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Biological performance and carcass yield of yearling Gumuz sheep under graded level concentrate supplementation in Ethiopia

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ABSTRACT. An experiment was conducted to investigate the effects of graded levels of concentrate on feed intake, biological performance and carcass characteristics of yearling Gumuz sheep. The sheep were purchased and treated against endo- and ecto- parasites before commencing the study. The experimental animals were offered natural grass hay as a basal ration. The experimental design was a Randomized Complete Block Design (RCBD) with six replications. Treatment feeds were arranged in the same amount of wheat bran but in different levels of sesame seed cake which comprises: 150 g wheat bran + 0 g sesame seed cake DM day^{-1} (T1), 150 g wheat bran + 250 g sesame seed cake DM day^{-1} (T2), 150 g wheat bran + 350 g sesame seed cake DM day^{-1} (T3) and 150 g wheat bran + 450 g sesame seed cake DM day^{-1} (T4). The experiment was conducted for 90 days after 15 days of adaptation period to the experimental feeds and conditions, which were then followed by carcass evaluation at the end. Sheep in T2 and T4 achieved higher total DM intake (1004.03-1072.57 g day^{-1}) than T1 and T3. Sheep fed on graded-level sesame cake supplements (T2, T3 and T4) recorded significantly higher average daily gain (ADG) than the control (T1) and resulted in higher feed conversion efficiency (FCE). As a result of better slaughter weight (SW) achieved significant hot carcass weight (HCW) was recorded in sheep at T3 and T4. Among the concentrate levels, T2, T3 and T4 were found optimum in improving carcass yield and major meat quality attributes. Sheep supplemented with T3 had the highest net return (26.66 USD) and highest marginal rate of revenue (MRR) (6.53) compared to the other high-level sesame cake-supplemented groups. Thus, it is recommended that the supplementation of hay with high-level sesame cake supplement (T3) is biologically efficient and potentially profitable in the feeding of growing *Gumuz* sheep.

Keywords: carcass yield; gumuz sheep; natural grass hay; sesame seed cake; wheat bran.

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Introduction

Small ruminants are valuable sources of meat, milk and fiber globally. The importance of small ruminants is far-reaching especially in developing countries since they are immediate sources of cash income, serve as a saving account, ensure household food security, and are used as a means to build assets and alleviate poverty among the poorest sections of society. Moreover, meat from small ruminants is ideal for family consumption without deteriorating in quality owing to their comparatively small carcass size, particularly in rural communities which lack effective cooling systems for meat preservation (Devendra, 2001).

Ethiopia has around 42.9 million sheep which stands as the second-largest sheep population in Africa. Although Ethiopia has a large population of sheep that are widely distributed across all agroecological zones of the country, their productivity is very low, mainly due to inadequate production inputs such as animal feeds. Based on reports of various scholars, sheep productivity in Ethiopia is estimated at 16 to 126 g day^{-1} average daily gain, 7 - 18 kg hot carcass weight and dressing percentage of 34 to 49% (slaughter body weight basis) at 18 - 26 kg slaughter body weight have been recorded for Ethiopian sheep breeds fed various type of basal and supplement diets (Central Statistical Agency [CSA], 2021). Most of the sheep in Ethiopia which are owned by smallholder farmers and pastoralists depend entirely on natural grasslands and crop aftermaths as sources of feed. These feed resources contain less than 7% crude protein (CP) and more than 75% neutral detergent fiber (NDF) (Gashu, Tegene, & Aster, 2017). Such poor feed stuff are known in compromise feed intake and digestibility, resulting in inadequate nutrient supply to satisfy the maintenance requirement of sheep, and thus cause severe weight losses, particularly in the non-forage growing season.

Therefore, it is imperative to improve the utilization of poor-quality feed resources such as crop residues by correcting their nutrient deficiencies through supplementation. One alternative in this regard is the use of agro-industrial by–products as supplements in the straw-based feeding of livestock (Reverdin & Sauvant, 1991). Such a strategy could enable the high nutrient requirements for growing livestock to be met to attain the desired degree of finish for the market. Out of all the agro-industrial byproducts available in Ethiopia particularly in the study area, sesame seed cake (SSC) as protein source feed and wheat bran (WB) as an energy source could be used as feed supplements in grazing and crop residue-based feeding of sheep.

However, these by-products are not effectively utilized by smallholder farmers in their area of production, mainly due to a lack of information about their potential as feed supplements as well

as the optimum ratio at which they can be mixed in supplementary rations for sheep. Therefore, the objectives of the study were to evaluate the effect of graded levels of concentrate on biological performance and carcass characteristics of yearling Gumuz sheep fed on natural grass hay as a basal diet and to estimate the profitability of the feeding regimes.

Material and methods

Description of the study area

The study was conducted at Gende wuha Gumuz sheep conservation and improvement station which is located between 12° 46'45.26'' N latitude and 36° 24' 20.68'' E longitude, at an elevation of 745.4 m. a. sl. Mean annual rainfall ranges from about 850 to around 1100 mm, and it receives unimodal rainfall. The mean minimum and maximum temperature of the area ranges from 19°C up to 35°C.

Experimental animals and their management

Twenty-four yearling Gumuz ram lambs with a mean body weight of 20.00±2.20 kg were purchased from the surrounding market and quarantined for 15 days. Following the quarantine period, the sheep were weighed and blocked based on their initial weight into 6 blocks and each animal within each block was randomly assigned to one of the four dietary treatments. Prior to the experimental data collection, each sheep was given two weeks of adaptation to the experimental diet, treated against internal and external parasites using Ivermectin. Experimental animals were housed in separated (1.2×1.0 m) individual pens. Experimental feed was offered twice a day at 8:00 and 16:00 hours, while natural grass hay, water, and salt licks were provided *ad libitum*. The protocol that we used in the present experiment was evaluated by a team of researchers.

Experimental design and treatments

The experiment was conducted in a randomized complete block design with six replications. Besides natural grass hay as basal diet, dietary treatments were: 150 g wheat bran + 0 g sesame seed cake (T1), 150 g wheat bran + 250 g sesame seed cake (T2), 150 g wheat bran + 350 g sesame seed cake (T3) and 150 g wheat bran + 450 g sesame seed cake (T4) on DM basis.

Feed intake, growth and feed conversion efficiency

The feed offered and refused was recorded daily, and daily feed intake was calculated as the difference between offer and refusal. Animals were weighed every ten days early in the morning after 12 hours of restriction from feed and water using Salter Scale with a sensitivity of 100 g. The average daily weight gain was determined by regressing the body weight (BW) of each animal on days of feeding. Feed conversion efficiency (FCE) was calculated as a proportion of ADG to daily corresponding dietary intake (Gülten, Rad, & Kindir, 2000).

Carcass parameters

At the end of the growth trial, all experimental sheep were restricted from feed and water for about 12 hours, weighed and slaughtered for determination of carcass characteristics. Slaughtering was conducted in the slaughterhouse constructed at the station for carcass evaluation. The parameters measured to end the experiment were carcass parameters (slaughter weight, empty body weight, hot carcass weight, dressing percentage, rib-eye muscle area and fat thickness) and main carcass components (fore-quarter, neck region, sternum, thoracic and lumbar region, rib-eye muscle, abdominal muscle, hind-quarter, pelvic (rump) region, ribs and tail fat weight). Based on the surrounding community culture after stratifying offals into edible and non-edible offal components they were also measured and evaluated. Slaughter weight (SW) was taken immediately before the animals were killed. The empty body weight (EBW) was calculated as the difference between slaughter weight (SW) and gut content. Hot carcass weight (HCW) was recorded immediately after slaughter and computed by excluding contents of thoracic, abdominal and pelvic cavities, head, and skin with fetlock. Dressing percentage (DP) was computed as a proportion of hot carcass weight to slaughter weight (Gilmour, Cullis, Fogarty, & Banks, 1994).

The rib-eye muscle area (REA) of each animal was determined by tracing the cross-sectional area of the 11^{th} and 12^{th} ribs after cutting perpendicular to the backbone rib eye area based on the recommendation of Torell and Suverly (2004). The left and right rib-eye muscle areas were traced on a transparent waterproof paper and the area was measured by using a 1 cm^2 grid square having 5 by 5 dots within a grid (Alemu, Solomon, & Kifetew, 2021). Fat thickness was measured at the middle upper part of the rib eye area by using a graduated ruler having a sensitivity of 1 mm.

Cost-benefit analysis

A partial budget analysis was performed to evaluate the profitability of feeding regimes. The cost of all variable inputs, buying and selling prices of lambs including labour cost for chopping hay were recorded to determine the net income of production. The initial price of lambs was directly taken as the purchasing price. At the end of the experiment, three experienced sheep dealers estimated the selling price of each experimental sheep before slaughtering. Monetary values of all other variable inputs were considered at the prevailing market price. All the costs were estimated in Ethiopian Birr (ETB) and then converted into USD. During January, 2021 the exchange rate for 1 USD was 44.32 ETB.

Statistical analysis

Statistical analysis was performed to determine the effect of supplement level. Data from feed intake, body weight change, feed conversion efficiency and carcass parameters were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of (SAS, 2003). When the difference is significant, LSD (least significant difference) test was used to locate differences between the treatment means. The statistical model used for data analysis was: $Y_{ij} = \mu + t_i + b_j + e_{ij}$, Where Y_{ij}= the response variable, μ = the overall mean, t_i = the i^{th} treatment effect, bj = the j^{th} block effect and e_{ij} = the random error.

Results and discussion

Feed intake

The intake of hay, supplement and total DM intake by sheep allocated to different treatments is shown in Table 1. Supplementation significantly ($p < 0.05$) affects hay DM intake. The higher intake (604- 607g day^{-1}) of hay achieved in T1 and T2 might be due to the deficiency of nutrients in the supplement feed offered which resulted in animals thriving to satisfy their nutrient requirement by increasing hay intake. The higher the composition of the NDF and ADF in feedstuffs, the lower the nutritive value of the feed and animals increase intake as far as gut fills limit further intake to satisfy their nutrient requirement (McDonald, Edward, Greenhalgh, & Morgan, 2002). Similar to the results of the current study, Preston and Leng (1984) suggested that supplements can substitute fibrous feeds if the levels of supplementation exceed 20% of total DM intake. The total daily DM intake was significantly ($p < 0.05$) higher for high-level concentrate-supplemented groups (T4) than for the lower ones. The observed increase in total DM intake in the high-level supplemented sheep might be due to better contents of CP as a result of the increased level of sesame seed cake in the supplement feed. Feed intake can be maximized if the feed provides all the nutrients required by appropriate rumen microbes and by the tissue of the animal. The increased total DM intake in the present study agreed with the results of Alemu et al. (2021) that reported increasing levels of concentrate supplement (600 g $head^{-1}$ day^{-1} comprised of 75% noug seed cake and 25% wheat bran) resulted in higher daily total DM intake.

The total DM intake as a percent of body weight in the current study was significantly ($p < 0.05$) different among the treatment groups. Sheep in T4 recorded relatively higher total DM intake as a percent of body weight than sheep in T1 and T3.

Table 1. Mean daily dry matter intake of Gumuz sheep supplemented with graded level of concentrate.

Parameters	Treatments				SL
	T1	T2	T3	T4	
Dry matter intake					
Hay DM intake (g day^{-1})	607.60^{a}	604.00^{a}	451.40^{b}	472.60^{b}	*
Supplement DM intake (g day^{-1})	150.00^{d}	400.00^{c}	500.00^{b}	600.00^{a}	***
Total DM intake (g day^{-1})	757.64^{c}	1004.03^{ab}	951.39^{b}	1072.57^{a}	*
DM intake (% BW)	3.17^{b}	3.50^{ab}	3.23^{b}	3.74^{a}	*
DMI (per kg $W^{0.75}$) (g day^{-1})	46.83	38.59	30.1	35.85	ns

[*]a,b,c,d= means within rows having different superscript letters are significantly different at *** = $p < 0.001$; *= $p < 0.05$; ns = non-significant at ($p > 0.05$); BW= body weight; DM= dry matter; DMI= dry matter intake; SL= significance level; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake $head^{-1}$ day^{-1}; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake $head^{-1}$ day^{-1}; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake $head^{-1}$ day^{-1}; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake $head^{-1}$ day^{-1}.

This could be probably due to the higher concentrate intake achieved. For indigenous *Gumuz* yearling sheep, DM intake in the range of 2.7-3.62% body weight was reported by Alemu, Yeshambel, and Firew (2020) when they were supplemented with different levels of concentrate, which is by far lower than the result obtained in this study. This is due to the differences in type and level of concentrate used at different times which ultimately affect the amount of total dry matter intake and body weight. Daily total dry matter intake per unit metabolic body weight (g kg^{-1} $W^{0.75}$) was not significant ($p > 0.05$) among sheep fed different concentrate levels.

Body weight change and feed conversion efficiency

Final body weight, net gain, average daily gain (ADG) and feed conversion efficiency (FCE) were significant ($p < 0.05$) between treatment groups (Table 2). Among the treatments sheep fed on T2, T3 and T4 recorded relatively higher final body weight and heavier ($p < 0.05$) average daily body weight was gained than the control (T1). This might be due to the BW gain tended to increase for the higher CP intakes as a result of increasing in concentrate level. Alemu et al. (2020) also noted that supplementation with high levels of protein source supplements resulted in higher final body weight (BW) and daily body weight gain than the low level of supplementation. The results of average daily body weight gain of sheep supplemented with different levels were higher than Alemu et al. (2020) who reported 44.26- 86.67 g day^{-1} average daily body weight gain in Gumuz sheep fed basal diet grass hay and supplemented with 400g day^{-1} $head^{-1}$ of Noug seed cake and Wheat bran at different proportions. Mulugeta and Gebrehiwot (2013) also reported a relatively lower average daily body weight gain which was in the range of 60.00 - 77.80 g day^{-1} for indigenous (*Koraro* sheep) fed a basal diet of tef straw supplemented with 150 - 300g day^{-1} Sesame seed cake in mixture with the 150g Wheat bran, respectively. This could be due to the differences in sheep breed, concentrate level and ratio, environment and age of animals used at different times. In agreement with the results of Mulugeta and Gebrehiwot (2013) a positive weight gain of sheep was maintained in the control group (T1) showing us that wheat bran is very important in improving the nutritive values of poor-quality roughages.

A significant ($p < 0.05$) difference was observed in FCE between sheep fed on different concentrate levels. The observed higher FCE in T2, T3 and T4 may be due to higher daily body weight gain achieved than feed consumed. The current result was comparable to the FCE recorded in indigenous (*Koraro* sheep) fed on teff straw supplemented with 150- 300 g day^{-1} Sesame seed cake in a mixture with the 150 g Wheat bran (Mulugeta & Gebrehiwot, 2013).

Table 2. Mean initial, daily and final body weight of Gumuz sheep supplemented with graded level of concentrate.

Parameters	Treatments				SL
	T1	T2	T3	T4	
Initial BW (kg)	20.17	20.00	20.17	19.67	ns
Final BW (kg)	24.12^{b}	28.63^{a}	29.43^{a}	29.07^{a}	**
Net gain (kg)	3.95^{b}	8.63^{a}	9.27^{a}	9.40^{a}	**
ADG (g d^{-1})	43.89^{b}	95.93^{a}	102.96^{a}	104.45^{a}	**
FCE	0.06^{b}	0.10^{a}	0.11^{a}	0.10^{a}	*

[*]a, b= Means within the same row not bearing a common superscript letters differ significantly at **= $p < 0.01$; * = $p < 0.05$; ns= non-significant at ($p > 0.05$); ADG= average daily body weight gain; BW = body weight; FCE: feed conversion efficiency; SL= significant level; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake $head^{-1}$ day^{-1}; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake $head^{-1}$ day^{-1}; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake $head^{-1}$ day^{-1}; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake $head^{-1}$ day^{-1}.

Carcass parameters

The slaughter body weight (SW), empty body weight (EBW), hot carcass weight (HCW), and rib-eye muscle area were better ($p < 0.01$) for the high-level concentrate-supplemented group than the low-level supplemented (T1) (Table 3). The higher EBW in the high-level supplemented sheep might be due to the lower proportion of gut content Alemu et al. (2021) and BW increase than the low-level concentrate supplemented sheep since EBW is the difference between SW and gut content (Jagdish, 2004). As a result of better SW achieved by high-level concentrate supplemented group significant ($p < 0.05$), HCW was recorded by T3 and T4. Though there was no significant difference ($p > 0.05$) among the treatment groups in dressing percentage, it is still within the range of the average dressing percentages (ADP) of tropical sheep (40-50%) as reported by (William, Payne, & Wilson, 1999).

Rib-eye muscle area in T3 and T4 was significantly ($p < 0.01$) higher than in T1. This implies that the highly supplemented group's carcass leanness increased significantly from the control treatment. Comparable results to this study were reported by Mulugeta and Gebrehiwot (2013) for indigenous (*Koraro* sheep). However, the result we obtained was relatively lower than the values reported by Alemu et al. (2021) for *Gumuz*, *Rutana* and *Begiet* sheep breeds when supplemented with different levels of concentrate. While only a significant ($p < 0.05$) difference was absorbed between the treatment groups in fat thickness with the highest values in high-level concentrate supplemented groups.

Table 3. Mean Carcass characteristics of Gumuz sheep supplemented with graded level of concentrate.

Carcass parameters	Treatments				SL
	T1	T2	T3	T4	
No. of animals slaughtered	6	6	6	6	
Slaughter BW (kg)	24.12^{b}	28.63^{a}	29.43^{a}	29.07^{a}	**
Empty BW (kg)	11.08^{c}	12.95^{b}	15.00^{a}	14.90^{a}	**
Hot carcass weight (kg)	9.30^{c}	11.05^{bc}	12.98^{a}	12.60^{ab}	**
Dressing percentage (%)					
Slaughter BW base	38.58	38.28	44.17	43.51	ns
Empty BW base	83.83	84.97	86.65	84.77	ns
Fat thickness (mm)	2.58^{b}	5.67^{a}	7.17^{a}	5.50^{a}	*
Rib-eye muscle area (cm^2)	6.95^{b}	9.02^{ab}	10.97^{a}	11.18^{a}	**

[*]a, b= Means within the same row not bearing a common superscript letters differ significantly at ** = $p < 0.01$; * = $p < 0.05$; ns= non-significant at ($p > 0.05$); BW = body weight; SL= significant level; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake $head^{-1} day^{-1}$; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake $head^{-1} day^{-1}$; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake $head^{-1} day^{-1}$; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake $head^{-1} day^{-1}$.

Main carcass components

According to the main carcass components, the study showed significant differences among the treatment groups in all the parameters other than neck region (Table 4).

Table 4. Mean Main carcass components (gram) of Gumuz sheep supplemented with graded level of concentrate.

Main carcass components	Treatments				SL
	T1	T2	T3	T4	
Fore- quarter	1792.00^{c}	2145.30^{b}	2719.40^{a}	2452.40^{ab}	***
Neck region	796.40	603.50	927.00	908.50	ns
Sternum (Brisket)	283.22^{c}	366.32^{bc}	486.38^{a}	443.5^{ab}	**
Thoracic and lumbar region	301.02^{b}	481.63^{a}	560.35^{a}	565.02^{a}	**
Rib-eye muscle	484.42^{c}	715.67^{b}	905.88^{a}	780.38^{ab}	**
Abdominal muscle	443.03^{b}	636.27^{a}	774.47^{a}	617.35^{ab}	*
Hindquarter	2045.10^{b}	2637.20^{a}	2978.80^{a}	2885.40^{a}	**
Pelvic (Rump) region	854.60^{b}	1129.50^{a}	1299.10^{a}	1273.00^{a}	*
Tail fat weight	92.53^{b}	187.05^{ab}	253.20^{a}	164.62^{ab}	*
Ribs	535.68^{b}	692.47^{a}	794.97^{a}	746.88^{a}	**
TMCC (Kg)	7.62^{c}	9.59^{b}	11.70^{a}	10.83^{ab}	***

[*]a,b= Means within the same row not bearing common superscript letters differ significantly at ***= $p < 0.001$; **= $p < 0.01$; *= $p < 0.05$; ns= non-significant at ($p > 0.05$); SL= significant level; TMCC= total main carcass components; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake $head^{-1} day^{-1}$; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake $head^{-1} day^{-1}$; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake $head^{-1} day^{-1}$; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake $head^{-1} day^{-1}$.

A significant amount of main carcass components and total main carcass yield was recorded relatively in high-level concentrate-supplemented sheep. This might be due to the lower proportion of gut content and BW increase than the low-level concentrate supplemented sheep.

Main carcass components and total main carcass yield results obtained in this study are in disagreement with those reported by Alemu et al. (2021) for *Gumuz*, *Rutana* and *Begiet* sheep breeds when supplemented with different levels of concentrate. This could be due to the differences in concentrate level and ratio, and age and sheep breed used at different times.

Edible offal components

The mean edible offal component results of the study are presented in Table 5. There was no significant ($p > 0.05$) difference exhibited in any of the values of blood, heart, kidney, omaso-abomasum, testicle, pelvic fat, pancreas, total usable product (kg) and total usable product (% SW) among the treatment groups (Table 5).

However, the values of kidney fat, omental and mesenteric fat and total edible offal significantly ($p < 0.01$) heavier in high-level supplemented groups especially in T3 and T4. On the other hand liver, tongue, reticulo-rumen and hindgut were also significant ($p < 0.05$) in T3 and T4 than T1. The current result was comparable to the edible offal components recorded in Gumuz, Rutana and Begiet sheep breeds when supplemented with high levels of concentrate (Alemu et al., 2021).

Table 5. Mean Edible offal components (gram) of Gumuz sheep supplemented with graded level of concentrate.

Edible offals	Treatments				SL
	T1	T2	T3	T4	
Blood	870.30	1040.97	1080.73	988.35	ns
Heart	105.17	138.77	168.50	154.55	ns
Liver	321.97^{b}	462.87^{ab}	543.73^{a}	502.97^{a}	*
Kidney	83.67	90.65	125.52	121.52	ns
Tongue	88.48^{bc}	107.47^{ab}	130.93^{a}	76.15^{c}	*
Reticulo-rumen	522.28^{b}	640.58^{a}	697.20^{a}	641.12^{a}	*
Omaso-abomasum	239.20	284.98	302.62	330.17	ns
Hind gut	732.18^{c}	920.77^{ab}	973.45^{a}	785.67^{b}c	*
Testicle	231.62	296.22	288.98	308.22	ns
Kidney fat	30.00^{b}	88.80^{b}	184.37^{a}	202.60^{a}	**
Pelvic fat	32.43	44.67	54.55	95.07	ns
Pancreas (g)	118.97	144.82	146.42	134.33	ns
Omental and mesenteric fat(g)	44.27^{b}	153.28^{b}	343.73^{a}	357.32^{a}	**
Total edible offals (kg)	3.12^{b}	4.12^{a}	4.74^{a}	4.38^{a}	**
Total usable product (kg)	14.57	16.07	16.09	16.49	ns
Total usable product (% SW)	61.10	55.93	54.74	57.22	ns

*a, b= Means within the same row not bearing a common superscript letters differ significantly at ** = $p < 0.01$; *= $p < 0.05$; ns= non-significant at ($p > 0.05$); SL= significant level; SW= slaughter weight; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake head^{-1} day^{-1}; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake head^{-1} day^{-1}; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake head^{-1} day^{-1}; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake head^{-1} day^{-1}.

Non-edible offal components

Skin and total non-edible offal for T2, T3 and T4 were significantly ($p < 0.01$) higher than those of T1 (Table 6). Head without a tongue was also significantly ($p < 0.05$) greater in T2, T3 and T4 compared with the control. On the other hand gut content was significantly ($p < 0.05$) lower in T3 and T4 related to T1 and T2. This is because animals in the low-level supplemented group consumed relatively higher hay than high-level concentrate-supplemented sheep, which resulted in high retention time in the rumen and ultimately higher gut content.

Partial budget analysis

The result revealed that supplements with a high proportion of Sesame seed cake resulted in higher profit margins than supplements with low proportions of Sesame seed cake and Wheat bran alone (Table 7). Minimal net return observed in T1 may be associated with less improvement in the body weight of sheep, the observed rough hair coat and the unattractive general physical appearance of animals than sheep in T2, T3 and T4 as a result of lower nutrient intake. Generally, sheep which had a better CP intake had superior ADG as a result, had a higher sale price to earn a higher net return. The marginal rate of return for graded-level sesame seed cake supplemented sheep in T2, T3 and T4 was 4.03, 6.53 and 3.86 USD, respectively. This indicates that to attain the required BW by supplement feeding, each additional unit of 1 USD increment per sheep to purchase supplement feed resulted in a profit of 4.03 USD for T2, 6.53 USD for T3 and 3.86 USD for T4, respectively.

Table 6. Mean non-edible offal components (gram) of Gumuz sheep supplemented with graded level of concentrate.

Non-edible offal	Treatments				SL
	T1	T2	T3	T4	
Head without a tongue (kg)	1357.32[b]	1468.47[a]	1661.62[a]	1628.30[a]	*
Skin (kg)	1.75[b]	2.42[a]	2.71[a]	2.62[a]	**
Penis (g)	51.17	83.87	70.07	116.22	ns
Feet (g)	515.55	650.85	704.98	622.68	ns
Lung with the trachea (g)	542.50	559.50	538.70	541.80	ns
Esophagus (g)	542.50	559.50	538.70	541.80	ns
Spleen (g)	92.30	144.82	146.42	134.33	ns
Gall bladder with bile (g)	17.07	67.68	57.05	58.63	ns
Bladder (g)	35.43	22.72	38.08	68.12	ns
Total non-edible offals (kg)	4.58[b]	5.79[a]	6.30[a]	6.17[a]	**
Gut content (kg)	5.29[ab]	5.90[a]	3.94[c]	4.14[bc]	*

*a, b= Means within the same row not bearing common superscript letters differ significantly at *= $p < 0.05$; ns= non-significant at ($p > 0.05$); SL= significant level; SW= slaughter weight; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake head^{-1} day^{-1}; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake head^{-1} day^{-1}; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake head^{-1} day^{-1}; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake head^{-1} day^{-1}.

Table 7. Partial budget analysis results of Gumuz sheep supplemented with graded level of concentrate.

Variables	Treatments			
	T1	T2	T3	T4
Number of animals	6	6	6	6
Purchase price of sheep (USD head^{-1})	39.58	39.58	39.58	39.58
Total feed consumed (kg head^{-1})	68.19	90.37	85.63	96.53
Total variable cost (USD)	5.24	8.56	8.59	10.11
Gross income (USD)	49.66	66.36	74.82	73.31
Total return (USD)	10.09	26.78	35.35	33.73
Net return (USD)	4.84	18.22	26.66	23.62
Δ TVC	-	3.32	3.34	4.87
ΔNI	-	13.38	21.82	18.78
MRR (ratio)	-	4.03	6.53	3.86

*USD= United States Dollar; MRR= marginal rate of revenue; T1= Grass hay + 150 g Wheat bran and 0 g sesame cake head^{-1} day^{-1}; T2= Grass hay + 150 g Wheat bran and 250 g sesame cake head^{-1} day^{-1}; T3= Grass hay + 150 g Wheat bran and 350 g sesame cake head^{-1} day^{-1}; T4= Grass hay + 150 g Wheat bran and 450 g sesame cake head^{-1} day^{-1}.

Conclusion

The present study demonstrated that yearling *Gumuz* ram lambs fed natural grass hay as a basal diet when supplemented with high-level concentrate resulted in improving total dry matter intake which leads to satisfactory feedlot performance, carcass yield and quality. The use of supplementation provided optimum levels of nutrients to support maintenance and growth compared to a basal diet and resulted in higher FCE. Different concentrate levels did not improve the dressing percentage (DP) of yearling *Gumuz* ram lambs. Compared to the high-level Sesame cake supplemented group for profitable sheep feeding (Grass hay + 150 g Wheat bran and 350 g sesame cake head^{-1} day^{-1}) was found more economical in obtaining higher net income and marginal rate of revenue. Hence, according to the results of this study for better animal performance, carcass yield and quality, feeding growing Gumuz ram lambs with Grass hay + 150 g Wheat bran and 350 g sesame cake head^{-1} day^{-1} was biologically efficient and potentially profitable.

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