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Effect of Barley Bran, Linseed Meal and Their Mixes Supplementation on Carcass and Non-Carcass Components of Arsi-Bale Sheep Fed on Basal Diet of Faba Bean Haulms

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Abstract
Twenty five yearling male Arsi-Bale sheep breed with mean initial body weight of 19.8 ±1.29kg were used to evaluate the effect barley bran (BB), linseed meal (LSM) and their mixes supplementation on carcass, edible and non-edible offal components. A complete randomized block design consisting of five treatments and five blocks was employed. The treatments were T_1: *ad libitum* feeding of faba bean haulms, T_2: *ad libitum* faba bean haulms + sole supplementation of BB, T_3: *ad libitum* faba bean haulms + supplementation of 2BB:1LSM, T_4: *ad libitum* faba bean haulms + supplementation of 1BB:2LSM and T_5: *ad libitum* faba bean haulms + sole supplementation of LSM. To increase intake, haulms were chopped 2-5cm prior to offering. The supplement feeds were offered at 300 g/head per day in DM basis at 08:00 and at 16:00 hours by dividing the daily offer into two equal portions. The feeding trial was conducted for 90 days. At the end of the feeding trail, sheep were fasted for 12 hours (with free access to water), weighed and slaughtered for carcass and non-carcass components analysis. Unsupplemented sheep resulted significantly lowest carcass ($P<0.001$), liver ($P<0.05$), kidneys and intestines ($P<0.01$) weights as compared to supplemented treatments. There were no significant differences ($P>0.001$) observed among supplemented groups. In conclusion, different proportion of concentrate supplements could affect the weight of both the carcass and non-carcass components.
Keywords: Barley bran, carcass, faba bean haulms, linseed meal, offal

1. Introduction

In the tropics, Ethiopia is among the countries that posses large sheep populations. According to CSA (2013), Ethiopia has 25.5 million sheep, which is third in Africa next Sudan and South Africa, and sixth in the tropics (FAO 2001; FAO 2004). According CSA (2013) about one million sheep were slaughtered in Ethiopia where most of the sheep were slaughtered at about 12 months of age with live weight of 18 to 20 kg (FAO 1996) with the mean carcass weight of about 10 kg (FAO 2004), which is the second lowest amongst sub-Saharan African countries.

Although grains are important as concentrate feeds for animals, they are not usually used as animal feed in Ethiopia because the quantity produced in the country has not yet satisfied the needs of human being. Due to this agro-industrial by-products are used as alternative feed supplements livestock. This is particularly important in Ethiopian farming systems where crop residues and agro-industrial by-products are major feed resources for sheep production. There is a wide cultivation of faba bean, linseed and barley in the study area. Moreover, there are factories that process barley and linseed into flour and oil, respectively, and barley bran and linseed meal were used as animal feed supplements in the study area. However, the effect of these feeds supplementation on carcass components, edible and non-edible offal of Arsi-Bale sheep was not studied so far. Therefore, this study was carried out to investigate the effect of barley bran, linseed meal and their mixes supplementation on carcass and non-carcass components of Arsi-Bale sheep fed on faba bean haulms as a basal diet.

2. Materials and methods

2.1 The study area

The study was conducted in Bekoji (7°33' 09"N latitudes and longitudes of 39°15' 37"E), Ethiopia located in Arsi Administrative Zone of Oromia Region 231 km southeast of Addis Ababa. The study area is typically highland with mean altitude of 2804 meter above sea level having a bimodal rainfall pattern (main rainy season extends June to September and short rainy season extends February to April) with a mean annual precipitation of about 1120 mm with a mean minimum and maximum temperature of 7.8°C and 18.9°C, respectively (KARC 2005).

2.2 Experimental animals

Twenty five male yearling Arsi-Bale sheep with mean initial body weight of 19.8 ±1.29kg were bought from farmers and used for the study. The age of the sheep was estimated using dentition. The sheep were vaccinated against pasteurellosis and sheep pox (within five days interval) which were common sheep diseases in the study area, and quarantined for 15 days. In the meanwhile, animals were de-wormed against endo-parasites and sprayed against ecto-parasites. Then they were put in independent pens for 90 days feeding trial.

2. 3 Experimental design and treatments

A complete randomized block design that consists of five treatments and five blocks was used. The treatments were T_1: *ad libitum* feeding of faba bean haulms (control), T_2: *ad libitum* faba bean haulms + sole supplementation of barley bran (BB), T_3: *ad libitum* faba bean haulms + supplementation of 2BB:1LSM, T_4: *ad libitum* faba bean haulms + supplementation of 1BB:2LSM and T_5: *ad libitum* faba bean haulms + sole supplementation linseed meal (LSM). The treatment feeds were randomly assigned to each sheep in the blocks. The faba bean haulms were chopped to a size of approximately 2 to 5 cm prior to feeding. The supplement feeds were offered at 300 g/head daily in DM basis at 08:00 and at 16:00 hours by dividing the daily offer into two equal portions.

2.4 Carcass and non-carcass component analysis

At the end of the feeding trial, the sheep were fasted for 12 hours with free access to water, weighed and slaughtered. The blood individual sheep was collected, the skins were properly removed and their weights were recorded. The hot carcass was weighed and dressed into main carcass components (CC) and the weight of each CC was recorded. Similarly, each edible offal (EO) and inedible offal (IEO) were separated and weighed.

2.5 Statistical analysis

The statistical model used for the study was:

$$Y_{ij} = \mu + T_i + Bi + E_{ij},$$

Where: Y_{ij} = the response variable; μ = the overall mean; T_i = the treatment effect; Bi = Block effect; E_{ij} = the random error

The data were analyzed using means procedure of SAS (2002) version 9 and when treatment means were significant, least significant difference (LSD) was used to locate differences.

3. Results and discussions

3.1 Carcass components

The initial body weight, slaughter weight, empty body weight and hot carcass weight of experimental animals are given in Table 1. The slaughter body weight (SW), empty body weight (EBW), hot carcass weight (HCW) were better ($P<0.001$) for supplemented treatments than the control. In agreement, feeding system had significant effect on live-weight at slaughter and hot carcass weight of lambs' (Joy *et al.* 2008; Carrasco *et al.* 2009). Slaughter BW was lower ($P<0.001$) for T_2 compared to T_4 and T_5, whereas, T_3, T_4 and T_5 performed better ($P<0.001$) in EBW and HCW than T_2.

Table 1. Average initial, slaughter, hot carcass and empty body weight of Arsi-bale sheep

Parameter	T_1	T_2	T_3	T_4	T_5	SL	SEM
Average initial BW (kg)	19.9	20.0	19.4	19.7	19.6	ns	0.73
Average slaughter BW (kg)	18.5^{c}	25^{b}	26.5^{ab}	27.6^{a}	27.2^{a}	***	0.78
Average empty BW (kg)	13.7^{c}	19.9^{b}	21.7^{a}	22.7^{a}	21.6^{a}	***	0.68
Average hot carcass weight (kg)	6.3^{c}	10^{b}	11.4^{a}	12.2^{a}	11.6^{a}	***	0.38

*Means within a row not bearing similar superscript are significantly differ; BW = body weight; ns=not significant; SEM = standard error of means; SL = significant level; *** = p<0.001; ** = p<0.01.*

All carcass components of the supplemented treatments were higher ($P<0.001$) than the control (Table 2). The forelegs, neck region, abdominal muscle, ribs, tail and total carcass components (TCC) were higher ($P<0.001$) for T_3, T_4 and T_5 compared to T_2. The highest weight of fore and hind legs was recorded in T_5 and the lowest in T_1. Among the TCC, the hind legs took highest share (22.3 to 25.5%) of the hot carcass weight and followed by forelegs that took 18.1 to 20.5% share, and the third was the ribs that took 9.3 to 10.3% of the hot carcass weight for all treatments. Joy *et al.* (2008) reported that feeding system has significant effect on all joints except leg and the concentrate supplemented lambs carcasses. Supplemented lambs produce relatively more commercial (retail) cuts (loin, leg, rib (rack), shoulder/neck and total meat than the non-supplemented groups (Moron-Fuenmayor & Clavero 1999).

Table 2. Carcass components of Arsi-Bale sheep fed on a basal diet of faba bean haulms and supplemented with different proportion of barley bran and linseed meal

Parameter	T_1	T_2	T_3	T_4	T_5	SL	SEM
Forelegs (g)	1292^c	1853^b	2113^a	2209^a	2240^a	***	68.10
Neck region (g)	567^c	939^b	1134^a	1194^a	1152^a	***	61.45
Sternum (brisket) (g)	269^b	428^a	447^a	468^a	419^a	***	23.95
Thoracic and lumbar region (g)	585^b	832^a	912^a	935^a	911^a	***	46.70
Rib-eye muscle (g)	294^c	500^b	647^a	605^{ab}	713^a	***	35.68
Abdominal muscle (g)	275^c	478^b	651^a	647^a	651^a	***	37.85
Hind legs (g)	1578^b	2553^a	2600^a	2720^a	2630^a	***	112.43
Pelvic (rump) region (g)	503^c	809^b	930^{ab}	1019^a	961^{ab}	***	55.88
Tail (g)	234^c	642^b	844^a	641^b	811^a	***	42.33
Ribs (g)	618^c	935^b	1171^a	1174^a	1193^a	***	49.23
TC (kg)	$\mathbf{6.2^c}$	$\mathbf{10.0^b}$	$\mathbf{11.5^a}$	$\mathbf{11.6^a}$	$\mathbf{11.7^a}$	***	**0.35**

*Means within a row not bearing similar superscript are significantly differ; SEM = standard error of means; SL= significant level; TC = total carcass; *** = p<0.001.*

3.2 Edible offal components

The blood weight of the control treatment was lower (P<0.001) than the supplemented treatments (Table 3). The proportion of blood to slaughter BW were 4.1%, 3.9%, 3.9%, 3.9% and 4.3% for control, T_2, T_3, T_4 and T_5, respectively. The control treatment recorded lower (P<0.05) and (P<0.01) weight of liver, kidneys and large and small intestines as compared to supplemented treatments, but no significant difference (P>0.001) were observed among supplemented treatments. The proportion of liver to slaughter BW were 1.4%, 1.6%, 1.4%, 1.4% and 1.4% for control, T_2, T_3, T_4 and T_5, respectively. The control treatment had lower (P<0.001) kidney, omental, heart and genital fat as compared to the supplemented treatment group. The proportion of collected blood to slaughter BW in the current study ranged from 3.9 to 4.3%. In agreement, Dysko (2007) reported that approximately 4-5% blood volume of the BW of an animal can be removed by terminal exsanguinations. Similarly, the proportion of liver to slaughter BW in this study ranged from 1.4 to 1.6% which agreed with Frandson *et al*. (2003) finding (liver consists 1 to 2% of the adult animal live weight). In agreement with the this result, Targhee sheep fed alfalfa and supplemented with concentrate gained heavier weight of visceral fat than sheep solely fed alfalfa (Fluharty *et al*. 1999). Mushi, *et al*. (2009) reported that all edible viscera are significantly affected by the levels of concentrate supplementation. The same authors reported the total non-carcass fat significantly increases with increasing levels of supplementation mainly due to omental fat. Similarly, Joy *et al*. (2008) reported that concentrate supplemented lambs' has significantly heavier edible red organs (heart, liver and kidney) and digestive tract (stomach, small intestine and large intestine). Feeding system significantly affect the total body fat depots (Moron-Fuenmayor & Clavero, 1999; Joy *et al*. 2008; Carrasco *et al*. 2009). Similarly, according to Hagos (2007) supplemented Afar sheep result better weight of visceral organs than the control.

Table 3. Edible offal components of Arsi-Bale sheep fed on a basal diet of faba bean haulms and supplemented with different proportion of barley bran and linseed meal

Parameter	T_1	T_2	T_3	T_4	T_5	SL	SEM
Blood (g)	760^d	980^c	1040^{bc}	1080^{ab}	1160^a	***	40.04
Liver (g)	261^b	405^a	362^a	390^a	389^a	*	21.32
Kidneys (g)	54.5^b	68.8^a	73^a	77.3^a	74^a	*	3.81
Heart (g)	79.2^c	114.2^{ab}	113.1^b	119^{ab}	125.7^a	***	4.07
Tongue (g)	77.4^b	71.4^b	110.5^a	112.2^a	92.1^{ab}	*	7.62
Kidney fat (g)	50.7^c	125.8^b	151^{ab}	159^{ab}	183^a	***	14.39
Omental fat (g)	30.6^c	167^b	144.2^b	273.8^a	269^a	***	22.52
Heart fat (g)	10.2^d	25.2^{bc}	23.3^c	30.9^{ab}	36.9^a	***	2.82
Genital fat (g)	18.2^c	88.8^b	78.8^b	90.6^b	155.7^a	***	7.26
Reticulo-rumen (g)	460^b	533^{ab}	536^{ab}	597^a	586^a	*	32.57
Omasum-abomasum (g)	192	201	236	233	218	ns	13.55
Large & small intestines	548^b	783^a	916^a	968^a	918^a	**	58.75
TEO (kg)	$\mathbf{2.5^c}$	$\mathbf{3.6^b}$	$\mathbf{3.8^{ab}}$	$\mathbf{4.1^a}$	$\mathbf{4.2^a}$	***	**0.15**

*Means within a row not bearing similar superscript are significantly differ; ns = not significant; SEM = standard error of means; SL = significant level; TEO = total edible offal; *** = p<0.001; * = P<0.05; ** = p<0.01.*

3.3 Inedible offal components

Skin weight of the control treatment was lower (P<0.001) than the supplemented treatments. Whereas, no significant differences (P>0.001) observed among T_2, T_3 and T_5, and among T_3, T_4 and T_5. Head without tongue, testicles, lung and diaphragm, spleen, bladder and TIEO of the control treatment were lower (P<0.001) than the supplemented treatments (Table 4). Mushi, *et al.* (2009) reported that except for the spleen and diaphragm, all other inedible viscera are significantly affected by the levels of concentrate supplementation. Concentrate supplemented lambs' has significantly heavier lung and trachea, spleen, pancreas, gall bladder, bladder, testicles, penis, head, skin and feet (Joy *et al.* 2008).

Table 4. Inedible offal components of Arsi-Bale sheep fed on a basal diet of faba bean haulms and supplemented with different proportion of barley bran and linseed meal

Parameter	T1	T_2	T_3	T_4	T_5	SL	SEM
Skin (g)	1740^{c}	2420^{b}	2520^{ab}	2760^{a}	2660^{ab}	***	109.62
Head without tongue (g)	1100^{d}	1420^{c}	1520^{bc}	1700^{a}	1580^{ab}	***	56.08
Penis (g)	36	39	41	44	46	ns	2.65
Testicles (g)	176^{d}	314^{bc}	307^{c}	365^{a}	358^{ab}	***	15.30
Lung and diaphragm (g)	187^{c}	294^{ab}	313^{a}	273^{ab}	256^{b}	***	15.39
Trachea (g)	69^{b}	70^{b}	105^{a}	100^{a}	91^{a}	**	5.90
Esophagus (g)	47^{b}	37^{b}	41^{b}	44^{b}	57^{a}	**	3.28
Spleen (g)	37^{d}	88^{a}	69^{b}	76^{ab}	50^{c}	***	5.64
Pancreas (g)	24^{b}	34^{a}	35^{a}	31^{ab}	25^{b}	*	2.86
Gall bladder with bile (g)	4	5	7	7	9	ns	1.77
Bladder (g)	9^{b}	22^{a}	24^{a}	22^{a}	24^{a}	***	1.06
TIEO (kg)	$\mathbf{3.4^{c}}$	$\mathbf{4.7^{b}}$	$\mathbf{5.0^{ab}}$	$\mathbf{5.4^{a}}$	$\mathbf{5.2^{ab}}$	***	**0.15**
Gut fill (g)	4820	5080	4840	4860	5540	ns	256.90

*Means within a row not bearing similar superscript are significantly differ; ns = not significant; SEM = standard error of means; SL = significant level; TIEO = total inedible offal; *** = p<0.001; ** = p<0.01; * = P<0.05.*

3.4 Proportion of carcass and non-carcass components

The proportion of gut fill to slaughter weight (GF: SW) of the control treatment was higher (P<0.01) than in the supplemented treatments (Table 5). The proportion of TEO: TIEO was not significantly different among treatments, but numerically higher in the supplemented groups as compared to the control treatment. The TEO: EBW were almost similar among the treatments. As the proportion of LSM supplementation in the ration increased, the TEO: TIEO also increases. In comparable with the current finding, Carrasco *et al.* (2009) reported that feeding system did not affect the proportion of first category of commercial meat it slightly affected light lamb carcass characteristics. In contrary, the weight of head, hocks and empty gastro intestinal tract as percentage of empty body weight decreased significantly with increasing levels of concentrate supplementation. The weight of liver as percentage of empty body weight increased significantly with increasing levels of supplementation. Similarly, percentage of total non-carcass fat empty body weight increased significantly with increasing levels of supplementation (Mushi, *et al.* (2009).

Table 5. Proportions of carcass and non-carcass components (%) of Arsi-Bale sheep fed on a basal diet of faba bean haulms and supplemented with different proportion of barley bran and linseed meal

Parameter	T_1	T_2	T_3	T_4	T_5	SL	SEM
GF:SW	26^{a}	20^{b}	18^{b}	18^{b}	21^{b}	**	0.97
TEO:TIEO	74	75	76	76	82	ns	2.45
TEO:EBW	19	18	17	18	20	ns	0.58
TIEO:EBW	25	25	23	24	24	ns	0.62

*Means within a row not bearing similar subscript are significantly differ; EBW = empty body weight; GF = gut fill; LS = significant level; ns = not significant; SEM = standard error of means; SW = slaughter weight; TEO = total edible offal components; TIEO = total inedible offal components; ** = P<0.01.*

4. Conclusions

The control treatment had the lowest carcass characteristics as compared with the supplemented treatments. Supplementation improved the weight of total carcass component, edible offal and non-edible offal components. The gut fill was no statistically different among all treatments. However, sheep fed faba bean haulms alone had highest gut fill as a proportion of slaughter BW than supplemented treatments. This was attributed to the low passage rate of the digesta and the lower slaughter BW in the control treatment. In conclusion, different proportion of concentrate supplementation could affect the weight of both the carcass and non-carcass components.

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