DIFFERENT PRODUCTION SYSTEMS AND THEIR IMPACTS ON GROWTH PERFORMANCE AND CARCASS QUALITY OF LOHI LAMBS IN PAKISTAN

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ABSTRACT: This study aimed to evaluate the impact of different production systems on the growth performance and carcass composition of male Lohi lambs. A total of 64 male Lohi lambs were assigned to two main groups (A and B) of 32 lambs each, with each group further divided into subgroups of eight per pen. Half of the lambs in each group were castrated. Group A received a concentrate diet at 85 g of dry matter (DM) per kg of metabolic body weight per day, containing 15% crude protein (CP) and 3010 kcal/kg Metabolizable Energy (ME), along with hay at 100 g per lamb per day. Group B was fed fresh green forage ad libitum and supplemented with 400 g of concentrate per lamb per day containing 20% CP and 2940 kcal/kg ME. Feed composition (offered and refused), daily feed intake, and weekly body weights were recorded throughout the study. At the end of the trial, all lambs were slaughtered, and half carcasses were sampled from each pen for composition analysis. Results showed that lambs in the concentrate-fed group exhibited significantly lower daily dry matter intake (DDMI; P=0.001) and feed conversion ratio (FCR; P<0.05) but demonstrated superior growth performance (GP; P<0.05), higher carcass weight (CW; P<0.001), dressing percentage (DP; P<0.001), and conformation scores (CS; P<0.05). In conclusion, a concentrate-based diet enhanced growth rates, carcass characteristics, and overall performance metrics compared to a forage-based diet supplemented with concentrate, suggesting its effectiveness for optimized lamb production.

Keywords: Body Condition, Carcass Composition, Concentrate Feeds, Fodder, Sex, Lamb.

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INTRODUCTION

Growth performance and carcass characteristics are crucial factors in determining cost-benefit analysis in sheep husbandry. However, they are also affected by various factors like the animal's age and sex (Prache *et al*., 2022), the feeding plans (Jacques *et al*., 2011; Khan et al. 2023), and the breed (Kremer *et al*., 2004; Waheed et al., 2015). Each of these elements is essential to any production system. The composition of the diet has a major impact on the partitioning of retained fat and protein (Ponnampalam *et al*., 2024; Abbas, 2020; 2020a). Underfeeding produces low-quality products and can stop the animals from reaching their genetic potential in terms of weight and stature, whereas overfeeding may result in an excessive amount of fat in the carcass (Prache *et al*., 2022; Pena *et al*., 2005). On the other hand, the production of carcasses with higher meat yields due to genetic selection for lean meat output has proven successful, but at the expense of the meat's intramuscular fat content and eating quality, making it more challenging to finish lambs on pasture (Prache *et al*., 2022). Furthermore, through stable ruminal conditions and better nutrient utilization, an unprocessed diet of whole corn and soybean hulls improved growth, feeding, carcass quality, and total lean output, according to many studies (Khan *et al*., 2023).

The percentage of fat deposits, rib measurements, dressing %, age at slaughter, "non-carcass" components, and neck and shoulder percentage were all significantly impacted by sex. The measures of the carcass increased in tandem with the weight. At the same time, the carcass, limb, and dressing percentages' conformation indices improved, while the tissue composition and primal market cuts of the animal remained largely unaffected. The quantity of all kinds of fat deposits was largely influenced by sex (Pena *et al*., 2005). To fulfill domestic and export needs and production of mutton, Pakistan's traditional mutton production system must be converted into a highly commercialized one (Khan *et al*., 2003). On-castration enables males to use feed more effectively and finish faster with a slimmer carcass, even if castration enhances the quality of the meat. Mahgoub *et al*. (2003) found that sheep who were castrated did not exhibit the same average daily gains as intact and cryptorchid sheep. The main element influencing the quality of all fat deposits is the animal's sex (Pena *et al*., 2005).

This experiment was designed with specific objectives: i) to evaluate the effect of different feed regimes on the growth performance and carcass composition of lambs, and ii) to assess how sexual status (intact or castrated) influences the growth performance and carcass composition of lambs, aiming to identify the optimal production system for Lohi breed lambs.

MATERIALS AND METHODS

Sixty-four weaned Lohi lambs of 4 to 6 months of age were bought from Okara, Faisalabad, and Toba Tek Singh, the original habitat of the breed. Before the initiation of the experiment, all the lambs were dewormed using Nilzan® ICI and vaccinated against enterotoxaemia. Half of the lambs were castrated. After weighing, they were randomly assigned to 8 pens with 4 pens of each treatment (4 of castrated and 4 intact animals) and 8 animals of the same average live weight per pen. Four pens (Group A) were assigned to a concentrate diet and the four remaining (Group B) to a fodder diet. The concentrate diet (concentrate A) contained 15% of crude protein (CP) and 3010 kcal/kg of metabolizable energy (ME) and was offered at a rate of 85g DM /kgW0.75 plus 100g hay /lamb/day. Group B was receiving Mott grass (fresh green fodder) *ad libitum*, along with 400g/day of a concentrate (concentrate B) containing 20% of CP and 2940kcal/kg of ME. The chemical composition of the different experimental diets is given in Table 1. Animals were acclimatized to the pens and the diets for ten days before placing them on the treatment diets. During this acclimatization period, animals of group B were fed green fodder *ad libitum* while animals of group A were given 50 g of concentrate for each lamb, along with unlimited hay at the beginning. Up until the completion of the acclimatization period, the concentrate feeding was gradually increased and the hay feeding was gradually decreased.

Table 1: Chemical composition of experimental feedstuffs (on dry matter basis)

Composition	CONC[1]. A	CONC. B	Berseem hay *(clover)*	Mott Grass	Jantar *(spiny sesbania)*	Oats	Guara *(Cyamopsistetragonoloba)*
DM (%)	87.48	88.28	88.28	25.5	75.54	25.3	18.7
CP (%)	15	20	20	8	12.84	11.14	24.1
ME (Mcal/kg)	3.01	2.94	3.45	-	-	-	-
RUP (%)	3.24	6.3	-	-	-	-	-
RDP (%)	11.76	13.7	-	-	-	-	-
NDF (%)	24.95	29.17	-	-	-	-	-
ADF (%)	12.89	14.88	-	-	-	-	-
Lignin (%)	3.19	3.96	-	-	-	-	-
Fat (%)	3.02	3.45	-	-	-	-	-
Ca (%)	0.7	0.6	-	-	-	-	-
P (%)	0.35	0.57	0.57	-	-	-	-
EE (%)	-	-	2.82	6.12	7.96	4.61	2.42
CF (%)	-	-	6.3	33.7	28.71	27.84	19.78
NFE (%)	-	-	13.7	35.44	20.74	45.84	39.7
Ash (%)	-	-	-	20.91	5.29	10.57	14

(Close and Menke, 1986) [1]CONC.: Concentrate

Samples of offered and refused feed were taken to measure the dry matter (DM) content. The difference in the amount of feed offered and refused during 24 hours was used to calculate the daily feed intake. During the experimental period of six months, the lambs were weighed weekly on a fixed day of the week using an electrical balance (RUDDWEIGH, MODEL 1200 KM25), and their growth rates were calculated.

According to Croston and Pollatt (1994), each lamb's condition score was determined by subjectively rating the amount of fat covering the transverse and spinous processes of the lumbar vertebrae on a scale of 0 to 5 with a 0.5-point increment. Lambs were selected for slaughter on reaching score 3 to produce carcasses of MLC (Meat and Livestock Commission, UK) fat class 2/3L. After splitting the carcass and removal of kidneys and fat, the left-hand side was sealed in labeled heavy plastic sacks and frozen at -18C^o. All the cutting lines were clearly defined by reference to anatomical points (Cuthbertson *et al.*, 1972) while making joints. After slaughter, cold carcass weight (hot carcass weight x 0.98) along with the killing-out proportion was expressed as the cold carcass weight divided by the final live weight. The outline of *muscle longissimus dorsi* was traced on translucent paper and the area in square centimeters (cm^2) was calculated using a planimeter. The method of dissection as described by Cuthbertson *et al.*, 1972 was used for the dissection of best end joints and half carcass. Protocols concerning animal care were followed in the light of guidelines recommended by the Animal Ethics Committee of the Faculty of AH (Animal Husbandry), UAF (University of Agriculture, Faisalabad-Pakistan), and humane animal care and handling procedures were followed throughout the study. The amount of muscle, fat, and bone of the half carcass of each slaughtered lamb was determined.

MINITAB statistical program was used to perform all the statistical analyses (MINITAB Release 13, 2000), and significant differences were considered at a 5% level. To predict lamb weight, growth rate, and carcass composition, data were subjected to regression analysis. Feed intake, lamb growth performance, and carcass characteristics were analyzed by the use of the General Linear Model (GLM) method used a linear model that incorporated the fixed effects of sex and nutrition.

RESULTS

Animals fed the concentrate diet had significantly lower DDMI (P=0.001) and FCR (P<0.05), but significantly higher DWG (P<0.05), CW (P<0.001), DP (P<0.001), CS (P<0.05), Kidney Knob and Channel Fat, KKCF (P<0.001), head and heart weight (P<0.05), liver weight (P=0.05), kidneys weight (P<0.001), stomach weight (P<0.05), skin weight (P<0.001), lungs weight (P=0.001), and trotter (feet) (P<0.05) than animals fed the forage diet, according to the results shown in Table 2. Tables 2, 3, and 4 display the measurements and composition of the carcass. Compared to animals on the forage diet, concentrate-fed lambs had higher fat and CS (P<0.001), as well as a larger buttock circumference (P<0.05). In contrast, animals fed with ration based on fodder had a significantly finishing period normally longer (P<0.001), total heavier bones (P<0.05), heavier weights of *longissimus dorsi* (P<0.05), and better Lean: Bone ratio (P<0.05).

Table 2: Effect of diet and sex on feed intake and growth performance of lambs.

	Diet				Sex			
	CONC[1].	**Fodder**	**SE**	**P**	**Entire**	**Castrated**	**SE**	**P**
n (lambs)	30	30			30	30		
ILW (kg)	25.2	22.7	0.64	NS	24.5	23.4	0.64	NS
FLW (kg)	39.5	33.4	0.64	<0.001	37.7	35.2	0.64	NS
Finishing Period (days)	129	167	1.2	<0.001	145	150	1.2	<0.05
DDMI(kg)	1.1	1.4	0.01	0.001	1.3	1.2	0.01	NS
DLWG (g)	130.7	65.3	3.2	<0.001	106	90	3.2	<0.05
FCR KgDM/kg WG	9.2	19.8	1.07	<0.05	13	16	1.07	NS

ILW= Initial Live Weight, FLW= Final Live Weight, DDMI = Daily Dry Matter Intake; DLWG = Daily Live Weight Gain; FCR = Feed Conversion Ratio [1]CONC.: Concentrate

Table 3 Diet and sex effects growth performance and carcass characteristics

	Diet				Sex			
	CONC[1].	**Fodder**	**s.e.d**	**P**	**Entire**	**Castrated**	**s.e.d**	**P**
n (lambs)	30	30			30	30		
Carcass Weight(kg)	20.1	16.2	0.36	<0.001	18.8	17.5	0.36	NS
Dressing % age	50.8	48.5	0.31	<0.05	49.7	49.6	0.31	NS
KKCF* (g)	603	323	27.5	<0.001	438	488	27.5	NS
Kidney (g)	112	98	1.9	<0.001	107	103	1.9	NS
Head (Kg)	2.8	2.4	0.07	<0.05	2.8	2.4	0.07	<0.05
Heart (g)	156	143	2.75	<0.05	155	144	2.75	0.05
Liver (g)	583	524	15.2	0.05	586	522	15.2	<0.05
Lungs (g)	583	496	12.2	0.001	568	511	12.2	<0.05
Stomach (kg)	1.5	1.3	0.04	<0.05	1.4	1.3	0.04	NS
Skin (kg)	4	2.7	0.11	<0.001	3.5	3.2	0.11	NS
Spleen (g)	104.5	94.4	3.6	NS	103.9	95	3.6	NS
Trotter (kg)	1.3	0.98	0.06	<0.05	1.17	1.1	0.06	NS
Chest width (mm)	78.3	74.1	0.6	0.001	77.1	75.4	0.6	NS
Circumference of the buttock (mm)	57.8	54.8	0.5	<0.05	57	55.6	0.5	NS
Side length (cm)	45.4	45.3	0.5	NS	45.5	45.1	0.5	NS
Fat score	2.7	2.3	0.05	<0.001	2.5	2.4	0.05	NS
Conformation Score	2.8	2.3	0.05	<0.001	2.6	2.5	0.05	NS

*Kidney knob and channel fat; [1]CONC.: Concentrate

Table4: Diet and sex effects on carcass composition (best end dissection data)

	Diet				Sex			
	CONC[1].	Fodder	SE	P	Entire	Castrated	SE	P
n (lambs)	30	30			30	30		
Lean (g kg-1)	481	501.5	5.4	NS	493.4	489	5.4	NS
Total fat (g kg-1)	247.6	232.1	6.8	NS	227.5	252.3	6.8	NS
Subcutaneous fat (g kg-1)	144.3	128.2	5.4	NS	129.7	142.8	5.4	NS
Inter-muscular fat (g kg-1)	103.3	103.9	5.1	NS	97.8	109.5	5.1	NS
Total bone (g kg-1)	200.7	184.8	5.2	NS	188.1	197.3	5.2	NS
Vertebral process (g kg-1)	113.4	96	4.6	NS	99.5	109.9	4.6	NS
Longissimus dorsi (g kg-1)	98	137	3.9	<0.05	117	118	3.9	NS
Lean: fat ratio	2.1	2.3	0.08	NS	2.3	2	0.08	NS
Lean: bone ratio	2.5	2.8	0.076	0.05	2.8	2.6	0.076	NS
Eye muscle area (cm2)	9.9	11.2	0.4	NS	10.5	10.6	0.4	NS
Intra-muscular fat* (g kg-1)	2.9	2.7	0.11	NS	2.7	2.8	0.11	NS

*****Values were obtained by using the ether extraction method; [1]CONC.: Concentrate

The daily live-weight gain ($P<0.05$) (Table 2), liver weight ($P<0.05$), lung weight ($P<0.05$), lean to bone ratio ($P=0.05$), head weight ($P<0.05$), and heart weight ($P=0.05$) of whole lambs were considerably higher than those of castrated lambs (Table 3).Nevertheless, compared to whole lambs, castrated lambs (wether) had longer finishing times ($P<0.05$) and higher levels of total and other fats (inter-muscular and subcutaneous fat) (Table 5).

Table 5: Diet and sex effects carcass composition (half carcass dissection data)

	Diet				Sex			
	CONC[1].	Fodder	s.e.d	P	Entire	Castrated	s.e.d	P
n (lambs)	4	4			4	4		
Lean (g kg^{-1})	566.15	601.2	7.7	NS	580.2	587.2	7.7	NS
Total Fat (g kg^{-1})	255.6	205.6	11.6	NS	218.2	243.1	11.6	NS
Subcutaneous fat (g kg^{-1})	186.5	150.4	8.2	NS	166.2	170.7	8.2	NS
Inter-muscular Fat (g kg^{-1})	69.2	56	5.6	NS	52.8	72.4	5.6	NS
Total Bone (g kg^{-1})	166.3	244.4	10.3	<0.05	183.45	227.3	10.3	NS
Waste (g kg^{-1})	16.2	17.8	7.7	NS	17.4	16.7	7.7	NS
Lean: fat ratio	2.2	3	0.22	NS	2.9	2.4	0.22	NS
Lean: bone ratio	3.4	2.5	0.08	<0.05	3.2	2.7	0.08	0.05

[1]CONC.: Concentrate

DISCUSSION

Compared to lambs on a fodder diet, those fed a concentrated diet exhibited superior growth performances and carcass shape. These results are consistent with those of (Borton *et al*., 2005; Priolo *et al*., 2002; Karim *et al*., 2001), who observed that lambs fed on a concentrate diet had higher conformation ratings, heavier final body weights, and bigger carcass weights than lambs fed pasture. McLeod and Baldwin (2000) found similar findings, finding that lambs fed 75% concentrate gained weight more quickly and efficiently than those fed 75% forage.

The results obtained by Mazumder *et al*. (1998), Fayyaz *et al*. (2002), and Damry *et al*. (2001) are in line with the lambs that were fed an early finishing concentrate and showed the biggest daily weight increases. Nevertheless, it was also mentioned that higher growth rates can be influenced by the feed's quality and the quantity of concentrate supplementation (Wildeus *et al*., 1998; Wildeus *et al*., 2001; Wildeus *et al*., 2004). Forage-based production techniques have a lower daily cost of production, but it takes longer to finish the animals (Notter *et al*., 1991). Lambs fed a fodder diet in our trial had a higher lean-to-fat ratio, which is consistent with findings by Borton *et al*. (2005). Additionally, it is consistent with the findings of (Priolo *et al*., 2002; Saatci *et al*., 2003) that lambs fed concentrate had higher final weights and carcass weights than lambs fed fodder. The concentrate-fed lambs had also a higher dressing percentage as compared to forage-fed lambs. This coincides with the findings of (Mahgoub *et al.*, 2003). However, in contrast to findings by (Hanrahan, 1999;

Gatenby, 1986), the sexual status of lambs did not affect the dressing percentage in the current experiment. Similarly to results obtained by (Mahgoub and Lodge, 1996), concentrate-fed lambs had significantly heavier heads, trotters, lungs, stomachs, and skin than their counterparts fed on fodder. The findings of Borton *et al*. (2005), who found that concentrate-fed lambs had 50% more dissectable fat than forage-fed ones at the standard slaughter weight, are consistent with the fact that the total fat content of the carcass was higher for animals on the concentrate diet. Additionally, Kremer *et al*. (2004) observed that lambs fed high calories similarly accumulated more fat. Lambs-given grass had a higher lean-to-bone ratio than lambs-fed concentrate. This aligns with the conclusions of Lanza *et al*. (2003). The ocular muscle regions of the lambs raised on the various treatments (concentrate or fodder) show minimal variation, which supports earlier findings by Arnold and Meyer (1988). However, others reported that concentrate-fed lambs had larger muscle areas than fodder-fed lambs (Kremer *et al.*, 2004; Burke and Apple, 2006).

The fact that ram lambs grew more than whether lambs has been widely documented (Edson Kremer and al., 2003). The study's findings about the differences between castrates and intact/cryptorchid sheep are consistent with those of Maghoub *et al*. (1998), who found that the former had lower feed conversion, higher slaughter weight, empty body weight, hot carcass weight, and cold carcass weight, as well as higher average daily gains than the latter. The results of this trial also confirm those of (Lee, 1986) who argued that fast growth rate can only be obtained if there is sufficient feed intake to maintain potential growth levels. The higher daily live weight gains of the entire lambs led to an increase in final live weights, which is in agreement with findings by (Kremer *et al*., 2003; Wellington *et al*., 2003; Nawaz *et al*., 1985)**.** The low-fat content in the carcass of entire male lambs has been widely reported (Ahmad and Lloyd Davies, 1986; Russell 1991; Hanrahan, 1999). Regarding the conformation score, the non-significant difference between entire and castrate lambs obtained in our study does not agree with the work of (Ahmad and Lloyd Davies, 1986; Russell 1991; Hanrahan, 1999; Wellington *et al.*, 2003). The non-significant difference between ram and wether for the eye muscle area is in agreement with findings by (Zinn *et al*., 1963), but contrasts with those by (Arnold and Meyer, 1988). We may infer that even if the concentrate-based feeding system produced better outcomes for the better growth performance of lambs and carcass composition, the choice of the best feeding system must be guided by economic considerations.

REFERENCES

Abbas, G. 2020. An Augmented Review about Anti-Nutrients and Toxins of Feed Stuff and their Control Strategies, a Step toward Sustainable Resource Utilization. International Journal of Agriculture Innovations and Research. 8(4): 2319-1473.

Abbas, G. 2020a “Role of Poultry Production to Feed the Humanity on the Planet”. EC Agriculture 6.2: 01.

Afonso, J., and J. M. Thompson. 1996. Changes in body composition of sheep selected for high and low back fat thickness, during periods of *ad labium* and maintenance feeding. Anim. Sci., *63*(3):395-406.doi:10.1017/S1357729800015289

Ahmad, N.A. and H. Lloyd Davies. 1986. Effect of sex and dietary energy concentration on feed conversion ratio, growth and carcass characteristics in Merino x Border Leicester lambs. [Conference paper].Proceedings of the Australian Society of Animal Production, Australia.

Arnold, A.M. and H.H. Meyer. 1988. Effects of gender, time of castration, genotype and feeding regimen on lamb growth and carcass fatness. J. Anim. Sci., 66(10):2468-2475.doi: 10.2527/jas1988.66102468x

Barone, C.M.A., P. Colatruglio, A. Girolami, D. Matassino, and A. Zullo. 2007. Genetic type, sex, age at slaughter and feeding system effects on carcass and cut composition in lambs. Livest. Sci. 112(1-2): 133-142.doi: 10.1016/j.livsci.2007.02.003

Borton, R.J., S.C. Loerch, K.E. McClure, and D.M. Wulf. 2005. Comparison of characteristics of lambs fed concentrate or grazed on ryegrass to traditional or heavy slaughter weights. I. Production, carcass, and organoleptic characteristics. J. Anim. Sci., *83*(3):679-685.doi: 10.2527/2005.833679x

Burke, J.M. and J.K. Apple. 2007. Growth performance and carcass traits of forage-fed hair sheep wethers. Small Rumin. Res., 67(2-3): 264-270.doi:10.1016/j.smallrumres.2005.10.014

Croston D. and G.Pollatt.Planned Sheep Production, vol. 2, Collins, London, UK.

Cuthbertson, A., G. Harrington and R.J.Smith. 1972. Tissue separation—to assess beef and lamb variation. Proceedings of the British Society of Animal Production, 1, 113-122.

Fayyaz A., M.A. Jabbar and N. A. Naz. 2002. Optimum level of concentrates for gaining rapid growth in Lohi lambs. Pages 45-46 in 23rd Annual Report. Livestock Production research Institute, Bhadarnagar, Okara, Pakistan.

Gatenby R.M. 1986. Sheep production in the Tropics and

Sub-Tropics. Tropical Agriculture Series. Longman Group Limited.

Hanrahan J.P. 1999. Genetic and non-genetic factors affecting lamb growth and carcass quality. Sheep Production Department Teagasc. Research Centre Athenry, Co. Galway.

Jacques, J., R. Berthiaume andD.Cinq-Mars. 2011. Growth performance and carcass characteristics of Dorset lambs fed different concentrates: Forage ratios or fresh grass. *Small Rumin. Res.*, *95*(2-3): 113-119.doi:10.1016/j.smallrumres.2010.10.002

Johnson, D. D., J. S. Eastridge, D. R. Neubauer, and C. H. McGowan. Effect of sex class on nutrient content of meat from young goat. J. Anim. Sci., 73(1): 296-301.

Karim, S. A., A.Santra and V.K. Sharma. 2001. Growth performance of weaner lambs maintained on varying levels of dietary protein and energy in the pre-weaning phase. *Asian-Australasian J. Anim. Sci.*, *14*(10): 1394-1399.doi:10.5713/ajas.2001.1394

Khan, A. G., A. Azim and M.I. Anjum. 2003. Prospects of goat as meat animals of Pakistan. In *Proceeding of the International Seminar on Goat Production in SAARC Countries*. Pakistan Agricultural Research Council, Islamabad.

Khan, M., Rashid, M.A., Yousaf, M.S., Naveed, S., Mohsin, I., Rehman, H.U. and Loor, J.J., 2023. Effects of physical forms of a high grain-based diet on fattening performance, ruminal health, feeding behaviour, nutrient digestibility and carcass traits of finishing Lohi lambs. Archives of Animal Nutrition, 77(1), pp.77-92.

Khan, M. T., S. Mehmoodb, T. Asada, M. Azhara, M. Arslana, F. Raziqc, S. Liaqatd, I. H. Rajae, M. A. Gondalf, M. Raufg, S. Nazirh, G. Farani , Q. Nisaj, F. Abbasik, Z. Farooql, Z. M. Iqbalm, M. Qumare, F. Wadoodn, G. Abbas, E. Bughiop, A. S. Magsiq, U. Younasm and M. A. Arshad. 2023. Assessing the effect of feeding poultry byproducts compost on organoleptic characteristics and compositional profile of meat of broiler chicken. Braz. J. Biol. 83 • https://doi.org/10.1590/1519-6984.275633

Kremer, R., G. Barbato, L. Castro, L. Rista, L. Rosés, V. Herrera, and V. Neirotti. 2004. Effect of sire breed, year, sex and weight on carcass characteristics of lambs. Small Rumin. Res. 53(1-2): 117-124.

Lanza, M., M. Bella, D. Barbagallo, V. Fasone, L. Finocchiaro and A. Priolo. 2003. Effect of partially or totally replacing soybean meal and maize by chickpeas (*Cicer arietinum* L.) in lamb diets: growth performances, carcass and meat quality. *Anim. Res.*, *52*(3): 263-270.doi: 10.1051/animres:2003019

Lee, G.J. 1986. Growth and carcass characteristics of ram, cryptorchid and wether Border Leicester x Merino lambs: effects of increasing carcass weight." *Aust. J. Exp. Agric.*, 26(2):153-157.

Mahgoub, O., and G.A. Lodge. Growth and body composition of Omani local sheep 1. Live-weight growth and carcass and non-carcass characteristics. *Anim. Sci.*, 58(3): 365-372.doi: 10.1017/S0003356100007303

Mahgoub, O., D. J. Berkley, J. M. Chatsworth and R.M. Myhara. Effect of testicular status and feeding diets containing palm by-products on growth and composition of the rack cut in Omani sheep. *Small Rumin. Res.*, 28(3): 281-288. doi: 10.1016/S0921-4488(00)00130-9

Mahgoub, O., C. D. Lu and R. J. Early. 2000. Effects of dietary energy density on feed intake, body weight gain and carcass chemical composition of Omani growing lambs. *Small Rumin. Res.*, *37*(1-2): 35-42.doi: 10.1016/S0921-4488(99)00132-7

Mazumder, M. A. R., M. M. Hossain, and S. Akhter. 1998. Effect of levels of concentrate supplement on live weight gain and carcass characteristics in sheep on restricted grazing. *Asian-Australasian J. Anim. Sci.*, 11(1): 17-20.doi: 10.5713/ajas.1998.17

McLeod, K. R. and R. L. Baldwin. 2000. Effects of diet forage: concentrate ratio and metabolizable energy intake on visceral organ growth and in vitro oxidative capacity of gut tissues in sheep. *J. Anim. Sci.*, *78*(3):760-770. doi:10.2527/2000.783760x

MINITAB Release 13.2000. Statistical Software [Computer program manual]. Available from http://www.minitab.com/cgi-bin/demo/democountry.asp. (accessed, June 15, 2012)

Nawaz, M.,M.D. Ahmad, Z. Ahmad, G.R. Khan and M.A. Khan. 1985. Comparative performance of Awassi, Kachhi and crossbred (Kachhi x Awassi) lambs.*Pakistan J. Agri. Sci.*, 22(3): 181-187.

Nolan, J. V., R. E. Bell and E. S. Thomson. 2001. Duckweed as a protein source for fine-wool merino sheep: its edibility and effects on wool yield and characteristics. *Asian-Australasian J. Anim. Sci.*, *14*(4): 507-514. doi: 10.5713/ajas.2001.507

Notter, D. R., R. F. Kelly, and F. S. McClaugherty. Effects of ewe breed and management system on efficiency of lamb production: II. Lamb growth, survival and carcass characteristics. *J. Anim.*

Sci., 69(1): 22-33. doi: 10.2527/1991.6993523x

Peña, F., T. Cano, V. Domenech, M. J. Alcalde, J. Martos, A. Garcia-Martinez, M. Herrera and E. Rodero. Influence of sex, slaughter weight and carcass weight on "non-carcass" and carcass quality in Segureña lambs. *Small Rumin. Res.*, 60(3): 247-254.doi:10.1016/j.smallrumres.2004.12.011

Ponnampalam, E.N., Priyashantha, H., Vidanarachchi, J.K., Kiani, A. and Holman, B.W., 2024. Effects of nutritional factors on fat content, fatty acid composition, and sensorial properties of meat and milk from domesticated ruminants: an overview. Animals, 14(6), p.840.

Prache, S., Schreurs, N. and Guillier, L., 2022. Factors affecting sheep carcass and meat quality attributes. Animal, 16, p.100330.

Priolo, A., D. Micol, J. Agabriel, S. Prache and E. Dransfield. 2002. Effect of grass or concentrate feeding systems on lamb carcass and meat quality. *Meat Sci.*, *62*(2): 179-185.doi: 10.1016/s0309-1740(01)00244-3

Ribeiro, E.L.D.A., L.D.D.F.D.Silva, M.A.D. Rocha and I.Y.Mizubuti. 2003. Performance of intact or submitted to different methods of castration lambs slaughtered at 30 kg of live weight. Revista Brasileira de Zootecnia, 32(3):745-752.

Russell A. 1991. Body scoring of sheep. Pages 3-11 in Boden E. (ed.): Sheep and Goat Practice. Bailliere Tindall, Philadelphia, USA.

Saatci, M., S. Yildiz, and I. Kaya. New rearing systems for Tuj (Tushin) lambs. Small Rumin. Res., 50(1-2): 23-27.Doi: 10.1016/S0921-4488(03)00115-9.

Waheed, M., S. Ali, M. S. Khan, S, Rehman, G. Abbas. 2015. Molecular genetic variations among some Punjab sheep breeds using RAPD analysis. Advances in Zoology and Botany, 3 (1): 1-5.

Wellington, G. H., D. E. Hogue, and R. H. Foote. Growth, carcass characteristics and androgen concentrations of gonad-altered ram lambs. Small Rumin. Res., 48(1): 51-59.doi: 10.1016/S0921-4488(03)00007-5

Wildeus S., H.N. Zerby, K.E. Turner and J.R. Collins. 2003. Growth and carcass characteristics in lambs from three hair sheep breeds raised on pasture and hay-based diets. J. Anim. Sci., 81:29 (abstract).

Wildeus, S., K. E. Turner and J. R. Collins. Effect of species and breed within species on forage intake and growth in hair sheep lambs and meat goat kids offered alfalfa and grass hay diets with a corn-based supplement. J. Anim. Sci 82: 223.

Wildeus, S., M. B. Solomon, A. D. Mitchell, J. S. Eastridge, and J. R. Collins. 2001. Differences in intake, growth rate and carcass characteristics in young males of three hair sheep and meat goat breeds. In Proceedings of the International Animal Agriculture and Food Science Conference, Pp. 450.

Zinn, D. W., L. A. Holland and P. E. Neale. 1963. Effect of breed and sex on live animal and carcass measurements in lambs. *J. Anita. Sci.*, 22: 829.