Effect of supplementing concentrate mixture with field pea hull on yearling ram lambs of local sheep: Nutrient intake, linear body measurements, and changes in body weight

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Abstract

The fattening of sheep has been recognized as a potentially profitable activity in the highlands of Ethiopia. However, feed shortage and increasing prices for conventional feed ingredients and commercially formulated concentrate mixtures critically affect the fattening practice of sheep in the country. So, this feeding trial was conducted to evaluate the effect of feeding field pea hull at different inclusion levels with a concentrate mixture on feed intakes, nutrient utilization, linear body measurements, and body weight gain. Eighteen yearling ram lambs were randomly allocated to three dietary treatments using a randomized complete block design. The dietary treatments were T1 (control), fed native hay adlibitum + concentrate mixture formulated using only conventional feed ingredients (0% field pea hull); T2 and T3 were fed native hay adlibitum + concentrate mixture formulated with inclusion of 35% field pea hull and 50% field pea hull, respectively along with other feed ingredients. The feeding trial was conducted for 90 days. Data were analyzed using GLM procedures of SAS, and Turkey's HSD multiple-comparison was used for means separation. The result showed a significant (p<0.001) variation in dry matter and nutrient intake among treatments. The DMI was the highest in T3, followed by T2, while it was the lowest in T1. The average total neutral detergent fiber and acid detergent fiber intakes and metabolizable energy intake were highest in T3 and followed by T2, while they were the lowest in T1. The average total body weight gain (kg) was higher in T3 (9.0kg) and T2 (8.67kg) than in T1 (6.58kg). Similarly, higher average daily body weight gains were recorded in T3 (100g) and T2 (96.3g) than in T1 (73.2g). Sheep that were fed field pea hull by the inclusion of 50 % in concentrate mixtures (T3) were more efficient in feed utilization (p<0.05) than T1 as they consumed significantly less amount of feed per 1 g of body weight gain. Hence, it is concluded that feeding of 50% field pea hull along with concentrate mixture could be used for better fattening performance of sheep.

Keywords*:* Concentrate mixtures; feed efficiency; grass hay; highland sheep; field pea hull.

Introduction

Sheep production plays a significant role in the Ethiopian economy (Gizaw *et al.,* 2013); it provides cash income for meat and skin production for the livelihoods of smallholder farmers. Sheep are also a significant means of employment and income in different production systems (Herrero *et al.,* 2013). The total population of sheep is about 42.9 million (CSA, 2021). However, the mutton production of the sheep is low compared to its potential.

Fattening sheep has been recognized as a potentially profitable activity that enhances the income of smallholder farmers in Ethiopia (Pasha, 2006). However, it is a seasonal activity across all the production systems due to the unavailability of feed throughout the year. Feed shortage is one of the limiting factors for increasing the production and productivity of sheep in most agroecological zones in Ethiopia (Bachano and Etefa, 2022). The most commonly used conventional feed ingredients to prepare concentrate mixtures for ruminant animals include Niger seed (*Guizatia abyssinica*) cake, wheat bran, wheat middling, etc. (Berhane *et al.,* 2013). However, the price of these conventional feed ingredients and the formulated concentrate mixtures are expensive and are increasing at an alarming rate from time to time. Gizaw *et al.* (2017) also indicated that a shortage of feed constrains sheep productivity in Ethiopia and higher price increments of feed, among other factors. Hence, the use of non-conventional feed resources could be an alternative feed ingredient to reduce feed costs in fattening sheep, as most of them are relatively cheaper compared to conventional feeds.

According to FAO (2014), Non-Conventional Feed Resources (NCFR) refers to all those feeds that have not been traditionally used for animal feeding either by farmers or by feed manufacturers in commercial feeds, and these are not used in the ration of commercially produced animals. Non-conventional feeds include agro-industrial by-products, food left over, pulse (such as field peas, grass peas, faba bean, lentils, etc.), hulls, banana peels, and avocado peels, etc. (FAO, 2014). Utilization of non-conventional feeds could be an alternative and relatively cheaper source of supplements (Salem *et al*., 2004).

Pulse hulls are a by-product of pulse seed processing to get pure cracked pulses for human consumption, which are abundantly available in most urban and peri-urban areas of Ethiopia. They are non-conventional feed resources which include field pea (*Pisum sativum* L.) hull, grass pea (*Lathyrus sativus* L.) hull, lentil (*Lens culinaris*) hull, faba bean (*Vicia faba*) hull, etc., where the protein content of these pulse hulls range between 15 to 16% (Berhane *et al*., 2013). Although pulse hulls are available in large quantities in most places of Ethiopia and are good potential non-conventional feed resources, limited research has been conducted on feeding field pea hulls to fatten sheep. Therefore, the objective of the study was to investigate the effect of feeding field pea (*Pisum sativum* L.) hull inclusion level in the concentrate mixtures on feed intake, nutrient intake, body linear measurements, and body weight gain in yearling ram lambs of local sheep.

Materials and methods

Description of the study area

The feeding trial was conducted at Ambo University, Guder Mamo Mezemmir Campus (AUGMC), Guder town, West Shewa Zone, Oromia National Regional State, Ethiopia. Guder town is located 126 km away from Addis Ababa, which is the capital city of Ethiopia, and 12 km away from Ambo Town (capital town of West Shewa Zone). The town of Guder lies with an altitude of about 1850 above sea level, and the temperature varies from 17 to 23.4^{0}C, the average being 20.35^{0}C. The rainfall amounts range between 1200 and 1,700mm (AUGM website, 2021) (https://ambou.edu.et>mmc). The sheep population of Oromia National Regional States is 9,752,385, of which West Shewa Zone, being one of the 21 zones of the region, has a sheep population of 1,074,939 contributes 11.02 % of the population (CSA, 2021).

Experimental animals and their management

For conducting a feeding trial, eighteen-yearling ram lambs were purchased from local markets around Holeta and its surroundings by considering their age of about one year (one pair of permanent teeth), using dentation body weight (17-22 kg), better body condition, and health of the yearling ram lambs. The ram lambs were tagged for identification after they were purchased and were kept in an experimental house. Each sheep was kept in a single pen in an area of 1.1 m^2 with individual feeding troughs. The house was cleaned and washed two times a day, early in the morning and afternoon, to keep the animals healthy during the whole experimental period. All purchased ram lambs were dewormed against internal parasites and injected with ivermectin 2 ml per head against external parasites. The experiment considers the ethical issues of animal handling. All animal handling practices followed the international guiding principles listed by the Council for International Organizations of Medical Sciences and the International Council for Laboratory Animal Science (2012).

Experimental design and treatment allocation

The animals were randomly assigned into six blocks (three animals in one block), representing one animal for each treatment using initial body weight taken after overnight fasting at the end of environmental adaptation. All experimental ram lambs were managed for one month of adaptation by providing the same feed during quarantine, deworming, and confining management system. They also kept ten additional days for experimental feed adaptation. The average initial body weight of experimental animals was 21.06±1.32 kg (mean ± SE). The three treatments were randomly allotted to each block. Then, the animals taking the same treatment were picked up from each block and formed one treatment group, i.e.,e there were six replications per treatment.

The descriptions of the three dietary treatments were as follows:

T1 (**Control) =** Fed native hay *ad libitum* + control concentrate mixture formulated by using only conventional feed ingredients of niger seed cake, maize, and salt at the rate of 49.5, 49.5, and 1%, respectively, according to Solomon *et al.* (1991), without field pea hull;

T2 = Fed native hay *ad libitum* + concentrate mixture formulated with the inclusion of 35% field pea hull along with niger seed cake, wheat bran, and salt at the rate of 34, 30, and 1%, respectively;

T3 = Fed native hay *ad libitum* + concentrate mixture formulated with the inclusion of 50% field pea hull along with niger seed cake, wheat bran, and salt at the rate of 33,16, and 1%, respectively (Table 1).

These three types of concentrated mixtures were formulated based on NRC (1989) requirements so as to have isonitrogenous and isocaloric rations. They had actual average crude protein content of 21.5%, ranging from 21.3 to 21.7% (Table 1).

Table 1.The proportion (%) of feed ingredients used in the formulation of different concentrate mixtures

Feed ingredients	T1	T2	T3
Maize	49.50	-	-
Niger seed cake	49.50	34	33
Wheat bran	-	30	16
Field pea hull	-	35	50
Salt	1	1	1
Total	100	100	100
Calculated CP%	20.30	20.30	20.30
Actual CP %	21.70	21.40	21.30

T1 native hay +standard concentrate mixture formulated from Niger seed cake (49.5%), maize (49.5%) and salt (1%) without pulse hull; T2 native hay + concentrate mixture formulated by inclusion of 35% field pea hull + Niger seed cake (34%), maize (30%) and salt (1%); T3 native hay + concentrate mixture formulated by inclusion of 50% field pea hull + Niger seed cake (33%), maize (16%) and salt (1%).

Feeding of experimental animals

The weighted amount of formulated concentrate mixtures was fed in equal proportion to individual sheep twice a day at 9:00 AM and 3:00 PM. Native hay (at 20% of refusal) and water were provided ad libitum to individual ram lamb. The feeding experiment was conducted for 90 days.

Data recording and measurements

Feed intake

The weighed amount of native hay and different concentrate mixtures were fed based on treatments for each yearling ram lamb on each day, and the data were recorded. The next day, the feed refusal from each type of concentrate mixture and hay from each sheep were weighed and recorded. The daily feed intake for each sheep was calculated by subtracting the amount of each feed refusal from each type of feed offered. The dry matter intake (DMI) was then calculated by multiplying the feed intake from each type of concentrate mixture and hay by the corresponding dry matter percentages of the consumed types of feed.

Body weight gains and efficiency of feed utilization

The weight of each sheep was taken at the initial period, at fortnightly or 15-day intervals, and at the end of the experimental period after overnight fasting using a spring weighing balance. The body weight change/the body weight gain (BWG) of each yearling ram lamb was calculated as the difference between the final body weight (FBW) and initial body weight (IBW), i.e., BWG = FBW-IBW. Average daily body weight gain (ADWG) was calculated as the difference between the FBW and IBW and divided by the number of experimental days, i.e., ADG = FBW-IBW/the number of experimental days. The feed conversion ratio (FCR) is the parameter used to calculate the efficiency of feed utilization. FCR was calculated as the ratio between the average daily dry matter intake (DMI) per sheep (g) to the average daily gain per sheep (g), i.e., FCR = Average daily DMI of each sheep (g)/ average daily gain per sheep (g) (AOAC, 2005).

Linear body measurements and body condition scores

The body condition score for each sheep was taken at the start of the experiment, at fortnightly intervals, and at the end of the experimental period. The body condition score was done by palpation at the back and loin of the sheep with fingers to estimate the amount of muscle and fat deposited in the animal body using three trained personnel. For each sheep, values were given from one to five by each person, and then the average values were taken. Body surface measurements of body length, body height, chest circumference, and chest width were also taken. Body length was taken from pin bone up to shoulder area. Body height was taken at the wither height (from the ground to the top of the wither), heart girth was measured at the circumference of the sheep behind the front legs, and chest width was measured at the front width of the sheep using centimeters (FAO, 2012). All measured data were taken at the initial of the experimental period, at fortnightly intervals, and at the end of the experimental period using centimeters.

Feed sampling and chemical analysis of experimental feeds

Feed samples for chemical analysis were taken from each feed ingredient of hay, field pea hull, Niger seed cake, wheat bran, and maize. Samples were also taken from three types of formulated concentrate mixtures at fortnightly intervals for two consecutive days till the end of the feeding trial. The collected samples were then pooled per treatment. Composite samples were made after thorough mixing for laboratory analysis and sent to Holeta Agriculture Research Center Animal Nutrition Laboratory for chemical analysis**.** The partially dried samples of each feed were ground using a laboratory mill to pass through a 1-mm sieve screen size. The samples were analyzed for dry matter, organic matter, crude protein, and total ash contents using the proximate method of analysis (AOAC, 2005). Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Digestibility of Organic Dry Matter (DOMD), and Metabolizable Energy content of different feeds were determined as per the methods described by Goering and Van Soest (1970).

Data analysis

All the data collected on the different parameters were analyzed using least square analysis of variance for RCBD as per General Linear Models (GLMs) procedures using SAS software packages version 9.2 (SAS, 2008). Means were separated using Tukeys' HSD multiple-comparison techniques whenever ANOVA showed significant variation.

The model used for data analysis was:-

$$Yijk = \mu + \tau i + \beta j + \tau\beta ij + \varepsilon ijk$$

Where yijk = observation k in treatment i and block j (individual measurement on each sheep such as body weight, body length, etc.)
μ = overall mean effect.
τi = fixed effect due to the i^{th} treatment.
ßj = fixed block effect due to body weight.
Tßij = the interaction effect of treatment i and block j.
εijk = random error.

Results

Chemical composition of different feed ingredients and concentrate mixtures

The chemical compositions of different feed ingredients used to formulate the concentrate mixture are given in Table 2. The dry matter contents of different feed ingredients ranged from 90.4% in maize to 93.39% in Niger seed cake, while the crude protein (CP) contents ranged from 9.5% in maize to 33% in Niger seed cake. The highest NDF and ADL contents in the feed ingredients were recorded in native hay (74.29 and 5.53%, respectively), while the lowest NDF was recorded in maize (19.11%), and the lowest ADL was observed in wheat bran (2.62%).

The CP contents of the formulated concentrate mixtures were ranged from 21.31% (T3) to 21.69 (T1). The highest NDF and ADF contents were recorded in T3 (59.39 and 27.88, respectively), while the lowest contents were recorded in T1 (42.94 and 10.19, respectively). The ADL content was slightly higher in T3 (7.38%) and lower in T1 (4.80 %) (Table 2).

Table 2. The chemical composition of different feed ingredients, concentrate mixtures, and hay fed to a yearling ram lamb

Type of Feeds	DM (%)	OM	CP	Ash	NDF	ADF	ADL	DOMD	IVD MD	ME (MJ/kg DM)
T1	91.02	94.45	21.69	5.55	42.94	10.19	4.80	65.66	72.39	10.5
T2	90.86	95.18	21.44	4.82	54.81	22.70	6.05	60.19	67.24	9.63
T3	91.07	96	21.31	4.00	59.39	27.88	7.38	57.31	64.53	9.17
NSC	93.39	89.3	33	10.7	46.38	19.32	9.64	51.30	58.87	8.21
FPH	90.58	95.34	16.52	4.66	68.11	40.05	5.02	58.69	65.83	9.39
WB	90.63	95.45	14.0	4.55	36.33	5.54	2.62	72.71	79.02	11.6
Maize	90.40	93.13	9.5	6.87	19.11	3.03	3.58	79.12	85.05	12.7
NH	90.79	90.61	7.0	9.39	74.29	38.34	5.53	53.11	60.57	8.50

T1: native hay + concentrate mixture formulated from Niger seed cake (49.5%), maize (49.5%) and salt (1%) without pulse hull; T2: native hay + inclusion of 35% field pea hull + concentrate mixture formulated from Niger seed cake (34%), maize (30%) and salt (1%); T3: native hay + inclusion of 50% field pea hull + concentrate mixture formulated from Niger seed cake (33%), maize (16%) and salt (1%); DM: Dry Matter; OM: Organic Matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin; DOMD, ME, MJ, IVDMD: Invitro dry matter digestibility; NSC: Niger seed cake; FPH: Field pea hull; WB: Wheat bran Maize; NH: Native hay

Dry matter intake (DMI) of yearling ram lambs

The average dry matter intake (g/h/d) of yearling ram lambs with different levels of field pea hull in concentrate mixtures is shown in Table 3. A significant difference (p<0.001) was observed in the dry matter intake of yearling ram lambs among the treatments. The average total dry matter intake during the experimental period was the highest (p<0.001) in T3 (714.15g), followed by T2 (705.51g), while the lowest intake (643.22g) was recorded in T1. The dry matter intake of hay followed the same pattern as the total DMI, where the highest dry matter intake of hay (p<0.001) was in T3 (368.2g), followed by T2 (363.56g), while the lowest intake was in T1 (346.39g) treatment. On the other hand, the dry matter intake of the concentrate mixture was higher in T3 and T2 than in T1 (Table 3). The DMI of yearling ram lambs at fortnightly intervals showed that treatment T3 and T2 had higher DMI than the control. The differences in DMI between T3 and T2 were minimal, although T3 showed slightly higher values than T2 in DMI. The DMI of sheep in all the treatments had reduced in the second fortnight, but the latter showed a continuous increase in DMI (Figure 1).

Table 3.The average dry matter intake (g/h/d) of yearling ram lambs during the experimental period

	Treatments (6 animals per treatment)				
Variables	**T1**	**T2**	**T3**	**SEM**	**P-Values**
Hay DMI (g)	346.39^{c}	363.56^{b}	368.2^{a}	0.78	0.001
Con. Mix DMI(g)	296.83^{b}	341.95^{a}	345.95^{a}	1.23	0.001
Total DMI (g)	643.22^{c}	705.51^{b}	714.15^{a}	1. 68	0.001

Con. Mix: Concentrate mixture; DMI: Dry matter intake; g: gram; T1: native hay + concentrate mixture formulated from Niger seed cake (49.5%), maize (49.5%) and salt (1%) without pulse hull; T2: native hay + inclusion of 35% field pea hull + concentrate mixture formulated from Niger seed cake (34%), maize (30%) and salt (1%); T3: native hay + inclusion of 50% field pea hull + concentrate mixture formulated from Niger seed cake (33%), maize (16%) and salt (1%); 0.001: Significant at (p<0.001)

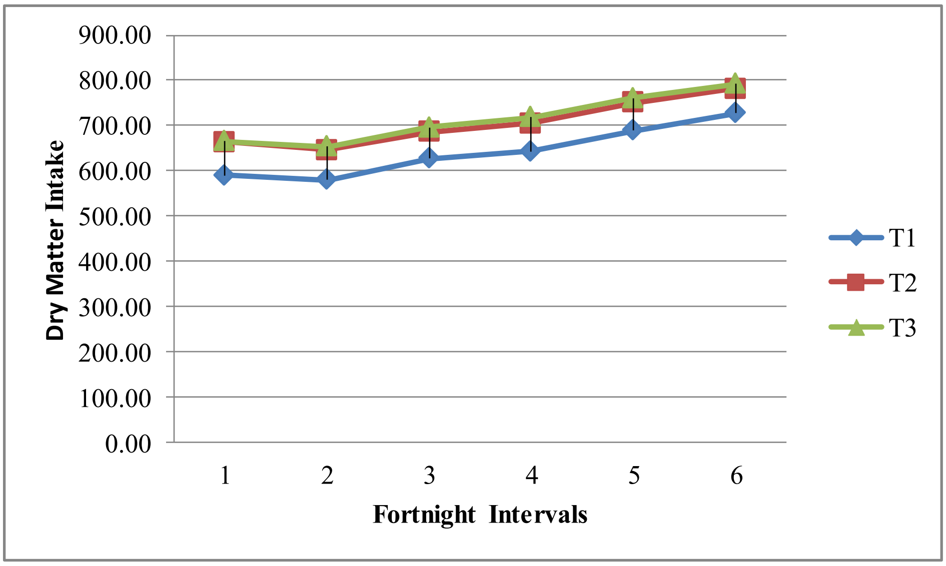

Figure 1. Trends of fortnightly dry matter intake of yearling ram lambs (g/d/h) during the experimental period

Nutrient intake of yearling ram lambs

The average nutrient intake (g/h/d) of yearling ram lambs is shown in Table 4. The average total CP intake of yearling ram lambs was higher (p<0.001) in T3 (99.56) and T2 (98.76) than in T1(88.66). The average total neutral detergent fiber (NDF) intake of yearling ram lambs was the highest (p < 0.001) in T3 (478.99), followed by T2 (457.51). The average hay and concentrate mixtures of neutral detergent fiber intakes followed the same pattern as the average total neutral detergent fiber intake, where the intakes were the highest (p<0.001) in T3, followed by T2. The ADF intakes of hay, concentrate mixtures, and total ADF intakes were the highest (p<0.001) in T3, followed by T2 than the T1 control. Similarly, ME intakes (MJ per sheep per day) were the highest (p<0.001) in T3, followed by T2, while intakes were the lowest (p<0.001) in T1 (Table 4).

Table 4. The average nutrient intake (g/h/d) of yearling ram lambs during the experimental period

Variables	Treatments (6 animals per treatment)			SEM	p-values
	T1	T2	T3		
CPI					
Hay CPI	24.25c	25.45b	25.77a	0.05	0.001
Con. Mix CPI	64.41b	73.31a	73.79a	0.26	0.001
Total CPI	88.66b	98.76a	99.56a	0.28	0.001
NDFI					
Hay NDFI	257.33c	270.09b	273.54a	0.58	0.001
Con. Mix. NDFI	127.46c	187.42b	205.46a	1.01	0.001
Total NDFI	384.79c	457.51b	478.99a	1.35	0.001
ADFI					
Hay ADFI	132.81c	139.39 b	141.17a	0.3	0.001
Con. Mix ADFI	30.25c	77.62b	96.45a	0.73	0.001
Total ADFI	163.05c	217.01b	237.62a	0.89	0.001
MEI(MJ/day)					
Hay MEI	0.041c	0.0428b	0.0433a	0.00	0.001
Con.Mix MEI	0.028c	0.035b	0.038a	0.00	0.001
Total MEI	0.069c	0.078b	0.081a	0.00	0.001

Con.Mix: Concentrate mixtures; MEI: Metabolizable energy intake; CPI: Crude protein intake; ADFI: Acid detergent fiber intake; NDFI: Neutral detergent fiber intake; T1: native hay + concentrate mixture formulated from Niger seed cake (49.5%), maize (49.5%) and salt (1%) without pulse hull; T2: native hay + inclusion of 35% field pea hull + concentrate mixture formulated from Niger seed cake (34%), maize (30%) and salt (1%); T3: native hay + inclusion of 50% field pea hull + concentrate mixture formulated from Niger seed cake (33%), maize (16%) and salt (1%).

Linear body measurements of yearling ram lambs

The average linear body measurements (cm) of yearling ram lambs are shown in Table 5. Body length and height did not show significant variation (p>0.05) among the treatment groups. However, there was a highly significant variation (p<0.001) in heart girth and chest width, which increased steadily throughout the experimental period.

Table 5. The average body linear body measurements (cm) of yearling ram lambs that were taken every 15 days interval during the experimental period

	Treatments (6 animals per treatment)				
Variables	**T1**	**T2**	**T3**	**SEM**	**p-values**
Body length	59.75	59.33	60.61	0.45	0.50
Heart girth	66.17[b]	68.25[a]	69.53[a]	0.30	0.001
Body height	60.28	60.22	61.33	0.29	0.23
Chest width	13.06[b]	13.94[a]	14.03[a]	0.12	0.001

T1: native hay + concentrate mixture formulated from Niger seed cake (49.5%), maize (49.5%) and salt (1%) without pulse hull; T2: native hay + inclusion of 35% field pea hull + concentrate mixture formulated from iger seed cake (34%), maize (30%) and salt (1%); T3: native hay + inclusion of 50% field pea hull + concentrate mixture formulated from Niger seed cake (33%), maize (16%) and salt (1%); SEM: Standard Error Mean.

Body weight gain and efficiency of feed utilization

The effect of feeding field pea hull at different levels of inclusion in concentrate mixtures on body weight gain and the efficiency of feed utilization of yearling ram lambs is presented in Table 6. There was no significant difference ($p>0.05$) among the dietary treatment groups. However, the total body weight gain (kg) was higher ($p<0.01$) in T3 and T2, which was 9.0kg and 8.67kg, respectively, than T1 (6.58kg). Similarly, the higher average daily body weight gain was higher ($p<0.01$) in T3 (100g) and T2 (96.3g) than in T1 (73.2g) during the experimental period. Feed conversion ratio (FCR) showed significant ($p<0.05$) variation among the treatment groups, where the yearling ram lambs in T2 and T3 were more efficient in feed utilization than the control group (T1).

Table 6. Average body weight gain of yearling ram lambs during the experimental period

Variables	Treatments (6 animals per treatment)				
	T1	**T2**	**T3**	**SEM**	**p-Values**
IBW (kg)	19.33	19.08	19.33	0.36	0.95
FW (kg)	25.92	27.75	28.33	0.53	0.16
TBWG (kg)	6.58[b]	8.67[a]	9.00[a]	0.39	0.01
ADBWG (g)	73.15[b]	96.30[a]	100.00[a]	4.29	0.01
FCR	8.93[a]	7.39[b]	7.38[b]	0.46	0.05

T1: native hay + concentrate mixture formulated from Niger seed cake (49.5%), maize (49.5%) and salt (1%) without pulse hull; T2: native hay + inclusion of 35% field pea hull + concentrate mixture formulated from Niger seed cake (34%), maize (30%) and salt (1%); T3: native hay + inclusion of 50% field pea hull + concentrate mixture formulated from Niger seed cake (33%), maize (16%) and salt (1%); SEM: Standard Error Mean; IBW: Intial body weight; FW: Final body weight; TBWG: Total Body weight gain; ADBWG: Average daily body weight gain; FCR: Feed conversion ratio.

Discussion

Chemical composition of experimental feeds

Dietary nutrients, especially energy and protein, are the significant factors affecting the productivity of sheep (Yimenu and Abebe, 2023). The CP content of native hay in the experimental feed is 7%, which is lower than the minimum maintenance requirement of sheep (7.5% on DM) (Van Soest, 1994). However, the CP content of the filed pea hull is 16.52, which was higher than the reported value for the filed pea hull (Yimenu and Abebe, 2023). The CP content of T2 (35% of field pea hull) and T3 (50% of field pea hull is comparable with T1 (concentrate mix), 21.31, 21.44, and 21.69, respectively. The level of CP contents for all concentrate mixtures in the present study was above the CP content of 12.5 % required to satisfy rumen microbial demands for nitrogen that would provide sufficient CP for the maintenance requirement of the animal (Van Soest, 1994). The better protein content of the filed pea hull and its inclusion with concentrate will support the fattening of ram lamb and could be included in the fattening ration. However, the value of NDF of the field pea hull was high. Still, its level in the concentrate mix T2 (54.81), and T3 (59.39) is considered as a medium, which indicates that the inclusion of filed pea with other concentrates will help to lower the NDF content instead of using it alone. Singh and Oosting (1992) pointed out that roughage feeds containing NDF values of less than 45% are classified as high, those with values ranging from 45 to 65% as medium, and those with values higher than 65% as low quality. The values of ADF contents of experiment feed ingredients are also considered low. Kellems and Church (1998) indicated that roughage with less than 40% ADF is categorized as better quality and those with greater than 40% as poor quality. The ADF of filed pea hull values were lower than the earlier reports of 63.9% ADF reported by Seyoum *et al.* (2007) and higher than 30.4-42.4% and 43.3% of ADF reported by Yetimwork (2005) and Ermias (2008) in that order for faba bean haulms.

Dry matter and nutrient intake

The present findings of higher total DMI and CP intake in T3 and T2 agree with the findings of Yoseph *et al.* (2002), who reported that feeding of pulse hulls (lentil, grass pea, and field pea hull) to the sheep improved total DMI and CP intake than the control group (feeding of native hay). Habte (2010) also revealed that supplementation of different levels of lentil hull to lambs resulted in higher DMI and CPI than the control group (feeding of native hay).

The higher crude protein intake in T3 and T2 in the current study compared to the control might be due to the optimal tannin content present in the treatment concentrate mixtures (T3 and T2), a result of the inclusion various levels of field pea hull, in the concentrate mixtures. Berhane *et al*. (2013) reported that field pea hull has a tannin content of 6.16%. But, when this field pea hull was included at the rate of 35 and 50% in concentrate mixtures formulated for dairy cows, the tannin content in the formulated concentrate mixtures was 0.88 and 1.57%, respectively. This indicated that the rate of tannin content in the formulated concentrate mixtures was lower than 4% and resulted in the beneficial effect of the bypass protein in the present experiment. Different authors also reported that the optimum tannin content (≤ 4%) in formulated concentrate mixtures facilitates the bypass protein by binding with macromolecules such as protein in the rumen; thereby, amino acids are more effectively utilized in the lower digestive tract improve the performance of the sheep (Barman and Rai, 2006; Dubey, 2007).

Body weight gain, efficiency of feed utilization, and linear body measurement changes

The current findings of the average daily body weight gains recorded in T3 (100g) and T2 (96.30g) were higher than the reported values of Yimenu and Abebe (2023), who reported an average daily body weight gain of 74.82 g for the Washera sheep supplemented with 400g concentrate feeds over the basal diet of natural pasture grass hay and 50% field pea hull with traditional brewery dried residue and concentrate feeds. On the other hand, the average daily body weight gain of T1 (73.2g) in the current study was similar to the reported values of 74.82g Hirute *et al*., 2011) in which Arsi bale sheep fed on urea-treated barley straw and 400g concentrate. Feed utilization efficiency variation among the treatments showed that T3 and T2 were more efficient in feed utilization than T1. This indicated that the amount of feed consumed per 1 g of body weight gain was higher in T1 (8.93g) than T2 (7.39g) and T3 (7.38g), indicating feeding of field pea hull at an inclusion level of both 35 and 50% is more efficient than the control.

Significant variation in Heart girth and Chest Width in the current study agreed with the report of Ayele and Urge (2019), who reported that there was a significant difference in linear body measurements between experimental groups of three sheep breeds. Higher values of Heart girth and Chest Width in T2 and T3 might be due to the compensatory growth of yearling ram lambs in higher inclusion levels of 35 and 50% field pea hull. The same authors also indicated that higher CP and ME intake of sheep might have contributed to enhanced skeletal growth. Luzardo *et al.* (2019) also indicated that higher feed intake and growth efficacy were associated with compensatory growth.

Conclusions

There was the highest total dry matter intake in those yearling ram lambs that were fed 50% field pea hull in concentrate mixture (T3), followed by those fed 35% field pea hull (T2), while it was significantly the least in control (T1). On the other hand, total crude protein intake was higher in both T2 and T3 than in the control. The total body weight gain and the average daily body weight gain (g) during the experimental period were significantly higher both in those yearling ram lambs that were fed concentrates mixtures formulated by the inclusion of 50% and 35% field pea hull (T3 and T2, respectively) than in the control group (T1). Feed utilization efficiency was higher in T2 and T3 than the control group (T1), which indicates that the amount of feed consumed (g) per g of body weight gain was the lowest in T3 and T2 than the control. Heart girth and chest width were also higher in T3 and T2 than in the control group (T1). Generally, it has been concluded that feeding of field pea hull at the inclusion level of 50% in concentrate mixture along with 33% Niger seed cake, 16% wheat bran, and 1% salt could be used for better fattening performance of sheep. The current result is limited to two levels of inclusion of field pea hull. However, further investigation could be conducted to evaluate the effects of feeding peal hull in concentrate mixture at different levels of inclusion for efficient utilization of field pea hull.

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