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Substitution of Poultry Litter for Concentrate Mix as Protein Supplement on Growth Performance of Arsi-Bale Goat

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Abstract: Twenty-five intact yearling goats, were randomly assigned to a complete randomized block design (CRBD) with five treatments and five replications. The aim was to assess the impact of different levels of poultry litter (PL) on feed intake, digestibility, growth performance, and economic return of Arsi Bale goats. Different levels of poultry litter were supplemented in various treatment groups i.e T1- 38.5 % Noug Seed Cake (NSC) + 60.5 % Wheat Bran (WB) + 1% Salt) being control group, T2 (31.6% NSC + 57.4%WB + 10% PL + 1% Salt), T3 (24.8% NSC + 54.3%WB + 20% PL + 1% Salt), T4 (17.9% NSC + 51.1%WB + 30% PL + 1% Salt) and T5 (11.5% NSC + 47.5%WB + 40% PL + 1% Salt). The trial lasted for 90 days, and there were seven days of digestibility testing. There was no significant difference in initial body weight (IBW) and final body weight (FBW) among the treatments, but a significant difference ($P<0.05$) was observed in the total body weight gain (TWG) and average daily weight gain (AGD). Goats supplemented with the highest level of poultry litter (T5) gained more weight ($P<0.05$) than the other groups. The results indicate that supplementing with 40% PL is more effective in increasing weight gain and is economically feasible compared to the other treatments and the control group. No significant difference ($P<0.05$) was observed in dry matter intake (DMI), organic matter intake (OMI), and crude protein intake (CPI) with increased levels of supplementation. Digestibility did not differ significantly among the treatments. The feed conversion ratio was 6.33, 8.00, 8.18, 11.77, and 11.29 g/gm gain for T1, T2, T3, T4, and T5, respectively. Therefore, poultry litter can substitute up to 40% as source of protein for NSC and/or WB without affecting the nutrients utilization but with improved growth performance of goats. Further levels of inclusion of PL and the necessary physical or chemical treatments are recommended to assess more profitable return and possible impact on carcass quality.

Keywords: Arsi Bale Goats, Body Weight, Feed Intake, Digestibility, Poultry Litter

1. Introduction

In Ethiopia, goats are commonly found across various agro-ecological zones and play a crucial role in the livelihoods of different communities. They are an essential part of households, providing both nutrition and disposable income [1]. Goats are raised in a range of farming systems, from small-scale operations on limited land resources to extensive pastoral systems on large tracts of land. These animals offer both tangible benefits, such as meat and milk for home consumption, cash income from animal and milk sales, manure used as crop fertilizer and fuel, fiber, and skins, as well as intangible benefits, such as savings, emergency insurance, cultural and ceremonial services [2]. Goat production is a significant contributor to Ethiopia's economy and supports the majority of farm and non-farm families. In 2021, there were approximately 52.46 million goats in the country [3].

The animals provide approximately 45.8% of all domestic meat consumption, with a small surplus that generates export income primarily from the sale of live animals [4]. However, the income from live animals and processed meat is relatively small compared to the country's potential. Ethiopia has the lowest levels of meat production per animal. The annual meat production per head of goat is 8.5 kg [5]. While there are various reasons for the low productivity of animals, feed resources and feeding systems are the primary factors that account for 65-70% of the total rearing cost of ruminants and other livestock. Feed is undoubtedly the most significant input cost in animal production [6]. Lack of proper nutrition has been identified as the key constraint to animal production in developing regions [7]. In such cases, the performance of animals is ultimately below optimal levels. Due to an increase in population, grazing land and land for fodder and grass production have decreased significantly. As a result, cereal crop residues such as wheat straw, teff straw, and maize stover have become the primary source of feed for many ruminant animals [8]. In fact, feed costs now make up over 70% of production costs. Over the past five years, feed ingredient and compound feed prices in Ethiopia have risen by an average of 52% and 82%, respectively, according to a report from the Ethiopian Meat and Dairy Industry Development Institute (reporterethiopia.com/article/animal-feed-prices-hike 2021). Some commercial farms, both dairy and beef producers, have even had to close due to low returns on investment. In the last five months, animal feed prices in Ethiopia have soared, with concentrate feed prices doubling since November 2020 (reporterethiopia.com/article/animal-feed-prices-hike 2021). For example, a product called noug seed cake, commonly used by dairy and beef farms, has increased in price from 1,400 birrs to 3,800 birrs. Additionally, a byproduct from wheat flour factories that used to cost 1,200 birr per quintal now costs 2,400 birrs [9]. Crop residues make up 80% of the feed for low land areas during dry seasons [8]. However, farmers have not been successful in establishing improved forage and supplementation, which could be due to a lack of awareness, availability of inputs, or affordability. As a result, many resource-poor smallholders, who make up the majority of livestock farmers in the tropical region, are unable to provide their animals with good quality feed and balanced nutrients. Lack of proper nutrition has been identified as the primary constraint to animal production in developing regions [7]. To address the issues caused by the scarcity and high cost of protein supplements, there is a need to explore alternative protein feed sources. The high costs and limited availability of plant protein sources have led to research interest in identifying cheaper protein alternatives [10, 11].

Reports from Ghaly [12] and Bolan et al. [13] suggest that poultry litter is a promising alternative feed resource, with up to 42% crude protein (CP) and a low cost of 135 birr/quintal. Of the CP available in poultry litter, one-third is true protein, while the remaining two-thirds are non-protein nitrogen [14]. In addition to providing protein, poultry litter also supplies energy, fat, calcium, phosphorus, magnesium, selenium, sulfur, and zinc, which are essential nutrients for animals [15]. Poultry production is one of the fastest growing sectors of livestock production in the world with an average annual growth rate of 35% [12]. Each broiler on average produces 1.5 kg poultry excreta over a period of 6 weeks whilst a layer type bird produces on average 16.7 kg poultry excreta annually [16]. The production costs of formulating the dietary rations were reduced by 20-40%. In this respect, the use of poultry litter is a novel approach, which provides a good opportunity to feed manufacturers and entrepreneurs to remove disparities in available feed and supplying balanced feed to the ruminant stock farmers on a large scale [16].

Even though there are different works in different country other than Ethiopia it is more focus on dairy animals, beef, and sheep with little on goats. There are also wide variations in the nutritional composition depending on bedding material, quantity of bedding material per surface unit, density of bird per unit, type of bird, length of rearing period, production intensity, level of Minerals (Mg, Cl, Na and K), ambient temperature and humidity, housing, feed wastage, litter management, nature of ingredients in the ration, type of storage and storage time [14]. In this regard, there are no well documented information on use of poultry litter for fattening of Goat in Ethiopia. Therefore, the objective of study was to evaluate substitution of Poultry litter for Concentrate mix as protein supplement on growth performance of Arsi-Bale goat.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at AdamiTullu agricultural research center, which is in East Shewa zone of Oromia Region at about 168 kilometers of Addis Ababa, situated in the central rift valley of Ethiopia (Figure 1). The center is located between 7°52′N to 38°42′E with an elevation of 1636 meters above sea level. The agro-ecological zone of the area is semi-arid and sub humid with acacia woodland vegetation type. The mean annual rain falls is 760mm. The minimum and maximum temperatures are 12.6°C and 27°C, respectively [9]. The Center was established in 1966 under the Institute of Agricultural Research (IAR), now EIAR. The total area of land it covers is 396 hectors.

2.2. Experimental Feeds Preparation and Feeding Management

Poultry litter was collected from poultry farm found in Adami Tullu agricultural research center. Sun drying method of poultry litter was used to process the collected poultry litter. The collected poultry litter was sun dried till the dry matter reaches 85%. The dried litter was sifted before feeding to remove foreign material, lumps, and bird’s carcass. Sun light heat treatment destroys pathogens and is the cheapest of drying methods.

Experimental feeds composed of concentrate mix having wheat bran and noug seed cake where poultry litter was used to replace the protein source in the concentrate and provided to the experimental animals. Experimental feeds were offered in two equal portions twice a day at 8:00 AM and 4:00 PM. The offer was adjusted once every two weeks based on the animal body weight and enough access to drinking water.

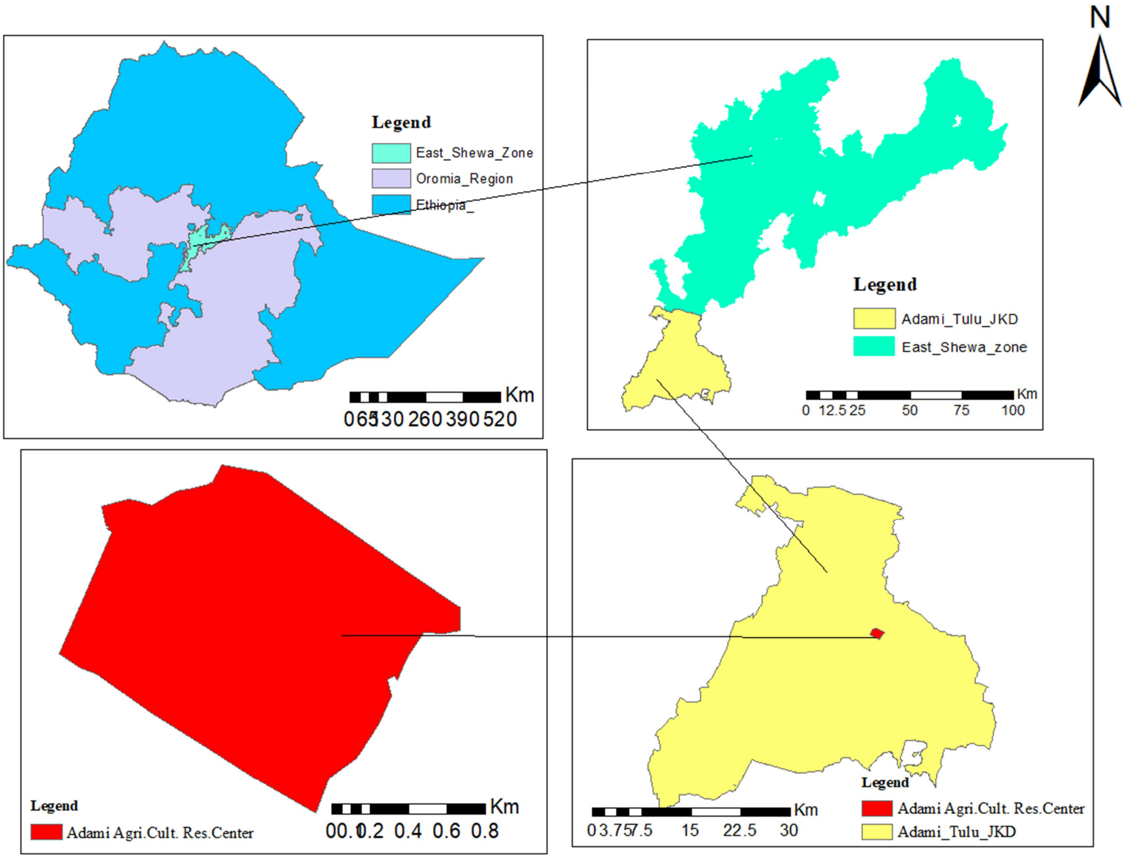


Figure 1. *Map that shows the study area.*

2.3. Experimental Animals and Their Management

For this experiment, twenty-five yearling male Arsi-Bale Goats were used from Adami Tullu agricultural research center stocks. The experimental animals were quarantined for fifteen days and vaccinated against common infectious diseases in the area. Thereafter, the experimental animals were assigned into different treatments after which the animals are randomly put into a separate well aerated pen having a feed trough (Figure 2). Each animal was offered feeds allotted for its respective treatment depending on NRC requirement [17] with grass hay and water is adlib.

Figure 2. *Goats under trial in different pen.*

2.4. Experimental Design and Treatments

The experiment was conducted by using a randomized complete block design (RCBD) with five treatments and five replications. Animals were blocked based on their initial body weight (IBW) into five blocks consisting of five animals. The ingredients used to formulate the concentrate include wheat bran (WB), Noug seed cake (NSC) where the NSC was replaced by poultry litter (PL) at the rate indicated in table 1 below.

Table 1. *Proportion of feed ingredient (on DM basis) across each treatment groups.*

Feed type	**Feed Mix Ratio**				
	T1	**T2**	**T3**	**T4**	**T5**
Grass hay	Adlibitum	Adlibitum	Adlibitum	Adlibitum	Adlibitum
Noug cake (NSC)	38.5	31.6	24.8	17.9	11.5
Wheat bran (WB)	60.5	57.4	54.3	51.1	47.5
Poulty litte (PL)	0	10	20	30	40
Salt	1	1	1	1	1
Total	100	100	100	100	100

2.5. Feeding Trial

The feeding trial was conduct for 90 days following 14 days of adaptation period. The amount of feed offered and the corresponding refusal was weighed and recorded for each goat to determine feed intake. Representative samples of feeds offered and refusal for each animal was collected and pooled per treatment and dried in an oven at 65^0C for 72 hours. Mean daily DM and nutrients intake was determined as a difference of offered and that of refused.

2.6. Live Weight Change and Feed Conversion Efficiency

Refusal feeds from each goat in the treatment group were collected and weighed every day before the daily feed allowance was provided. All data on body weight change of experimental goats were collected fortnightly from the commencement of the trials to the end of the study periods.

All animals were weighed in the morning hours using suspended or digital weighing scale. Daily body weight gain was calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Feed conversion efficiency (FCE) was calculated according to the following author [18] as:

FCE = Daily live weight gain (g)/ Daily feed intake (g)

2.7. Digestibility

The digestibility trial was conducted at the end of feeding trail for seven days. The expermental animals were fitted with fecal collection bags and adapted to carrying them for three days before actual data collection. After acclimatization, the experimental animals were given their respective rations during which time the voluntary intakes of each animal was determined. The preliminary period was then be followed by a collection period of seven days, during which time daily feed offered and refusal, feces voided was measured.

The amount of feces voided daily was collected separately in a bag harnessed to each animal. The content was emptied into a plastic bag labeled for each animal every 24 hours and the quantity were weighed and recorded. Ten percent of the feces voided was weighed and frozen in a container for each animal. The seven days collection was pooled and composite samples of feces was thawed to room temperature, mixed thoroughly, and dried at 65 ^{o}c to a constant weight for 24 h. The dried sample of the feces were ground to pass through 1 mm sieve and stored in air tight plastic bag containers until analyzed.

Nutrient digestibility of the feed was calculated using the data on the feed DMI, fecal DM output, nutrient intake, and fecal nutrient output. Digestible nutrients were computed by multiplying the percentage composition of each nutrient in the feed by its apparent digestibility.

$$\text{Digestibility of Nutrient \%} = \frac{\textit{Nutrient excreted in faces}}{\textit{Nutrient intake}} \times 100$$

Figure 3. *Feed analysis procedure in Adamii tulu agricultural research center.*

2.8. Chemical Analysis of Feed

The chemical analysis of the feed offered and refusal was performed at Adami Tulu Agricultural Research Center feed laboratory (Figure 3). Samples of feed offered and composite of refusal feed were dried in an oven at 65^0C for 72 hours and ground to pass 1 mm sieve screen size. The ground samples were kept in air-tight plastic bags pending chemical analysis. The nitrogen (N), Dry matter (DM), Organic matter (OM), and ash content were analyzed according to AOAC [19]. The crude protein (CP) content was calculated by multiplying N content with a factor of 6.25. Neutral detergent fibers (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed based on the method of Van Soest and Robertson [20].

2.9. Partial Budget Analysis

The partial budget analysis and marginal rate of return were calculated to determine the profitability of the five different supplemental feeds fed to growing bucks under on station management conditions. According to Ehui and Rey [21] Net income (NI) was calculated as the amount of money left when total variable cost (TVC) was subtracted from total returns (TR). In this experiment the variable costs included estimated purchase price of the bucks before entering the feeding trial, purchase of supplemental feed cost and labour cost for preparation of the supplemental feed and cost for medicaments and treatments. While total return (TR) was estimated sale price of the goats. (NI= TR-TVC). Change in net income (ΔNI) was computed as the difference between change in total return (ΔTR) which was total return of the given treatment minus total return of the control treatment (T1) and change in total variable cost (ΔTVC) was total variable cost of the treatment minus total variable cost of the control. ΔNI = ΔTR - ΔTVC. The marginal rate of return (MRR), which measures the increase in net income (ΔNI) in relation with additional unit of expenditure on supplemental feeds (ΔTVC) is expressed as MRR = ΔNI/ΔTVC.

2.10. Statistical Analysis

Data on feed intake and body weight change were analyzed using the general linear model procedure of SAS (2009). The treatment means will be separated by least significant difference (LSD). The model used for data analysis was:

$$Yij = \mu + Ti + Bj + Eij$$

Where; Yij = Response variable, μ = Overall mean, Ti = Treatment effect, Bj = Block effect, Eij = Random error

3. Results and Discussions

3.1. Chemical Composition

The dry matter (DM), Ash, organic matter (OM), Neutral Detergent Fibre (NDF), Acid Detergent Fiber (ADF), Lignin, and Crude Protein (CP) contents of all the feed ingredients used in the feeding trial was presented in Table 2. The CP content of noug cake used in this experiment was comparable to that reported by Van Ryssen [22] (30 %) but lower than the report of Olson and Daniel [23] (35%). However, the ash content of noug cake (15.45%) was higher than reported by [11] (7.35 %). These differences may be due to the method of extraction employed, which brings about differences in chemical composition [24].

Table 2. *Proximate compositions of ingredients of grass hay, concentrate and treatment.*

Feed sample	DM	Ash	OM	NDF	ADF	Lignin	CP	ME (MJ/Kg/DM)
Hay	92.74	9.32	90.68	81.44	56.08	11.67	3.96	-
PL	90.18	15.45	84.55	58.09	20.83	6,15	27.00	-
NSC	91.98	12.51	87.49	39.64	31.56	9.16	32.00	-
WB	90.56	4.58	95.45	36.44	9.78	2.74	16.00	-
TI	91.28	6.94	93.06	44.26	22.06	5.25	22.00	11.93
T2	92.02	10.16	89.84	48.66	23.61	6.59	22.00	11.78
T3	91.36	9.07	90.93	38.86	16.03	3.85	22.00	11.d45
T4	91.28	11.33	88.67	47	17.2	4.47	22.00	11.27
T5	91.45	10.2	88.8	46.15	18.06	5.4	22.09	11.38

DM = Dry matter, CP = Crude protein, NDF = Neutral detergent fiber, ADF = Acid detergent fiber. T1= treatment one … T5= treatment five.

The CP content of wheat bran in this study was comparable to the value of 16.5 and 16.82 reported by Melaku et. al [25] and Tesfaye [26] respectively. But lower than the value 17.19% and 19.99% reported by Tesfaye [26] and Fitwi and Tadesse [27] respectively. The variation might be because of processing in milling industries and the quality of the original grain used in the milling industries. The CP content of the poultry litter used in this study was 27.00 % (DM basis), which was similar to those reported for layers litter [28] and 27.8% [29]. Goetsch and Aiken [30] also reported the range of CP content in poultry litter to be between 15 - 35% of DM. However, it was lower than the CP content of 30.3% [31], and higher than (18-22%) reported by Van Ryssen [22] and (16.5%) report by Nwaigwe [32].

Many factors could contribute to the observed variation in CP content of poultry litter which includes methods of processing [33], the proportion of excreta in the litter [34], types of bedding material [35] and the environmental conditions under which the manure was conserved [34]. As indicated in Table 3, although the CP content of poultry litter was lower than that of noug cake, the quantity CP in poultry litter (27.00%) is more than adequate for supplementing animals fed on poor quality feeds with low N content [17]. Poultry litter in the current trial contained higher total ash (15.45%) as compared to that found in noug cake (12.51%), which was also higher than the content in wheat bran that contained 9.32 %. This may be attributed to the bedding material used in the poultry house. The ash content of poultry litter in this experiment was low as compared to the value of 21.50% reported by Hadjipanayotou [36], but was comparable to the value of 18.01% reported by Negesse [37]. McDonald [24] indicated that other things being equal, the higher the level of ash in the feed samples, the lower will be its energy value.

The CP content of the hay in the current study (3.96%) was lower than the value of 7.75 % reported by Berhanu [38] and 6.77% reported by Negesse [37], but higher than that reported (4%) by Ayalew [39]. Such difference could be attributed to the stage of harvesting during the preparation of hay, soil type and structures [24] and types of forage used for hay making. Numerous evidences indicated that high cell wall constituents set a limit to the intake potential by physical fill and by reducing the digestibility of feeds. As plants mature, the cell wall constituents (cellulose and hemicelluloses) and lignin also increase and the percentage of protein decrease [24]. The same author reports that the higher fiber content results in lower DM digestibility, digestible energy, and TD. Therefore, it is important to supplement the basal feed with better N containing feeds in order to balance its deficiency of N, and thereby support reasonable animal production. Indeed, Greer et. al [40] suggested that basal forages with less than 7% CP require protein supplementation to offset limitations on voluntary feed intake. The CP content of the diets is sufficient enough to use them as supplements, since they supplied more than the minimum (7%) CP content recommended to support optimum rumen function [40]. Reports indicated that the levels of NDF are usually between 30 and 60%; [23] whereas the present finding has lower ADF but higher NDF than the report of Abdul et. al [41] which indicated 28.2%, 30.29 and 38.62.

Similarly, DM and ash content observed in this study are within the expected limits for normal rumen functions [17]; however, the CP content of PL was quite low compared to results by [42, 43]. This is however, acceptable as poultry manure has a wide variability in terms of its nutrient content [44]. Furthermore, Animut et. al [45] and Alam et. al [46] also identified that poultry litter is more nutritious. Nevertheless, the CP content is above the dietary requirement of 7.3 – 7.8 g/kg DM as reported by NRC [17] for goats. The NDF content of PL in the current study is considered adequate for ruminant animals although the ADF was quite low. This was also expected since poultry litter is low in energy [47].

3.2. Feeding Trial

3.2.1. Daily Feed and Nutrient Intake

Average daily intakes of supplement were given in Table 3. The mean daily supplement feed DMI and OMI were not significantly different (P > 0.05) among treatments. Feed intake in goats is influence by many factors, i.e energy level, protein concentration, palatability, digestibility, live weight, fatness, breed, sex, age, environmental temperature, and physiological state of animal [48]. Of these factors' energy level, digestibility and physical state of the diet are the most important factors that limit intake. Owen et. al [49] reported that with decreasing metabolize energy in the diet, voluntary feed intake was increased. Body weight gain and feed efficiency are affected by feed intake. As Esenbuga et al [50] stated, animals which eat more will produce more.

Table 3. *Effect of substituting different level of poultry on nutrient intake of Arsi-Bale goats.*

Intake (g/head/day)	Treatments					Mean	SEM	P Value
	T1	T2	T3	T4	T5			
DM	441	481	493	473	437	465	0.067	0.46
OM	436	472	486	467	430	459	0.066	0.61
CP	106	115	118	114	105	112	0.034	0.62
NDF	214	236	241	231	214	227	0.034	0.60
ADF	91	102	104	100	90	98	0.016	0.53

DM: Dry matter, OM: organic Matter, CP: Crude protein; NDF: Neural detergent fiber and ADF: Acid detergent fiber, T1= treatment one … T5= treatment five.

Dry matter intake of the supplemental feed was not significantly affected by substitution with poultry litter (Table 3). Mixing the poultry litter with the concentrate did not have significant effect on the intake of poultry litter by the ruminants. The mixing action also delivered adequate amount of energy and protein for the microbes in the rumen to utilize the non-protein nitrogenous substance in the poultry litter. Based on the results, adding PL in the diet did not decrease DMI which was in consistence with the results of [42] reported that increasing PL level in the diet did not reduce DMI. Knowlton, et al. [51] also indicated that PL containing diets did not reduce DM and water intake in Holstein and Jersey cows. No decrease in DMI in PL fed goats may be related to appropriate processing method of litter. The litter processing had an important role in removing pathogens and palatability of diets, so goats can consume it properly [52]. The observation of feed intake indicated that the feed intake of the diets was not affected as increasing the PL level in the diets. In agreement with the results of this study, Talib and Ahmed [53], found that PL containing diets have appropriate feed intake and did not decrease DMI.

The present result is disagreed with the result of [28] which indicated in an increase in total feed intake as the replacement level of noug cake by poultry litter in the diets increased up to the level of 28 % inclusion and the intake was decreased when the substitute is beyond 28%. This result also disagrees with the report of Tinnimit et. al [54] who reported that goats even refused to consume ration containing more than 30% poultry litter and Ensminger and Olentine [55] who reported that high mineral content of rations reduces appetite of animals. The DMI of this result also contradicted with [31] reported increased level poultry litter inoculation in the goat diet decreased the DMI of the goats. This may arise from the sources of the poultry litter and the feed ingredients incorporated in the litter.

Obeidat, et al. [42] suggest that poultry manure is a valuable ruminant feed relative to any other environmentally-friendly way of poultry manure disposal [52]. Feed intake was relatively low in the first two weeks of the trial but steadily increased with time until the last week of the experiment. This concurs with the observations made by [56], who reported that, feed intake increases with time for housed goats. In another study by [52], DMI increased in lambs fed a diet containing 450 g/kg sundried poultry litter compared with those fed 0, 150 or 300 g/kg of poultry litter. This suggests that generally poultry manure does not influence DMI.

3.2.2. Live Weight Change

Least-square means (LSM) of final body weight (FBW), total weight gains (TWG), and average daily weight gains (ADG) of the experimental goats fed on the different levels of poultry litter are indicated in Table 4. There is no statistically significant difference in IBW, and FBW but there was significant difference (P<0.05) in the TWG and AGD.

Table 4. *Final body weight and body weight gains of the Goats during the fattening days.*

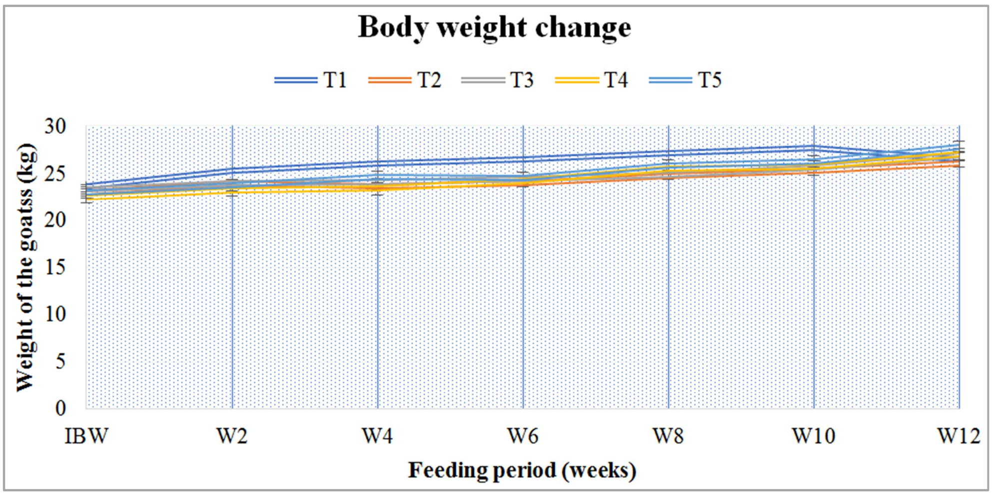
Parameter	Treatments				
	T1	T2	T3	T4	T5
IBW (kg)	23.64±0.52	23.02±0.85	23.33±0.49	22.49±0.66	22.99±0.14
FBW (kg)	26.43±0.34	26.07±1.10	26.86±0.49	26.97±0.74	27.76±0.31
TWG (kg)	2.79±0.29^{b}	3.05±0.67^{b}	3.53±0.28^{ab}	4.48±0.27^{a}	4.77±0.23^{a}
ADG (g)	31.01±3.23^{b}	33.89±7.42^{b}	39.22±3.14^{ab}	49.78±2.99^{a}	53.00±2.58^{a}
FCR	6.33± 0.73^{c}	8.00 ±1.51^{bc}	8.18± 0.58^{b}	11.77±1.37^{a}	11.29±0.74^{a}

Where ADG = average daily gain, TWG= total weight gain, FBW= Final body weight and IBW = initial body weight; FBW = final body weight; TWG; ADG = average daily gain; FCR= Feed conversion ratio, T1= treatment one … T5= treatment five.

In this study, ADG tended to be significantly different among different treatments, in which ADG was greater for the goats consuming feed group of T4 (30%) and T5 (40%) diet than those consumed other diets. Control and T3 diet had the least ADG. High ADG in higher levels of PL fed goats compared to the other group may be related to numerically higher DMI. In contrast to this finding Obeidat et al [42] reported that there was no significant difference in ADG in lambs which were fed different levels of PL in their diet.

The ADG and TWG of goats under PL were higher compared to control groups. This was disagreed with reports by [53, 57] who reports that ADG and TG of goats under PL is low compared to grazing animals by mentioning the major reason for this could be the effect of Star grass and Luecaena leucocephala browse species in which the goats had free access throughout the trial.

As observed in the whole feeding trial, the increment in LBW change was low at the initial stage of the trial, but increased gradually (Figure 4).



Where, IBW =initial body weight, W2 = Weeks 2, W6 = weeks 6, W10= weeks 10 and W12= weeks 12, *T1= treatment one … T5= treatment five.*

Figure 4. *Body weight change of yearling Arsi Bale Goats in the five treatments over the total fattening period.*

The current result is in agreement with conclusion of [58] which indicated that low supply of rumen undegradable protein in animals supplemented with the highest levels of poultry litter inclusion, and rumen undegradable protein were reported to be more useful in promoting daily live weight gain. An increased daily weight for higher level of poultry litter show that the additive benefit of noug cake and poultry litter as ingredients in the diets. The CP in poultry litter consists of both true protein N and NPN, with uric acid as the main NPN component. The NPN was used to meet the ammonia requirement of microorganism found in the rumen; therefore, making more microbial protein available to the animal which was expressed in better daily gains [14]. The DLWG found in supplemented bucks of this study was in agreement with the observation of [59] who reported 41.67±3.56 g/d for Babari goats supplemented with a concentrate mix with poultry litter proportion was 30%. However, the DLWG of this study was smaller than 70±10 g/d gain of West African Dwarf goats in replacement of concentrate by 50% poultry litter [32]. This difference may arise from the difference of processing methods and breed of goat used. In case of [32] they use silage, processing methods which may increase the nutritive value of any feedstuffs. The result disagrees with [31] who report that reduced weight gain in kids when the level of poultry litter increased from 28%.

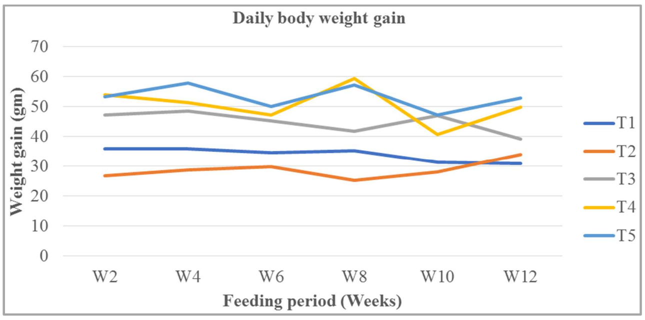


Figure 5. *Trend of daily weight gains of the yearling Arsi Bale Goats.*

Where, IBW =initial body weight, W2 = Weeks 2, W6 = weeks 6, W10= weeks 10 and W12= weeks 12, *T1= treatment one … T5= treatment five.*

Moreover, the result is in agreement with the finding of [60] supplementing dairy cows with concentrate mix at 22% poultry litter as a replacement of ground nut cake increased total dry matter intake and did not depress the body weight and reproductive performance of a cow as compared to cow fed supplementation only on ground nut cake in experiment conducted in Haramaya University. The ADG in the current study shows smooth increment up to the end of the trial (Figure 5).

3.2.3. Feed Conversion Ratio (FCR)

The treatment 4 and 5 had significantly higher ($p \leq 0.05$) feed conversion ratio than the other substitution and control once. T3 had significantly lower ($p \leq 0.05$) feed conversion efficiency as compared to the highest-level poultry litter substitution group (T5). This indicates that goats in T5 were efficient in the utilization of nutrients.

There was no significant ($p>0.05$) difference in their FCR among the substitution treatments except T4 and T5. There was an increasing trend of FCR as the level of substitution increased (i.e., T1< T2< T3<T4<T5) difference in their feed conversion efficiency among the treatments. The feed conversion efficiency measured was higher in this experiment than reported by [61] for fed diets containing different levels of poultry litter to cross goats. This work confirmed early results obtained by [62] which indicated that increase of levels of poultry litter increased the feed efficiency.

3.3. Apparent Digestibility of Nutrients

Digestibility in goats fed a basal diet of wheat straw or hay and different types of supplements is presented in Table 5. Goats fed T1 and T2 diets had higher DM and OM digestibility than those fed T4 and T5 diets, whereas T3 had intermediate digestibility. No differences were observed in DM and OM digestibility among all the treatment diets. The highest digestibility of NDF was in T1 and T2 where that of ADF is in T3 diets and the lowest was in T3 diet.

Table 5. *Digestibility (%) in goats fed basal diet of hay and different level of poultry supplements.*

Variable	T1	T2	T3	T4	T5	Mean	SEM	P-Value
DM	84.25	83.15	82.87	81.34	81.24	82.57	0.57	0.07
OM	79.53	78.53	76.3.	75.88	75.10	77.07	0.34	0.11
CP	7.23	8.15	7.46	7.13	6.91	7.37	0.09	0.09
NDF	42.76	42.15	37.19	37.96	30.48	38.11	0.91	0.12
ADF	27.46	27.82	26.45	28.49	28.42	27.73	0.15	0.06

Where; DM: Dry matter, OM: organic Matter, CP: Crude protein; NDF: Neural detergent fiber and ADF: Acid detergent fiber, T1= treatment one … T5= treatment five.

In the current study, it was demonstrated that the digestibility of DM was not significantly affected while PL level in the diet increases. But there is slightly numerical decrease in DM digestibility which may be the presence of indigestible bedding material in the PL. The current result disagrees with Elemam et. al [52] and Obeidat et al [42] reported that DM digestibility decreases by increasing PL level in the diet. In this experiment, increasing PL level in the diets had not significant effect on CP digestibility, which was disagree with [63] results, indicated that CP digestibility was influenced by increasing PL level in the diet. Reduced CP digestibility in PL containing diets was also reported by [64]. The decreased CP digestibility of PL reported by many authors is due to the occurrence of Maillard reaction which can reduce nutrient digestibility particularly diet CP [65]. Heat production through litter processing can initiate such reactions, for this reason it can decrease CP digestibility in PL containing diets. Chaudhry and Naseer [48] reported that the produced heat over 60 ˚C during poultry litter processing causes Maillard reaction. In the current study sun drying was applied to process the poultry litter which cannot form maillard reaction and reduce CP digestibility. Acid detergent fiber (ADF) digestibility was not significantly affected by dietary treatments. This is in disagreement with the previous study by [64], NDF and ADF digestibility were reduced in the dietary treatments in comparison with the control group. They assumed that decreased NDF and ADF digestibility were related to the reduced rumen pH in PL containing diets. Elemam et. al [52] also indicated that the crude fiber digestibility was reduced in lambs fed 300 g kg-1 PL. Non change in ADF digestibility in current study may be related to the less content of indigestible bedding materials in the litter that are less content of lignin.

3.4. Economic Return of Fattening Arsi Bale Goats

The partial budget analysis of fattening the yearling Arsi Bale goats fed on five different feeds for 90 days is indicated in Table 6. As it can be seen from the Table, there were no changes in purchase price of the goats which were due to the similarity in the mean initial live weight of the animals. However, there were differences in total costs among the treatment groups. Total revenue to be obtained from finished animals depends mainly on price per kg live weight and the final weight of the animals. In the current study, total revenue was higher in treatment T5 which had higher final weight than the other groups. The results showed that experimental goats fed with T5 had higher gross margin per animal (660.09 Birr) than goats fed onT1, T2. T3 and T4 which had gross margins of 132.27, 253.31, 142.77 and 533.69 Birr, respectively. Hence feeding goats with T1, T2 and T3 diets are less profitable as compare to feeding T4 and T5 diet. This is because of the high cost of noug seed cake used in T1, T2 and T3. But the cost of PL used in T4 and T5 are highly low as compare to other feed items used in the control. The PL containing diets not only did not have any negative effects on goat weight gain, but also decreased production costs. Recently, the cost of usual protein sources such as noug seed cake and soybean meal has been increased in Ethiopia. According to the results of this study, replacing NSC by PL decreases cost per kg of feed. Higher PL fed goats had the greatest ADG and the best FCR among all the other treatments, hence had the greatest net income. In addition, the cost per kg of live weight gain was the least in that study.

Table 6. *Partial budget analysis of fattening the Goats.*

Items	Treatment				
	T1	T2	T3	T4	T5
Number of goats	5	5	5	5	5
Average purchase price (ETB)/kg	123	123	123	123	123
Average live weight (kg) at purchase /h	23.64	23.02	23.33	22.49	22.99
Average purchase price (ETB)/head	2918.59	2842.10	2885.88	2776.62	2838.35
Operating cost (per head)					
Feed (Concentrate)	1166.18	1080.01	984.10	905.24	801.11
Labor	20	20	20	20	20
Medicine	90	90	90	90	90
Total operating cost/head	1276.18	1190.01	1094.10	1015.24	911.11
Total cost per head	4084.75	3922.10	3869.95	3681.85	3749.45
Average live weight @ sale/head	26.07	26.86	26.43	26.97	27.76
Average selling price/kg/live weight	180	180	180	180	180
Average return (gross return)/head	4692.6	4834.8	4757.4	4854.6	4996.8
Average net return	607.85	802.74	783.05	1062.74	1247.35
∆ NI	-	194.89	175.2	454.89	639.5
∆ TVC	-	86.17	95.91	78.86	104.13
MRR (Ratio)	-	2.26	1.83	5.77	6.14

∆ NI = Change in net income, ∆ TVC = change in variable cost, MRR = Marginal ret of return, T1= treatment one … T5= treatment five.

Even though the analysis revealed that feeding goats using all feed options in the trial was profitable, there was a defined trend with in increasing profit as the substitution of poultry litter increase. One-way farmers might increase profitability is by reducing feeding costs per animal.

4. Conclusion and Recommendation

In Ethiopia, there are many poultry farms that produce surplus poultry litters and in some cases the accumulation of this by-product has become a problem. On the other hand, there are a lot of small holder farmers who live near and around the poultry farms but are not using the poultry litter as animal feed. Poultry litter is an acceptable source of protein for goats, and it is typically in expensive relative to other high-protein feedstuffs. The chemical composition of the feeds showed that poultry litter contained high CP (27.00 %), which indicated its potential as a protein supplement to ruminants. This finding and other research results indicated that poultry litter also contains substantial levels of minerals which can reduce the number of supplemental sources needed.

From the present study, there were statistically highest in daily weight gain (DWG), total weight gain (TWG) and Feed conversion ratio (FCR) of the yearling Arsi Bale goats fed on the feed which have 30 and 40% inclusion of poultry litter. Significant differences were observed between treatments in cost of feed and cost of feed per unit DWG. Goats fed on poultry litter at inclusion levels of 40% performed well with less cost of feed per live weight gain as compared to control diet. According to the results of this experiment, the growth and nutrient digestion of poultry litter at different levels of inclusion suggested that noug cake can be replaced with poultry litter to up to 40% without any effects on goats. Thus, feeding such animal organic waste to ruminants as a feed ingredient will not only provide the nutrients for animals, but will also solve pollution problems arising from animal wastes. The use of such locally available feeds resources by our farmers will increase their income and hence their living standard as such feeds are cheap and easily available. Even if this was the case, efforts must focus on the best way to use such a by-product, from both technical and economical point of view, by applying the necessary physical or chemical treatments.

It could also be recommended that this feed compounding using up to 40% inclusion of poultry litter enhances the growth performance of goats and yet is cost-effective. IT could be demonstrated to a village where households raising goats near commercial poultry unit generating wastes. As the nutritive value of poultry litter is affected by bedding material and processing methods it is recommended that more investigations must be carried out in order to identify the potential processing method to incorporated poultry litter in the diets of animals.

Conflicts of Interest

Authors declared that there is no conflict of interests.

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