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Effect of substituting concentrate mixture with dried woybeta (*Terminalia brownii Fresen*) leaf meal on body weight gain and cost-benefit analysis of yearling Woyto-Guji goats in Konso, Southern Ethiopia

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Abstract

The current experimental work was aimed to evaluate weight gain, linear measurement and economic feasibility of yearling woyto-guji goats supplemented dried woybeta leaf meal (DWLM) as a substitute of concentrate mixture (CM). Twenty intact bucks with an average initial body weight of 19 ± 0.25 kg were selected from Baide community based breeding program (CBBP) and assigned to one of the five treatment feeds in a completely randomized block design as: (T1= Grazing + 300 g CM, T2= Grazing + 75g DWLM + 225 g CM, T3 = Grazing only, T4 = Grazing + 225 g DWLM + 75 g CM and T5= Grazing + 300 g DWLM). All animals were allowed to ad libitum access of water and the experiment was taken for the duration of 90 days. Supplemental feeding of air DWLM in current experiment positively influenced the performance of animals by providing higher feed intake and greater weight gain as compared to control group (T3). The results from ADG were 131.5g, 84.2g, 70.3g, 99.5g and 109.5g for T1, T2, T3, T4 and T5, respectively with T1 and T5 gained significantly ($P<0.05$) better than all other treatments. The results from DMI were 4.1kg, 3.3kg, 3.0kg, 3.5kg and 3.7kg for T1, T2, T3, T4 and T5 respectively. Though goats in T1 performed better than all other treatments, supplementation of air DWLM (T5) was economically dominant and thus is recommended for the initiation of growth of yearling bucks based on the target of the producer. Therefore, it could be concluded that DWLM is a potential feed to replace CM especially during lean periods where other sources may not be readily available and expensive

Keywords: Woybeta Leaf Meal; Substitution; Weight Gain; Cost-Benefit Analysis; Woyto-Guji Goats

1. Introduction

Goats are amongst the commonest farm animal species which sustain the livelihoods of smallholder farmers, pastoralists and agro-pastoralists. They fulfill various functions such as generating cash income, serving as household security, accumulating capital, and fulfilling cultural obligations [1; 2; 3; 4]. Goats play an important role in all production systems due to their low initial capital investment, ability to produce multiple products (meat, milk, skin, manure etc.) at low input costs, high rates of reproduction, and high turnover rates due to the short time they take to attain maturity.

However, goat production in Ethiopia suffers from feed shortages at all levels with an estimated 40% deficit in the national feed balance. This is aggravated by seasonal availability of forage and crop residues in the highlands and by recurrent and prolonged drought in the lowlands. FAO [5] estimated that average dressed carcass output per individual goat in Ethiopia is 8 kg, which is among the lowest in African countries. Because of the poor quality of natural pasture and crop residues, substantial weight loss of animals is encountered, especially during dry seasons. Supplementing the required nutrient from other sources is critical to generate the desirable product form the ruminants.

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It is well recognized that the productivity of goats increases by concentrate feeding or supplying good quality forage [6]. However, feed stuffs for animals are getting progressively expensive, thus necessitating minimization of feed cost, which could be achieved through the incorporation of relatively cheap and non-conventional feed ingredients [7]. Leaves of tree legumes like *terminalia brownii* are rich in most essential nutrients such as proteins and minerals and tend to be more digestible than the grasses and crop residues.

Despite the fact that *terminalia brownii* is highly produced in many areas of low lands of Ethiopia including Konso, Derashe and Arbaminch, system for its utilization as animal feed has not been developed and made available to small scale farmers. Moreover, the effect of feeding *terminalia brownii* leaf meal as a supplemental feed on place of concentrate mixture was not investigated in the diet of goats. Therefore, the study was designed to evaluate the effect of supplemental feeding of dried leaves of *terminalia brownie* as replacement of concentrate mixture on body weight change, linear measurements and economic efficiency of Woyto-guji goats under semi-intensive management condition.

Objective

To evaluate the supplementary effect of dried woybeta (*T.browni*) leaf meal as substituent of concentrate mixture on body weight gain, linear measurements and economic feasibility of yearling woyto-guji goats.

2. Material and methods

2.1. Study area

The experiment was conducted at Konso Zone, Baide station, which is located between latitude and longitude of 5° 15′ N and 37° 29′ E coordinates and an elevation of 550-2100 m above sea level. The average daily minimum and maximum temperatures were 25 and 30 °C, respectively. The average annual rainfall is 519-1094 mm. Rainfall is bimodal type: the main rainy season is locally known as *Hagaya* (March–May) and the shorter rains as *Katana* (September–November). The soils are dominantly nitosols (fertile agricultural soil).

2.2. Management of Experimental Animals

A total of 20 yearling Woyto-guji bucks with an average initial body weight of 19 ± 0.25 kg were used. The goats were housed individually with concrete floor and corrugated iron roof. There was a preliminary period of 15 days general adaptation followed by 15 days of adaptation to the experimental feeds during experiment which lasted for 90 days. At the beginning of adaptation period, the animals were treated against internal parasite as prescribed by the manufacturer. The animals were weighed every two weeks after overnight fasting, before feeding in the morning to monitor body weight changes as well as linear measurements throughout the experimental period. At the beginning and end of the experiment, goats were weighed for two consecutive days and the average of the two were taken as initial and final weights, respectively.

2.3. Feeds and feeding management

Table 1 Experimental treatments

Treatments	Basal diet	Supplements	
		CM (g/d)	DWLM (g/d)
T1	GNP	300 g (100%)	0
T2	GNP	225 g (75%)	75 g (25%)
T3	GNP	0	0
T4	GNP	75 g (25%)	225 g (75%)
T5	GNP	0	300 g (100%)

T1: Treatment 1, T2: Treatment 2, T3: Treatment 3, T4: Treatment 4, T5: Treatment 5, GNP: Grazing on natural pasture, CM: Concentrate mixture, DWLM: Dried woybeta leaf meal and g/d: Gram per day

Terminalia brownii leaves were collected in December 2019 (dry season) from farmers' arable land and backyard from different ages of the plant. The leaves collected were transported to the experimental site and dried under shed. After drying, the leaves were chopped and thoroughly mixed to minimize variation and improve intake by experimental goats.

Noug seed cake and wheat bran were purchased from Woze livestock feed processing enterprise found in Arbaminch town. Goats were allowed to graze 8:00 hours per day along with free access of water. The concentrate supplements, i.e., noug seed cake and wheat bran were mixed in 50:50 ratios and the DWLM was offered based on the proportions indicated in Table 1.

2.4. Body weight change and feed efficiency

Animals were weighed within 15 days interval in the morning after overnight fasting using spring balance. The average weight gains (ADG) were calculated on a daily, monthly and final basis. It was calculated as the difference between final BW and initial BW divided by a number of feeding days. The feed efficiency of experimental animals was determined by dividing the ADG into the amount of feed consumed.

2.5. Chemical Analysis

Samples of treatment diets (DWLM, NP and CM) were ground to pass through a 1-mm sieve (Willy mill) for chemical analysis. These ground materials were stored individually in an airtight plastic bag till sent to Arbaminch University, soil laboratory pending chemical analysis. DWLM sample was collected from three potential areas (Konso, Derashe and Arbaminch) prior to grinding. Dry matter, Organic matter and CP contents of DWLM, NP and CM were determined following the procedures described by AOAC [8]. The NDF, ADF and ADL contents were analyzed following the recommendations of Van Soest *et al*. [9] using an ANKOM 200 fiber analyzer and ANKOM F57 filter bags (ANKOM Technology Corp., Fairport, NY, USA).

2.6. Economic Analysis

Economic return analysis was computed to examine the economic profitability of substituting concentrate mixture with DWLM. The computation was done based on the average value of data obtained during the experiment. To examine the rate of return on annual bases, the annual financial rate of return (AFRR) to feeding was calculated using the formula [10]: AFRR = [(R-C)/C*(365/t)]*100% where; AFRR = Annual financial rate of return; R = revenue from selling of the goat; C = purchase and other variable costs and; t= number of days the animal was fed. The AFRR to feeding is, thus, revenue less purchase cost of the animal and other variable costs, multiplied by the number of days in the year the animal was fed.

The return was decomposed into its compounds (price, weight and their interaction) to examine the relative contribution of the components in the gross return. All the components are expressed as percentages of the financial margin. To disaggregate the gross margin into its components the following formula was used: 100% = {(DP*Wi +DWPi +DP*DW)/M}*100% where; DP= the difference between sale price and purchase price; DW= the difference between final weight and initial weight at purchase; Pi = purchase price; Wi = initial weight at purchase. Sensitivity analysis was also done to capture the likely change in prices of input (feed) and fattened goat. Price variation can occur in input and output. Thus, these variations were considered in the sensitivity analysis.

2.7. Statistical Analysis

Data on weight gain, body measurements and economic efficiency were analyzed using one-way ANOVA procedure of the Statistical Package for the Social Science [11]. Duncan's multiple range tests was used to differentiate the significant differences between treatment means. Statistical analysis was not done on chemical composition. The model used for analysis of the data on measured parameters was: $Y_{ij} = \mu + t_i + b_j + e_{ij}$ where Y_{ij} = dependent variables, μ = overall mean, t_i = the effect of the i^{th} treatments, b_j = effect of the j^{th} block and e_{ij} = random error of i_{th} treatment in the j^{th} block

3. Results and discussion

3.1. Chemical Composition

The chemical composition of feed components consisting treatment diets is presented in Table 2. Almost similar amount of dry matter (DM) is obtained in the feed components of the treatment diet. Higher crude protein (CP) content was recorded in CM and DWLM than natural pasture (NP). DWLM and CM showed similar lower fiber (NDF, ADF and ADL) contents than NP. The concentrate mixture had better nutritive value (cumulative result) as compared to DWLM and NP (Table 2). The chemical composition of the DWLM was within the range reported in the literature for browse forages [12; 13]. The role of this browse forage as source of nitrogen for ruminants, especially during lean periods, is the major contribution in many parts of the tropics where other sources may not be readily available and/or are expensive.

The high CP content, which is above the minimum required level for optimal rumen microbial activity (21.62%) and low fiber content (32.76%) which are readily digestible, justifies the use of *T. brownii* leaf in small quantities in order to supplement poor quality pastures and crop residues. In addition to this, *T. brownii* had low content of fibre which is a positive attribute of the plant since the voluntary DM intake and DM digestibility are dependent of the cell wall constituents especially the NDF and lignin [14]. Therefore, the fibre of *T. brownii* has been shown to be more digestible [15] than that of natural grasses and crop residues.

Table 2 Chemical composition of feeds

Nutrient	DWLM	Natural Pasture	Concentrate mix	
Dry matter (DM) (%)	93.85	95.05	88.94	91.00
Organic matter (% DM)	90.41	87.45	82.59	89.13
Ash (% DM)	9.59	12.55	17.41	10.87
Crude protein (% DM)	16.94	21.62	3.88	22.98
Neutral detergent fibre (% DM)	41.48	42.77	67.68	36.86
Acid detergent fibre (% DM)	29.45	32.76	36.44	26.08
Acid detergent lignin (% DM)	4.86	17.17	15.00	11.14
Source	[12]		Lab result	

DWLM: Dried Woybeta Leaf Meal; DM: Dry matter and %: Percentage

3.2. Weight changes, feed intake and conversion efficiency

The Mean weight gains, daily dry matter intake (DMI) and Feed conversion efficiency (FCE) of bucks fed DWLM supplemented diet as a replacement of concentrate mixture is presented in Table 3. The mean daily weight gain of bucks in the experiment was observed different ($p>0.05$) having higher daily weight gain (131.5gm) in the treatment group supplemented CM/T1 followed by treatment group supplemented DWLM/T5 (109.5gm). However, the lower daily weight gain (70.3gm) was observed in the treatment group without supplementation (T3). There was also significant difference ($p>0.05$) between monthly weight gain of bucks in the experiment having higher body weight gain (395.8gm) in the treatment group supplemented CM and lower body weight gain (212.5gm) in the treatment group without supplementation. Similar trend was observed in final/live weight gain of bucks in the experiment.

Table 3 Mean body weight gain, DM intake (kg/day) and FCE of yearling Woyto-guji goats fed DWLM supplemented diets as a replacement of Concentrate mixture

Measurements	Treatment					P-value	SEM
	T1	T2	T3	T4	T5		
LWG (kg)	11.87 ± 0.08^{a}	7.63 ± 0.08^{bc}	6.38 ± 0.08^{c}	9.00 ± 0.08^{abc}	9.88 ± 0.08^{ab}	0.043	0.08
ADG (g)	131.5 ± 0.01^{a}	84.2 ± 0.01^{bc}	70.3 ± 0.01^{c}	99.5 ± 0.009^{abc}	109.5 ± 0.01^{ab}	0.043	4.13
AMG (g)	395.8 ± 0.01^{a}	254.2 ± 0.01^{bc}	212.5 ± 0.01^{c}	300.0 ± 0.01^{abc}	329.2 ± 0.01^{ab}	0.043	9.88
FCR	31.31^{a}	25.52^{bc}	23.43^{c}	28.42^{ab}	29.60^{ab}	0.039	0.37
DM intake	4.1 ± 0.03^{a}	3.3 ± 0.04^{bc}	3.0 ± 0.02^{c}	3.5 ± 0.05^{b}	3.7 ± 0.06^{ab}	0.041	0.26

$^{a.b.c}$ Means within rows having different superscript letters are significantly different at ($p < 0.005$); T1-T5 are treatments; LWG: Live weight gain; ADG: Average daily gain; AMG: Average monthly gain; Kg: Kilo gram, g: gram and SEM: Standard error mean

DM intake was observed highest ($P < 0.05$) for T1 followed by T5 and lowest for T3 (Table 4). The goats in T1 had significantly ($P<0.05$) higher feed conversion efficiency than other goats in the rest treatment groups and T3 had significantly ($P<0.05$) lower FCR whereas, there was no significant ($P>0.05$) difference in both DM intake and FCR among T1 and T5.

Hence, it can be concluded that supplementation of DWLM as a replacement of CM in the diet of bucks had positive influence and improved weight gain, DMI and FCE while there observed no significant difference in measured all parameters between DWLM and CM supplemented diets reflecting that DWLM could be a possible replacement of CM in goat's diet. Similar observation has been reported on washara lambs by Mekuriew and Asmare [16].

3.3. Linear bodies (Heart girth, Height and Length) Measurement

The Mean linear body measurements of Woyto-guji goats fed on DWLM and concentrate mix supplemented diets are presented in the Table 4. Performance in linear body measurements mirrored the performance in body weight change. The mean cumulative heart girth of bucks in first month was observed non-significant ($p>0.05$). But the mean monthly cumulative heart girth of bucks in third month was observed significantly different ($P<0.05$) having higher monthly cumulative heart girth (72.25cm) in the treatment group with concentrate mixture followed by T5 (71.76cm), T4 (70.89cm) and T2 (70.07cm). However the lower monthly cumulative heart girth (68.28cm) was observed in the treatment group without supplementation. Findings of this study is also supported by Badi *et al.* [17] who reported that heart girth is the best parameter of estimating body weight. Nigm *et al.* [18] also reported that heart girth tended to be the best predictor of body weight.

The mean monthly cumulative measurement of bucks in first month was observed non-significant ($p>0.05$) in body length. Similar result was found in 2nd month. But the highest overall mean monthly body length (66.75cm) and (66.50cm) were observed in the treatment group feeding with concentrate mixture and DWLM and lowest overall mean monthly body length (64.00cm) was observed in the treatment group without supplementation. The mean monthly cumulative withers height of bucks in first month was also observed non-significant ($p>0.05$). But the highest overall/final mean monthly wither height (67.00cm) was observed in the treatment group feeding with concentrate mixture followed by T5 (66.75cm) and lowest overall mean monthly wither height (65.00cm) was observed in the treatment group fed without supplementation.

Table 4 Mean heart girth (HG), height at withers (HW) and body length (BL) of Woyto-guji bucks fed DWLM as replacement for concentrate mixture

Measurements	Treatment					P -valve	SEM
	T1	T2	T3	T4	T5		
HG (cm)	72.25±2.90^{a}	70.07±2.17^{ab}	68.28±2.06^{b}	70.89±2.31^{ab}	71.76±2.31^{ab}	0.049	4.08
HW (cm)	67.00±3.23^{a}	66.00±2.41^{ab}	65.60±2.30^{b}	66.16±2.57^{ab}	66.75±2.57^{ab}	0.048	3.85
BL(cm)	66.75±3.58^{a}	64.75±2.67^{ab}	64.00±2.54^{b}	65.75±2.84^{ab}	66.50±2.84^{a}	0.048	3.56

$^{a.b.c}$ Means within rows having different superscript letters are significantly different at ($p < 0.005$); HG: Heart girth; HW: Height at wither; BL: Body length, Kg: Kilo gram and cm: Cent meter

3.4. Economic Analysis

The results of economic analysis conducted to assess the benefit of different supplements fed to Woyto-guji goats under farmer's management are shown in Table 5. The total expenditure was observed highest (1339.42) in concentrate mix supplemented treatment groups (T1) and lowest (970.60) in none supplemental feed groups (T_3) and (983.10) DWLM supplemented groups (T5). However, the average net income was observed highest (522.53) in the treatment group having DWLM supplement and lowest (276.21) in the treatment group having concentrate mixture supplement and without supplemental feed (122.17). The B: C ratio was observed highest (0.53) in the treatment group having DWLM and lowest (0.13) in treatment without supplementation. A similar experience has also been reported in a previous study that used Arsi-Bale and Khari goats [19; 20; 21].

Table 5 Cost and economic return analysis (per animal) for yearling Woyto-guji goats supplemented DWLM as replacement for concentrate mixture

Item	Treatment					SEM	Sig
	T1	T2	T3	T4	T5		
Number of animals per treatment	4	4	4	4	4	-	-
Average purchase price (ETB**) per kg	50	50	50	50	50		
Average live weight (kg) @purchase per head	18.125	18.375	18.125	18.250	18.375	-	-
Average purchase price per head	906.25	918.75	906.25	912.50	918.75	-	-
Total operating costs (per head)	1318.82	1280.35	950.00	1068.72	962.50	121.43	NS
Average total cost per head(ETB)	1339.42	1300.95	970.60	1098.34	983.10	127.64	NS
Average live weight (kg)@sale per head	29.375^{a}	26.625^{a}	25.750^{a}	27.625^{a}	29.125^{a}	2.750	NS
Total body weight gain in kg per head	11.875^{a}	7.625^{bc}	6.375^{c}	9.00^{b}	9.875^{ab}	0.782	0.05
Average selling price per kg of live weight	55	55	55	55	55	-	-
Average return (gross return)/head(ETB)	740.625^{a}	493.750^{a}	466.875^{a}	561.88^{a}	543.13^{a}	87.154	0.051
Average net return (NR)(ETB)	276.21^{ab}	473.15^{a}	122.17^{b}	416.31^{a}	522.53^{a}	86.97	0.047
Marginal rate of return (MRR)	21.20^{bc}	49.40^{a}	9.61^{c}	40.27^{abc}	55.22^{a}	11.145	0.043
Annual financial rate of return (AFRR)(ETB)	92.47^{ab}	209.20^{ab}	45.54^{b}	171.35^{ab}	232.78^{a}	45.906	0.046

a.b.c Means within rows having different superscript letters are significantly different at ($p < 0.005$); ETB: Ethiopian birr; @: At; Kg: Kilo gram; SEM: Standard error mean and Sig: Significance

3.5. Components of the gross margin

The results from the gross margin analysis when described as percentages of financial return also indicates that weight gain, as a whole, accounted for 98.29% of the gross margin while price changes and the interactions accounted for 1.17 and 0.54%, respectively (Table 6). This suggests that weight gains over the feeding periods relatively played a crucial role in the determination of profitability in current experiment.

Table 6 Different components of the gross margin

Treatment	Components of gross margin (%)			Weight gain overprice (folds)
	Price	Weight gain	Interaction	
T1	0.83	98.58	0.59	118.77
T2	1.47	98.01	0.52	66.67
T3	1.13	98.34	0.53	87.03
T4	1.19	98.27	0.54	82.58
T5	1.25	98.23	0.52	78.58
Average	1.17	98.29	0.54	84.01

T1-T5: Treatments and %: Percentage

3.6. Sensitivity analysis

Sensitivity analysis was hypothesized for 20% increase in Feed cost (concentrate) and 10% decrease in selling price of goat in order to capture the likely change of price of input and fattened goat. In agricultural production, decrease or increases in input and output price have great impact on farmers' return. Apart from purchase price which constituted about 84.1% of the total production cost, feeding was the most expensive commodity ranging from 9% to 29.4%. A 20% increase in concentrate feed price would decrease the return per head by 71.5%, 13.3%, 387.2%, 93.1% and 100% for T1, T2, T3, T4, and T5, respectively. The result indicates that it is better for the farmers to reduce the utilization of

concentrate in the ration and look for cheaper feed sources that could substitute, commercially, produced feeds. Accordingly the use of dried woybeta leaf meal is vital in this case to fetch good profit.

On the other hand a 10% decrease in selling price of fattened goat will reduce net return in ETB/head by 41.5%, -4.3%, 269.05%, 61.7% and 71.2% for T1, T2, T3, T4, and T5, respectively (Table 5). The analysis indicated that feeding the goats was highly affected by changes in selling price of fattened goats especially for those fed T3 and T5 compared to other treatments since purchase price accounts for more than 98% of the total cost of production.

Table 7 Sensitivity analysis of net return for 20% increase in feed price and 10% decrease in selling price of fattened goats

Item	Treatment				
	T1	**T2**	**T3**	**T4**	**T5**
Initial net return(NR0) (ETB)	276.2	473.2	122.2	416.3	522.5
NR1 (ETB)	197.46	63.118	473.15	387.602	522.5
NR2 (ETB)	114.6	-20.1	328.8	256.7	372.0
ΔNR1 (%)	71.5	13.3	387.2	93.1	100
ΔNR2 (%)	41.5	-4.3	269.05	61.7	71.2
% of feed cost over total cost of production	29.4	22.7	0	9.0	0
% of purchase price over total cost of production	65.3	73.5	97.9	85.9	97.9

NR0: Initial net return without an increase in feed price and a decrease in selling price; NR1: Net return with 20% increase in feed price without a change in selling price; NR2: Net return with 10% decrease in selling price without changes in feed price; ΔNR1 (%): percentage change in net return with 20% increase in concentrate without a change in selling price; ΔNR2 (%): percentage change in net return with 10% decrease in selling price without a change in feed price

4. Conclusion

Although goats supplemented sole CM (T1) looks relatively better performed than goats in all other treatment groups, supplementary feeding of dried woybeta leaf meal (DWLM) as a substitute of concentrate mixture resulted in increased weight gain, better growth performance (measured through linear bodies), DMI and FCE which affected almost similar as CM supplementation. On the other hand, supplementation of air DWLM (T5) was economically dominant and thus is recommended for the initiation of growth of yearling woyto-guji bucks based on the target of the producer.

Compliance with ethical standards

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Disclosure of conflict of interest

DKH designed the experiment. MFH conducted, analyzed and drafted the manuscript. Both authors read and approved the final manuscript. So that, authors declare that they have no competing interest.

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