced into 3-5cm size using a chopping machine to increase goat intake, and goats were allowed to feed ad-libitum by taking 15% left-over of treatment as recommended by [7].

Investigational goats and design

About 24 Woyito-Guji bucks have an average preliminary weight of 17.34kg were purchased from the local market and ear-tagged and kept in quarantine for observation of parasites and diseases which are suspected to be in the study area. After the quarantine periods, all experimental bucks were vaccinated with Oxtetracycline-20% to control respiratory diseases and Ivermectin1% to control internal and external parasites. Then all bucks were grouped into 4 blocks of six bucks based on preliminary weight and housed in separate Pens having size of 5 meter by 2 meter ($10m^2$) that constructed from woods, which were collected nearby browsing area [7]. The groups of bucks per block were randomly allocated to one of the 4 investigational diets in a Randomized Complete Block Design (RCBD), and there was an acclimatization period of 15 days (August1st–15th, 2021) to acquaint the bucks with the investigational diet and the trial Pens. The investigational diets were given twice a day 10:00

AM in the morning and 4:00 PM afternoon, and all bucks had free admittance to the basal diet and clean water at all times. The investigational diets used in this study were; HBH *ad-libitum*+ 18% of WB+23% of MG+24% of SG+20% of NC+12% of SF+1.5% of common salt and+1.5% of limestone (T_1), HBH *ad-libitum*+18% of WB+22% of MG + 20% of SG+ 15% of NC+12% of SFS+ 10% of LPS+1.5% of common salt and+ 1.5% of limestone (T_2), HBH *ad-libitum*+20% of WB+23% of MG + 22% of SG+ 5% of NC+12% of SFS+ 15% of LPS+1.5% of common salt and+ 1.5% of limestone (T_3), and HBH *ad-libitum*+18% of WB+ 23% of MG + 24% of SG+12% of SFS+ 20% of LPS+1.5% of common salt and+ 1.5% of limestone(T_4).

Experimental diet intake

The amounts of diets given and rejected by goats were tracked on a day-to-day basis using manually hung weighing balance. The variance between the total amount of given diets and the total rejected diets by experimental bucks was used to calculate daily diet intake by bucks.

Weight gain performance

The weight-gain of the investigational bucks were measured using a manually hung weighing balance for every 15 days in the morning subsequently overnight abstaining from the diet. The average daily gain (ADG) was calculated by initial weight was deducted from the final weight and divided by the total feeding days (90days). The feed-conversion-efficiency (FCE) of each investigational buck was calculated by dividing ADG (g) by daily total-dry-matter-intake.

Digestibility measurement

Following acclimatization days, each experimental group's bucks were put to metabolic-crates, and each buck was fitted with a fecal-collecting-bag for collection faces. For a week, the bucks were trained to convey a fecal-collection-bag, followed by a week of actual fecal-collection. Feces were collected and quantified from each buck daily at 08:00AM prior to feeding experimental diet, and approximately 10% of total weights of faces were frozen at -20^{0}C for subsequent nutrient composition study. The apparent digestibility of nutrients was determined using feed consumption and fecal matter excreted [15].

Carcass yield measurement

After the investigation days were completed, approximately four bucks from each block were slaughtered after their final live weights were measured immediately by overnight abstention from feeding. Using a manual hung weighing balance; blood was collected and weighed soon after slaughter. The hot carcass weight (HCW) was obtained using the method of [16], and the weight of the gut fill was computed using the method of [16]. The edible and non-edible-carcass parts were used to compute the total-edible and non-edible-carcass parts using the method outlined by [16]. The dressing percentage (DP) in slaughter-body-weight (SBW) and empty-body-weight (EBW) basis of the carcass is determined by dividing the carcass weight by the slaughter live weight (Kg) and multiplying by 100. The eye-rib-muscle-area (ERMA) was calculated between the 12th and 13th ribs [16]. The cross-section-area was adequately frozen for two weeks before being split into two equal halves with a knife. After dissecting the rib eye area into two halves, all non-muscle portions were removed until the collected muscle was plainly apparent as an eye [17]. The ERMA was initially traced on transparency paper before being measured with a plan-meter by rotating the device. After cutting each buck into two equal parts on the right and left, the fat thickness was measured using a ruler, and the average of two was termed fat thickness.

Determination of chemical compositions

The percentages of dry-matter(DM), organic-matter(OM), crude protein, and ash content of diet provided to bucks and rejected by bucks were determined using the method described in [18] , while the values of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were calculated using the formulas described in [19] and [20], respectively.

Statistical analysis

The intakes of total-dry-matter, organic-matter, crude protein, NDF, ADF, and ADG, as well as nutritional digestibility and carcass yield, were calculated using the SAS General Linear Model (GLM) technique. Duncan's Multiple Range Test (DMRT) was employed with the following model to separate variances in experimental group means with model employed: Yijk = μ+Ii+Bij+eik; Where: Yijk = Individual values of the independent variables; Ii = Effect of investigational diets (T_1, T_2, T_3, and T_4); Bij = block effect (IBW); eik = Random error.

Results and Discussion

Quality parameters of trial diets

Table 1 shows the quality parameters of provided and rejected diets by experimental bucks. The SF contained

Citation: Hidosa D, Girma M. Replacement Effect of Noug-Cake with Lablab Purpureus Seed on Biological Performance of Woyito-Guji Goat Fed a Basal Diet of Haricot Bean Haulms. ES Vet Med Anim Sci. 2023; 2(1): 1004.

Table1: Chemical compositions (g kg^{-1}, DM) of experimental diets and refusals.

Experimental ingredients	Chemical composition of experimental diets				
	DM%	Ash	CP	NDF	ADF
MG	886.5	64.3	76.2	457	305
SG	912.5	67.2	88.3	483.2	194.5
WB	915	55.2	169.8	510	416
NC	932	76.2	293.5	463	278
SFS	894.5	90.6	164.6	534	398
LPS	902	53	255.5	448	194.3
HBH	831.5	137.7	62.8	625	482
Experimental diets					
T_1	914.5	63.9	146.2	554	321
T_2	920	58.7	125.2	559	353
T_3	928.5	54.9	147.9	573	375
T_4	926	58.3	136.6	461	271
Refusal diets by goats					
T_1	851	69.9	119.2	586	408
T_2	865.5	75.1	119.6	584	373
T_3	858.5	73.2	124	629	412
T_4	880.5	65.7	115.2	612	404
HBH	912	143	45	68.55	483.2

more ash, while the LPS and WB contained less. LPS and NC had higher CP content than SG and MG, but SF and WB had comparable CP contents. All grains used in this study had CP content greater than the minimum required level (80g Kg^{-1}, DM) for normal microbial digestion in the ruminant gut [19]. The CP content of WB, SF, NC, and LPS from current investigation is adequate to meet the CP requirements (130-140g kg^{-1}, DM) for high growth ruminant livestock [3]. The CP value of NC was lower than previously stated values (289g kg^{-1}, DM, 311g kg^{-1}, DM) by [7] and [21], respectively. The CP value for WB was with in agreement to previous reports of (159 g kg^{-1}, DM, 161.8 g kg^{-1}, DM) by [7] and [22], respectively, but it was lower than the conveyed value (180gkg^{-1}, DM) by [21]. The CP value of LPS from this investigation was with in values raged from the 200-280g kg^{-1}, DM reported by [9,23]. The CP value of MG from the current investigation was similar to values stated by different researchers [21,24]. The CP concentrate of HBH was similar to value stated by [7], but it was less than the minimum required CP levels (70-80g kg^{-1}, DM) for normal microbial digestion in the ruminant gut [19]. The lower CP concentration of HBH indicates that supplying the additional protein source is required to enhance the low-quality-diet intake, thus to improve animal performance. The NDF was higher in the NSC, SF, and HBH than in the LPS, SG, and MG. ADF was higher in the SF and HBH, but lower in the LPS and SG. When compared to offered diets, the experimental diets refused by bucks had greater NDF and ADF content but lower CP content. The NDF value for NSC from this study was higher than the reported values of 315gkg^{-1}, DM, 385g kg^{-1}, DM, 226gkg^{-1}, DM, and 385g kg^{-1}, DM by [7]; [21]; [22]; and [24], respectively. The higher NDF and ADF content and lesser CP content in the diet rejected by experimental bucks than the provided diet this study signified that experimental bucks had a superior capability to select more-cell-content than diet with higher fibers to meet their energy requirements. Different scholars have shown that animals prefer younger plant material to mature plant material due to the higher fiber and low protein content in mature forage, which prevents them from meeting the CP requirement [7,19,21,24].

Dry Matter and Nutrient Intake

Table 2 shows the total-dry-matter and nutrient intake of Woyito-Guji bucks fed a HBH and complemented with various amounts of NC and LPS. The supplement intake was greater (P<0.05) in bucks complemented with the T_1 than in bucks complemented with T_2 and T_4, however, it was comparable (p>0.05) to bucks complemented with T_3. Total-dry-matter-intake was greater (p<0.05) in bucks complemented with T_1 than in bucks complemented with T_2, T_3, and T_4, but total-dry-matter intakes were similar (P > 0.05) in bucks fed the T_2, T_3, and T_4. Higher total-dry-matter

Table 2: Replacement effects of different level of NSC with LPS on total dry matter and nutrient intake of Woyito-Guji goats fed on HBH as basal diet.

Intake	Experimental treatments					
	T1	T2	T3	T4	SEM	P-vale
DM intake (g/d)						
Supplements	409.85^a	395.04^b	399.84^{ab}	397.84^b	5.84	0.03
Basal diet	342.48^a	333.87^{ab}	329.09^b	331.90^b	4.52	0.02
Total	752.32^a	728.91^b	728.92^b	729.74^b	7.41	0.001
OM intake(g/d)						
Supplements	348.62	340.25	349.3	345.21	5.05	0.06
Basal diet	291.31	287.56	287.49	287.99	3.91	0.07
Total	639.93	627.81	636.79	633.20	6.4	0.06
CP intake (g/d)	54.80^a	45.50^c	54.91^a	50.32^b	0.74	0.001
ME intake (MJ/d)	10.05	9.86	9.99	9.94	0.1	0.121
NDF intake (g/d)	239.35^a	220.83^c	229.11^b	223.19^{bc}	3.31	0.001
ADF intake(g/d)	139.45^b	147.60^a	149.94^a	131.56^c	2.1	0.01

CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ME= Metabolisable energy, g/d= gram per day.

intake in bucks fed T_1 diet is due-to more supplement intake, which increased more amount of required protein in rumen that speed up and enhance the digestion process take place in the rumen by microbes, thus, the higher intake by goats. Moreover, the resemblance in total-dry-matter intake in bucks fed the T_2, T_3, and T_4 diets was due to resemblance in intake of the supplements. Likewise, the studies reported by [21] and [25] were signified that Horro and Gumuz lambs that were consumed higher amount of supplement had consumed the greater total dry-matter-intake than lambs consumed lower supplement. The total-dry-matter intake of bucks in the current investigation was lower than the reported values of (850g/d), (864g/d), and (887.5g/d) for Gumuz lambs complemented with an NC-based diet replaced with 25%, 50%, and 75% with cow pea hay, respectively by [25]. However, it was similar to the reported value of (719 g/d) by [7] for yearling Woyito-Guji bucks fed a diet containing 35% *LP* hay and 63% of WB.

Furthermore, a higher ($P<0.001$) total-CP intake was recorded for bucks complemented with T_1 and T_3 than bucks complemented with T_2 and T_4. The higher total-CP intake by bucks complemented with T_1 and T_3 is due to a higher supplement intake. Similarly, [26] discovered that Abergelle sheep fed a 120g/day concentrate diet had a lower CP intake (84.5 g/d) than sheep fed a 360 g/day concentrate diet (140.8g/d). This demonstrates that bucks that consume a lot of supplements are more likely to have a lot of CP than bucks that don't get a lot of supplements. The total-CP intake by bucks from current investigation was lower than reported values of (86.5g/d) and (140.8g/d) by [7] and [21] for Woyito-Guji bucks and Horro sheep, respectively. In general, the total-CP intakes obtained in current investigation were lower than the 80-90g/day stated by [14] for bucks weighed about 15 kg to achieve 50g/day of ADG under tropical condition.

The bucks complemented with the T_1 consumed more NDF ($p<0.001$) than bucks complemented with the T_2, T_3, and T_4, but the intake of NDF was comparable for bucks complemented with the latter of three diets. The higher NDF intake in bucks complemented with T_1 diet is due to a higher intake of HBH, which has a more NDF content. Similarly, [21] and [25] found that Horro and Gumuz sheep consumed more HBH had higher NDF intake than sheep that consumed less basal diet. Bucks complemented with a T_3 consumed more ADF content than bucks complemented with T_2 and T_4, but ADF intake was comparable between bucks complemented with T_1 and T_3.

Dry matter and nutrient digestibility

Table 3 shows the nutrient-digestibility potential of Woyito-Guji bucks consumed a HBH and complemented with various levels of NC and LPS. Bucks complemented with T1 digested more ($p<0.001$) dry-matter and CP than bucks complemented with T2 and T3, but the digestibility-potential of dry-matter and CP were similar among the bucks complemented with the T1 and T4. Similarly, bucks that complemented with T1 digested more ($p<0.001$) portion of NDF than bucks that complemented with the T2, T3, and T4, but NDF digestibility potential of bucks that complemented with the T3 and T4 was comparable. ADF digestibility was higher in bucks complemented with the T1 than in bucks complemented with the T2 and T3, but it was comparable in bucks that were complemented with the T1 and T4. The greater dry-matter and CP digestibility potential seen for bucks that complemented with T1 and T4 is as result of a greater consumption of supplements. The greater CP intake from the given supplement is needed for increased rumen-microbial-populations; as a result, the greater ability of rumen-microbial attachment in the rumen-gut, which results in increased microbial-degradation of dry-matter and CP that were ingested. It is well documented that ADF is highly correlated with nutrient digestibility, and thus animals consuming more ADF have a lower nutrient degradation potential [15]. The lower degradability potential of dry-matter and CP contents were seen in bucks that complemented with T2 and T3 is result of a greater consumption of ADF. The dry-matter-digestibility potential found in current investigation is greater than that of described values of (69.5%) by [7] for Woyito-Guji bucks complemented with a diet comprised of 35% of LP hay, (63.6%) by [21] for Horro sheep complemented with 400g/d of LP hay, and (70.89%) by [25] for Gumuz lambs complemented with sole cow pea hay. The digestibility-values of CP attained in the our investigation were larger than that of the reported digestibility-percentages (61.4%) by [21] for Horro sheep complemented with 400g/d of LP hay, (69.5%) by [7] for Woyito-Guji bucks complemented

Table 3: Replacement effects of different levels of NSC with LPS on dry matter and nutrient digestibility of yearling Woyito-Guji goats fed a basal die of HBH.

Apparent digestibility (%)	Experimental treatments					
	T1	T2	T3	T4	SEM	P-vale
DMD	87.2[a]	76.53[b]	74.21[b]	85.53[a]	2.07	0.000
OMD	87.5[a]	77.11[b]	74.74[b]	85.84[b]	0.92	0.000
CPD	92[a]	87.60[b]	86.37[b]	91.75[a]	0.94	0.000
NDFD	86.7[a]	81.41[c]	85.42[ab]	84.30[b]	0.99	0.02
ADFD	87.9[c]	89.78[a]	90.41[a]	88.94[b]	0.39	0.003

SEM =Standard error of mean.

with a concentrate diet that comprised 35% of LP hay, and (71.52%) by [27] for Borana goats complemented with a concentrate mixture of 37% NSC and 67% of WB. However, the CP digestibility value attained in our investigation is in agreement to describe digestibility percentage (89.04%) by [22] for Woyito-Guji bucks that complemented with a diet consisting of 38% Acacia tortilis leaf and 60% WB.

Body weight change

Table 4 shows the body weight changes (FBW, BWC, ADG, FCE) of Woyito-Guji bucks that complemented with various amounts of NSC and LPS. The FBC, ADG and FCE were greater (p <0.001) in bucks complemented with the T_4 than that of bucks complemented with the T_2 and T_3, but FBC, ADG and FCE were comparable in bucks complemented with the T_4 and T_1. The greater FBC, ADG and FCE for the bucks that complemented with T_1 and T_4 diets are as result of bucks' greater potential of dry matter and CP digestibility that allowed bucks to convert all nutrients in feed into meat. Similarly, the studies reported by [7] and [25] have showed that Woyito-Guji bucks and Gumuz lambs that digested more dry-matter and CP had attained higher ADG (96.67g/d) and (62.68g/d), respectively which is lower than digestibility percentages attained in our investigation for group of bucks that complemented with T_4 and T_1. Furthermore, similarity in ADG and FCE performances for bucks complemented with T_2 and T_3 revealed that replacing NSC with LPS up to 10-15% lowered ADG and FCE, but replacing NSC with LPS at 20%(T_4) seemed to be a better feeding option for use of LPS as a protein-supplement in the goat ration in pastoral areas to increase goat weight gain performance. The ADG values for the bucks complemented with T_1 and T_4 in our investigation were similar to the reported value of 106g/d by [26] for Abergelle sheep supplemented with a concentrate mixture of sesame-cake and short-milled-wheat, but higher than the reported value of 76.2g/d by [27] for Borana goats supplemented with a concentrate mixture of 37% NC and 67% WB.

Carcass characteristics

Table5 shows the carcass characteristics (HCW, SBW, EBW, DP, REMA and fat thickness) of Woyito-Guji bucks complemented with a various amounts of NSC and LPS. Bucks that complemented with the T_1 attained greater (p<0.001) HCW and SBW than bucks that complemented withT_2, T_3, and T_4, but SBW and HCW were comparable among the bucks complemented with the T_2, T_3, and T_4. In terms of fat thickness, bucks complemented the T_1 attained thicker fat (p<0.001) than bucks complemented the T_2, while fat thickness was comparable among bucks that complemented with T_1, T_3, and T_4. Likewise, group of bucks that were complemented with the T_1 gave higher (p<0.001) REMA than bucks complemented with the T_2 diet, but REMA was comparable among bucks complemented with T_1, T_3 and T_4. The larger HCW and EBW for the bucks complemented with the T_1 are due to the large portion of dry-matter and CP digestibility potential of bucks. The results of this study for SBW and HCW were relatively comparable to values (27.2kg) and (13.28kg) reported by [22] for Woyito-Guji bucks complemented with diets containing 38% of acacia pod and greater than values (9.36kg) and (9.68kg) of HCW reported by [25] for Gumuz lamb complemented with cowpea hay, respectively. The DP of investigational goats were not affected (P>0.001) by complementary diets. The resemblance in DP amongst the bucks complemented with T_1, T_2, T_3, and T_4 in the current investigation is as result of separating the attained weights into carcass and non-carcass parts. The current study's DP values for bucks supplemented with T_1, T_2, T_3, and T_4 were lower than the values reported by [22] for Woyito-Guji

Table 4: Replacement effects of different levels NSC with LPS on weight gain performances of Woyito-Guji goats fed on HBH as basal diet.

	Experimental treatments					
Growth indices	T1	T2	T3	T4	SEM	P-value
IBW(kg)	18	18	18	17.5	0.24	0.06
FBW (kg)	24.13^{ab}	21.75^{c}	22.33^{bc}	24.25^{a}	0.86	0.001
BWC (kg)	6.05	4.92	5	5.62	0.94	0.07
ADG (g)	100.83^{ab}	79.17^{b}	69.44^{b}	108.33^{a}	3.56	0.001
FCE(ADG/DMI)	11.73^{ab}	9.54^{ab}	8.41^{b}	13.11^{a}	1.78	0.001

Mean values in a row with different superscripts (a, b, c) are differ significantly at 0.001 or 0.05, SEM = Standard error of mean

Table 5: Replacement effects of different levels NSC with LPS on carcass characteristics of Woyito-Guji goats fed on HBH as basal diet.

Parameters	Experimental treatments					
	T1	T2	T3	T4	SEM	P-value
SBW (kg)	28.8^{a}	23^{b}	24^{b}	23.4^{b}	1.73	0.001
EBW (kg)	26.68	21.37	24.29	21.67	2.52	0.07
HCW (kg)	13.77^{a}	10.80^{b}	10.93^{b}	11.47^{b}	0.62	0.001
DP (%)						
SBW basis(%)	47.84	46.48	47.94	46.71	1.54	0.06
EBW basis (%)	51.67	50.53	48.42	50.43	3.45	0.12
Fat thickness (cm^2)	0.66^{a}	0.22^{b}	0.52^{ab}	0.60^{ab}	0.15	0.001
REMA (cm^2)	13.25^{a}	10^{b}	11.78^{ab}	13^{a}	11.17	0.001

Mean values in a row with different superscripts (a, b) are differ significantly at 0.001 or 0.05, SEM = Standard error of mean bucks complemented with a diet consisting of 38% acacia pod and 60% WB. The greater fat-thickness and REMA acquired by bucks complemented with T_1 compared to bucks complemented with T_2, T_3, and T_4 is fact that a greater intake of total-dry-matter and metabolisable-energy, resulting in higher depth and width development of rib-eye-muscle-area and fat-thickness. The studies reported by [28] and [29] signified that the small East African goats complemented with a diet high in protein and energy had greater fat thickness and muscle accumulation than goats supplemented with a diet low in protein and energy.

Edible-non-carcass components

Table 6 shows the edible-non-carcass parts of Woyito-Guji bucks complemented with various amounts of NSC and LPS. Weight of heart was larger (P<0.001) for the bucks that were complemented with T_1 over the bucks that complemented with T_2, T_3, and T_4, but it was comparable (P>0.001) amongst bucks complemented with T_2, T_3, and T_4. Testicle weight was bigger (P<0.001) in bucks complemented with the T_3 over bucks complemented with the T_2 and T_4, but comparable to bucks given the T_1. The visceral empty was heavier (P<0.05) in group of bucks given T_1 and T_2 over bucks given T3 and T_4. The weight of head and tongue, blood, kidney, liver, and intestinal empty weights were comparable for all experimental groups. Bucks given the T_1 gained more total edible offal (p<0.001) than bucks given the T_4, but it was comparable (P > 0.001) to bucks given the T_2 and T_4. There higher total edible offal for bucks complemented with a T_1 is result of greater nutrient digestibility. The values from this study for head and tongue, kidney, and total edible-non-carcass weights were significantly higher than the values of 1465g for head and tongue, 63g for kidney, and 3518g for total edible non-carcass reported by [22] for Woyito-Guji bucks complemented with concentrate mixture of 38% ATP and 60% WB.

Table 6: Replacement effects of different levels NSC with LPS on edible non-carcass components of Woyito-Guji goats fed on HBH as basal diet.

Edible non- carcass offal	Experimental diets					
	T1	T2	T3	T4	SEM	SL
Head and Tongue (g)	1933.3	1866.7	1766.7	1633.3	15.00	NS
Blood weight(g)	1033.3	1166.7	1500	1200	225.67	NS
Heart(g)	155^a	93.33^b	113^b	96.67^b	15.22	0.04
Kidney(g)	75	65	71.67	66.67	4.60	NS
Testicles weight(g)	200^{ab}	183^b	266.67^a	181.67b	33.57	***
Liver (g)	523.33	410	543.33	411.67	146.06	NS
Total fat(g)	1080^b	1443^{ab}	1280^{ab}	1705^a	207.88	***
Visceral empty (g)	811.67^a	911.67^a	318.33^b	383.33^b	119.05	***
Intestinal empty(g)	1226.7	1250	1016.7	1083.3	149.05	NS
Total edible offal (g)	6218.3^a	5946.7^{ab}	5596.7^{ab}	5056.7^b	455.41	***

*Mean values in a row with different superscripts (a, b) are differ significantly at ***= 0.001 or *=0.05, SEM = Standard error of mean, SL = Significance level.*

Non-edible-non-carcass parts

Table 7 shows the non-edible-non-carcass parts of Woyito-Guji bucks complemented with different levels of NC with LPS. Skin and gut content weights were higher (p>0.05) in bucks given T_1 and T_4 over bucks that given T_2 and T_3. Similarly, the heaviness of total-non-edible-offal, lung, and trachea were comparable (p>0.05) across investigational bucks. Spleen weights in bucks given the T_1 were larger (p<0.05) than in bucks given the T_2 and T_3, but comparable to bucks given the T_3. The higher skin and spleen weights of bucks given T_1 compared to bucks given T_2 and T_3 are result of bucks' better nutrient digestibility potential.

Table 7: Replacement effects of different levels of NSC with LPS on non-edible non-carcass components of Woyito-Guji goats.

Non-edible non- carcass offal	Experimental treatments					
	T1	T2	T3	T4	SEM	SL
Skin weight (g)	2333.3	2000	2033.3	2266.7	284.5	NS
Lung and Trachea(g)	633.33	716.67	436.67	733.33	144.93	NS
Spleen(g)	89.67^a	46.67^b	78.33^{ab}	48.33^b	15.22	***
Gut content (g)	2656.7	3000	2950	2116.7	574.9	NS
Feet weight (g)	633	750	700	666.67	148.92	NS
Total non-edible offal(g)	6006.3	5763.3	5438.3	4931.7	685.24	NS

*Mean values in a row with different superscripts (a, b) are differ significantly at ***= 0.001, SEM = Standard error of mean, SL = Significance level.*

Conclusions

The results showed that goats fed a diet that replaced NSC with LPS up to 15% had lower weight gain and carcass characteristics, but at 20% replacement of NSC with LPS significantly improved biological performance of Woyito-Guji bucks and seemed to be a suitable feeding alternative as protein complements to replace NSC that not effortlessly available to in pastoral and agro-pastoral regions of Ethiopia.

Acknowledgments

This research was funded by the Ethiopia Institute of Agricultural Research, Pastoral, Agro-pastoral, and Emerging Region Capacity Building Directorate for the purchase of experimental goats and the South Agricultural Research Institute for data collection and laboratory sample analysis. Therefore, the authors are extremely grateful for the assistance provided by both organizations.

Conflict of Interest Statement

We declared that we have no competing interests in publishing this manuscript.

Author Contributions

Mr. Denbela Hidosa wrote the proposal, secured funding, conducted the feeding trial, collected and analyzed the data, wrote whole paper and transliterated the entire paper setup in to Journal format, while Mr. Mekete Girma assisted in the monitoring and coordinating the research activity during trial period.

Ethical Statement

The Ethiopian animal care and management rule and regulation are considered before excuting the feeding trial.

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Citation: Hidosa D, Girma M. Replacement Effect of Noug-Cake with Lablab Purpureus Seed on Biological Performance of Woyito-Guji Goat Fed a Basal Diet of Haricot Bean Haulms. ES Vet Med Anim Sci. 2023; 2(1): 1004.