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Research Article

Effect of Age and Sex on Percentage of Retail Cuts and Offal Yield of Local Goats in Pakistan

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Age, Sex, Percentage of retail cuts, Offal yield, Goats, Pakistan

Abstract | Popularity in goat meat has led to increased interest in studying the retail cuts and offal yield of goat carcasses. This study aimed to investigate the effect of age and sex on the percentage of retail cuts and offal yield of local goats in Pakistan. Thirty-six goats were randomly selected and divided into four groups based on sex and age. Groups A and B (n=9) consisted of male goats with milk teeth and two teeth, respectively, while groups C and D (n=9) consisted of female goats with milk teeth and two teeth respectively. The results showed that age had a significant effect on the percentage of retail cuts, with two-teeth animals (male or female) having higher values than milk teeth animals. When comparing different age groups, the retail cuts in two teeth male goats showed higher percentages for forelimb (19.78% vs 17.09%), neck (9.96% vs 8.48%), ribs (7.31% vs 6.02%), breast (7.06% vs 5.57%), shoulder (15.46% vs 12.97%), chops (12.73% vs 10.61%), hind limb (37.34% vs 30.48%), flank (5.18% vs 3.71%), and sirloin (10.70% vs 8.26%) compared to milk teeth male goats. Comparison of two teeth female goats to milk teeth female goats, the average percentage of retail cuts in two teeth females was higher for forelimb (18.90% vs 16.60%), neck (9.40% vs 8.15%), ribs (6.60% vs 5.54%), breast (6.48% vs 5.17%), shoulder (14.70% vs 12.59%), chops (12.04% vs 10.02%), hind limb (35.32% vs 28.79%), flank (4.96% vs 3.43%), and sirloin (9.92% vs 7.51%) However, sex did not have a significant effect on retail cuts. Offal yield was influenced by both age and sex, with male goats and milk teeth animals showing higher values. Comparison between two-teeth and milk teeth animals showed significant differences in offal yield. Comparison of killing out percentage between different age and sex group shows average killing out percentage in two teeth male was 51.325, in two teeth female 51.402, in milk teeth male 48.601 and in milk teeth female 48.083. The study concluded that the effect of age on dressing percentage was significant, but the effect of sex was not significant. The killing out percentage value was higher in two-teeth animals and lower in milk teeth animals, but there was no significant difference between male and female goats. Overall, the study provides important insights into the optimal age and sex for slaughtering goats to achieve maximum returns and standardize the retail cuts of local Pakistani goats.

Novelty Statement | The present study on the effect of age and sex on percentage of retail cuts and offal yield of local goats in Pakistan sheds light on an unexplored aspect of the country's meat industry and provides valuable insights for the future development of the sector.

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Introduction

Goat meat is a nutrient-rich food that is low in fat and high in protein and mineral salts such as calcium, magnesium, and potassium. It is also a good source of iron, potassium, and fatty acids that play an important role in maintaining the proper functioning of the human body. In addition, goat meat contains valuable amino acids like lysine, threonine, and tryptophan, making it a healthier alternative to other types of red meat (Ivanovic *et al.*, 2016; Johnson *et al.*, 1995). Goat meat is nutritionally comparable to sheep meat, but its fine-fibered structure makes it easier to digest. Its low levels of saturated fatty acids and cholesterol, along with high concentrations of polyunsaturated fatty acids, make it a healthier option among red meats. Goat meat is also rich in important amino acids such as lysine, threonine, and tryptophan (Murshed *et al.*, 2014). Therefore, it can be considered as a healthier alternative to other red meat varieties. Goat meat, known as mutton, is a major source of red meat in the human diet (Webb *et al.*, 2005). The increased demand for goat meat has led to an interest in studying retail cuts in carcasses. Goats have lower fat, while calcium, magnesium, and potassium levels are higher (Johnson *et al.*, 1995). On the other hand, goat meat has a smaller amount of cholesterol and saturated fatty acids which is considered good for health compared to other types of red meat (Ivanovic *et al.*, 2016). Goat meat also has a minimum amount of bone to meat ratio among other red meat species (Sebsibe, 2011).

Goats are slaughtered at a younger age with lower carcass weight. Weight loss is the parameter most strongly influenced by hot carcass weight; higher carcass weight results in lower weight loss during chilling, partially due to the decrease in exposed surface area per unit of carcass weight for evaporative loss (Smith and Carpenter, 1973; Muela *et al.*, 2010). A direct effect is a decrease in the rate at which temperature declines, which prevents cold shortening (Smith *et al.*, 1976). The slaughter of goats at an early age with low weight shows that exporters are not taking advantage of their growth potential (Carse, 1973). Instead of slaughtering goats at an early age, they should be raised for at least one year to increase yield and profitability. Retaining male goats has production advantages, such as leaner carcasses and faster growth, compared to female goats (Wilson *et al.*, 1970; Lee, 1986; Hopkins *et al.*, 1990). Less attention has been paid to intramuscular fat (IMF), but in a recent study, Pannier *et al.* (2014) found that female lambs had significantly higher levels of IMF than male lambs.

The quality of different cuts of goat carcasses varies and exporters can generate more profit by exporting high-value cuts rather than the whole carcass. However, no significant work has been done in Pakistan regarding the different cuts of goat carcasses and there are no proper guidelines available regarding the optimal age and sex for slaughter. Certain muscles, such as the hind leg and loin, contribute to higher-priced cuts of the carcass because they contain less associated fat and connective tissue (Thonney *et al.*, 1987). It is still to be determined at which age goats should be slaughtered for better returns, quality and yield based on sex and age. Therefore, it is necessary to establish standards regarding the age and sex for slaughtering goats to gain maximum revenue from their carcasses.

The main purpose of this study is to evaluate the optimal age and sex of goats for slaughter to improve returns and to standardize the retail cuts of local Pakistani goats.

Materials and Methods

The study was conducted at Department of Meat Science and Technology, Main campus, University of Veterinary and Animal Sciences, Lahore. A total of thirty-six (36) goats were divided into four groups: A, B, C, and D. Groups A and B contained male goats, while groups C and D contained female goats. In Groups A and C, all goats had two teeth, while in Groups B and D, all goats had milk teeth. Each group had nine (9) goats.

After measuring the live weight, the animals were slaughtered manually using the Islamic Slaughtering method. The head and feet were removed according to the method described by Wood *et al.* (1983). The skinning was carried out in a hanging position. All offal were removed by making a longitudinal incision in the center of the abdominal muscles and the weights of the hot carcass and offal (feet, head, and others) were recorded following the method described by Bonvillani *et al.* (2010). The weight of the offal, hot carcass and internal fat (KPH: Kidney Pelvic Heart) were recorded immediately after slaughter using the Accurate Plus Scale System (ACS-AE6). The killing out percentage, internal fat percentage and other parameters were calculated. The live animal weight was recorded in kg using a weighing scale (Sang D-60) before the animal was slaughtered. The weight of the hot carcass was recorded in kg using a weighing scale before the carcass was chilled. The weight of all four legs was recorded, and their percentage was calculated. The skin was manually removed by hanging the goat. The percentage of skin, pluck, spleen, kidneys, internal fat (KPH: Kidney Pelvic Heart), KPH fat percentage and dressing percentage were calculated. The carcass was then moved to the chiller (0-4 °C) for 18 h. After chilling, the weight of the chilled carcass was recorded. The carcasses were cut into different parts. The weight and percentages of the forequarter cuts and hindquarter cuts were recorded, including the weight of forelimb, neck, ribs, breast, shoulder, foreshank, hind limb, flank, sirloin (commonly known as Puth in Pakistan)

and hind shank. The weight of the offal, including the head, pluck (liver, lungs, and heart), spleen, kidney, rumen (without ingested material), skin, legs, and testes, was also recorded. All the collected data were analyzed for two-tailed pair-wise T-test using IBM SPSS 25 software package.

Results

The provided data compares the percentage of retail cuts, offal yield and other related parameters of male and female animals at different ages based on their teeth type (Table 1). The following information outlines the findings on the impact of age and sex on the percentage of retail cuts and offal yield in native Pakistani goat breeds.

Table 1: Effect of age and sex on percentage of retail cuts and offal yield of local Pakistani goats.

No of animals	Two teeth animals		Milk teeth animals	
	Male (n=9)	Female (n=9)	Male (n=9)	Female (n=9)
Individual cuts (%)				
Weight of forelimb	19.781	18.907	17.091	16.602
Weight of neck	9.961	9.401	8.488	8.153
Weight of ribs	7.316	6.602	6.025	5.546
Weight of breast	7.061	6.486	5.572	5.176
Weight of shoulder	15.461	14.706	12.978	12.593
Weight of chanps	12.739	12.048	10.613	10.024
Weight of hind limb	37.34	35.322	30.481	28.799
Weight of flank	5.186	4.961	3.719	3.432
Weight of sirloin	10.707	9.923	8.266	7.518
Individual offal (%)				
Head	14.283	13.347	16.815	15.629
Pluck	7.67	7.084	9.089	8.631
Spleen	0.359	0.263	0.639	0.556
Kidneys	0.60	0.486	0.915	0.816
Rumen	4.612	4.339	6.237	5.658
Skin	14.126	12.963	17.701	16.305
Legs	5.793	5.471	7.103	6.826
Testes	1.385		1.68	
Other parameters				
Carcass weight	15.827	15.18	10.269	9.422
Chilling loss (%)	1.305	1.485	3.065	3.426
Internal fat (KPH) (%)	3.464	4.638	1.584	2.011
Killing out (%)	51.325	51.402	48.601	48.083

Effect of age on retail cuts

The results of the present study demonstrate that age significantly affects the percentage of retail cuts in both milk teeth and two teeth animals. As shown in Figure 3, when comparing different age groups, the retail cuts in two teeth male goats showed higher percentages for forelimb (19.78% vs 17.09%), neck (9.96% vs 8.48%), ribs (7.31% vs 6.02%), breast (7.06% vs 5.57%), shoulder (15.46% vs 12.97%), chops (12.73% vs 10.61%), hind limb (37.34% vs 30.48%), flank (5.18% vs 3.71%), and sirloin (10.70% vs 8.26%) compared to milk teeth male goats (Table 1). Similarly, in the comparison of two teeth female goats (Figure 4) to milk teeth female goats, the average percentage of retail cuts in two teeth females was higher for forelimb (18.90% vs 16.60%), neck (9.40% vs 8.15%), ribs (6.60% vs 5.54%), breast (6.48% vs 5.17%), shoulder (14.70% vs 12.59%), chops (12.04% vs 10.02%), hind limb (35.32% vs 28.79%), flank (4.96% vs 3.43%), and sirloin (9.92% vs 7.51%) (Table 1). The findings of this study suggest that age should be considered when selecting animals for meat production to optimize the percentage of desirable retail cuts.

Effect of sex on retail cuts

The present study investigated the potential effect of sex on the percentage of retail cuts in mutton, and the results showed no significant impact of sex on this parameter (Table 2). The comparison between male and female goat with two teeth revealed that the average percentage of different cuts varied slightly, with male goat showing slightly higher values for forelimb (19.78% vs. 18.90%), ribs (7.31% vs. 6.60%), breast (7.06% vs. 6.48%), and sirloin (10.70% vs. 9.92%) cuts. Female goat, on the other hand, showed slightly higher values for neck (9.40% vs. 9.96%), shoulder (14.70% vs. 15.46%), chops (12.04% vs. 12.73%), hind limb (35.32% vs. 37.34%), and flank (4.96% vs. 5.18%) cuts (Table 1). These differences in cut percentages between male and female goat were not statistically significant.

In general, the average percentage of retail cuts in two teeth male is higher compared to milk teeth male and two teeth female is higher compared to milk teeth female (Figure 1 and 2). The percentage of forelimb, shoulder, chops, hind limb, and sirloin are consistently higher in two teeth male and female compared to milk teeth male and female, while neck, ribs, breast, and flank show minor variations (Table 1).

Effect of age and sex on offal

According to the present study, there was a significant effect of age and sex on the percentage of offal in mutton (Table 3). Comparing two teeth male and two teeth female, the data of 9 animals showed that the average percentage of offal in two teeth male was as follows: head 14.28%, pluck 7.67%, spleen 0.35%, kidneys 0.60%, rumen 4.61%, skin 14.12%, legs 5.79%, and testes 1.38%. On the other hand, in two teeth female, the average percentages were:

Table 2: Effect of age and sex on retail cuts yield in local Pakistani goats.

Parameter	Two teeth (TT) animal		Milk teeth (MT) animal		Age	Sex	T.T Male vs M.T Male	T.T Female vs M.T Female	T.T Male vs T.T Female	M.T Male vs M.T Female
	Male	Female	Male	Female						
Weight of forelimb	3.138±0.6	2.874±0.34	1.759±0.51	1.568±0.23	*	ns	*	*	ns	ns
Weight of neck	1.586±0.32	1.430±0.17	0.874±0.24	0.771±0.12	*	ns	*	*	ns	ns
Weight of ribs	1.163±0.23	1.005±0.14	0.622±0.18	0.524±0.08	*	ns	*	*	ns	ns
Weight of breast	1.124±0.23	0.988±0.13	0.574±0.16	0.490±0.08	*	ns	*	*	ns	ns
Weight of shoulder	2.453±0.47	2.236±0.27	1.335±0.38	1.189±0.18	*	ns	*	*	ns	ns
Weight of chanps	2.021±0.38	1.832±0.22	1.093±0.32	0.948±0.15	*	ns	*	*	ns	ns
Weight of hind limb	5.947±1.24	5.380±0.73	3.147±0.99	2.724±0.44	*	ns	*	*	ns	ns
Weight of flank	0.828±0.18	0.756±0.1	0.384±0.1	0.325±0.06	*	ns	*	*	ns	ns
Weight of sirloin	1.702±0.34	1.510±0.19	0.852±0.26	0.711±0.11	*	ns	*	*	ns	ns

*significant at 5% ; (Mean ± S.D) showing significant difference P ≤ 0.05.

Table 3: Effect of age and sex on offal yield in local Pakistani goats.

Parameter	Two teeth (TT) Animal		Milk teeth (MT) Animal		T.T Male vs M.T Male	T.T Female vs M.T Female	T.T Male vs T.T Female	M.T Male vs M.T Female
	Male	Female	Male	Female				
Head	2.242 ± 0.32	2.021±0.16	1.722 ±0.18	1.469 ±0.17	*	*	ns	*
Pluck	1.205±0.17	1.070±0.07	0.929 ±0.08	0.809 ±0.08	*	*	*	*
Spleen	0.056±0.007	0.039±0.001	0.065 ±0.006	0.052 ±0.004	*	*	*	*
Kidneys	0.094±0.01	0.073±0.004	0.093 ±0.009	0.076 ±0.007	ns	ns	*	*
Rumen	0.725 ± 0.10	0.656±0.05	0.636 ±0.05	0.530 ±0.05	*	*	ns	*
Skin	2.223 ± 0.33	1.962±0.15	1.813 ±0.19	1.530 ±0.16	*	*	*	*
Legs	0.912 ± 0.14	0.828±0.06	0.727 ±0.07	0.641 ±0.06	*	*	ns	*
Testes	0.215 ± 0.02		0.171 ±0.008		*	*	*	*
Internal fat (KPH)	0.561 ± 0.14	0.712±0.12	0.167 ±0.05	0.194 ±0.06	*	*	*	ns
Killing out %	51.325±1.31	51.402±1.15	48.601±0.87	48.083±0.96			ns	ns

*significant at 5% ; (Mean ± S.D) showing significant difference P ≤ 0.05.

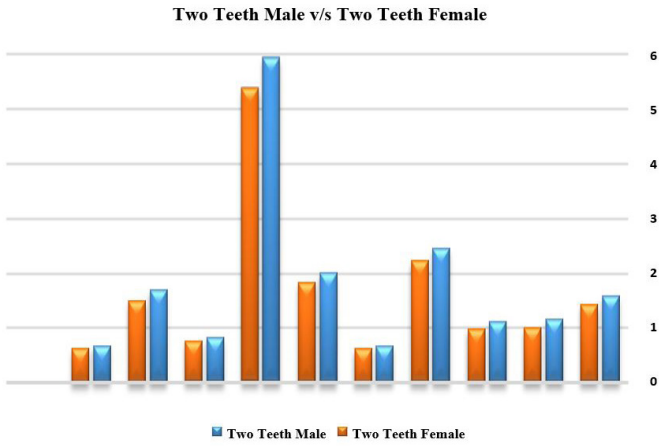

Figure 1: The average percentage retail cuts comparison between two teeth male and two teeth female.

head 13.34%, pluck 7.08%, spleen 0.26%, kidneys 0.48%, rumen 4.33%, skin 12.96%, and legs 5.47%. In the case of milk teeth animals, the average percentage of offal in milk teeth male was: head 16.81%, pluck 9.08%, spleen 0.63%, kidneys 0.91%, rumen 6.23%, skin 17.70%, legs 7.10%, and testes 1.68%. Whereas in milk teeth female, the average percentages were: head 15.62%, pluck 8.63%, spleen 0.55%, kidneys 0.81%, rumen 5.65%, skin 16.30%, and legs 6.82% (Table 1). Based on the comparison, it was observed that the offal values were higher in males and lower in females (Figure 5). However, in the case of two teeth male and two teeth female, there was a significant difference in pluck, spleen, kidney, and skin, while the difference was non-significant in head, rumen, and legs. On the other hand, in the case of milk teeth male and milk teeth female, all offal had a significant difference (Table 3).

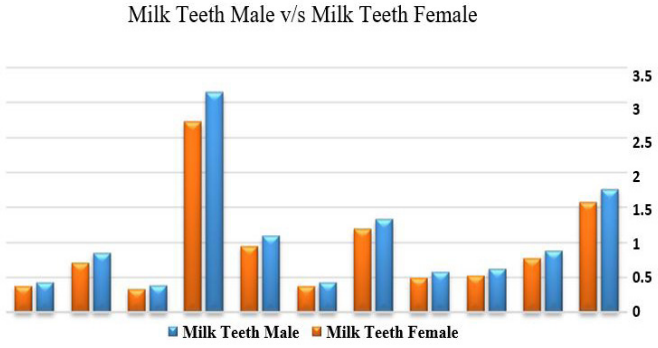

Figure 2: The average percentage retail cuts comparison between milk teeth male and milk teeth female.

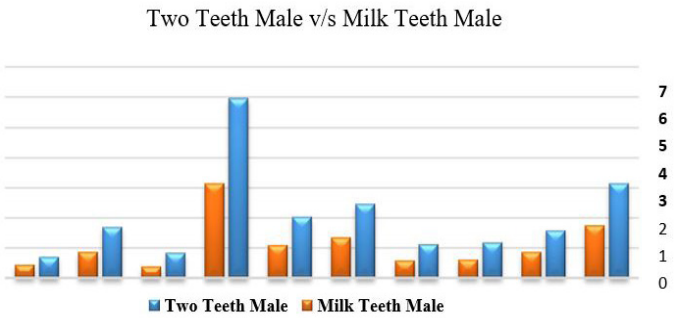

Figure 3: The average percentage retail cuts comparison between two teeth male and milk teeth male.

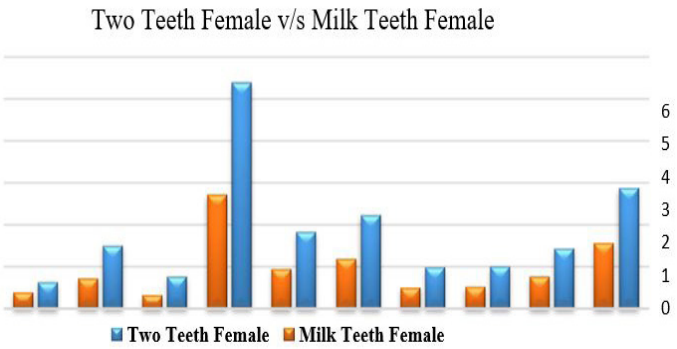

Figure 4: Retail cuts comparison between two teeth female and milk teeth female.
All data are average percentage considering age (milk teeth and two teeth) and sex (male and female).

When comparing by age, it was found that offal values were higher in milk teeth animals and lower in two teeth animals (Figure 5). Additionally, there was a significant difference between two teeth male and milk teeth male in all offal values except for kidneys, which was also observed in the comparison between two teeth female and milk teeth female (Table 3).

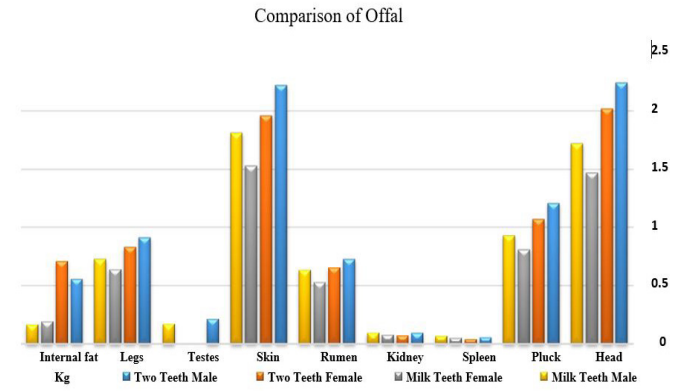

Figure 5: Comparison of offal between different age and sex groups.
All data are average percentage considering age (milk teeth and two teeth) and sex (male and female).

Effect of age and sex on killing out percentage

The present study concluded that age had a significant effect on dressing percentage, while sex did not (Table 3). Comparison of killing-out percentage between different age and sex groups showed that among 9 animals, the average killing-out percentage was 51.325 for two teeth male, 51.402 for two teeth female, 48.601 for milk teeth male, and 48.083 for milk teeth female (Table 1). The findings of the present study indicate that there was a significant effect of age on the killing out percentage, with a higher value observed in the two teeth animals compared to the milk teeth animals. In contrast, there was no significant effect of sex on the killing out percentage value. These results are supported by the data presented in Figure 6.

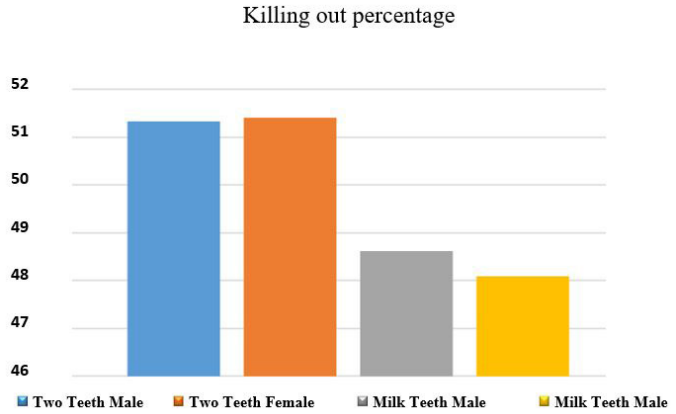

Figure 6: Comparison of killing out percentage between different age and sex groups.
All data are average percentage considering age (milk teeth and two teeth) and sex (male and female).

Furthermore, the analysis of variance revealed a significant difference in the killing out percentage between two teeth and milk teeth animals, while no significant difference was observed between males and females. These findings are summarized in Table 3.

In terms of non-retail cuts, two teeth male have a slightly higher percentage of head, skin, and legs compared to two teeth female. However, the pluck, spleen, kidneys, and rumen percentages are slightly higher in two teeth female. The percentages of non-retail cuts are higher in milk teeth animals compared to two teeth animals.

The killing out percentage, which is the percentage of carcass weight in relation to live weight, is slightly higher in two teeth female compared to two teeth male. The killing out percentage is lower in milk teeth animals compared to two teeth animals, which may be due to their immature development.

Discussion

Effect of age and sex on retail cuts

The results of the present study demonstrate a significant effect of age on the percentage of retail cuts

in goats. Specifically, the analysis revealed that older animals (i.e., two-teeth males and females) had a higher percentage of retail cuts compared to younger animals (i.e., milk teeth males and females). The results of the present study are consistent with the findings of Kawęcka and Pasternak (2022), who also reported that older animals tend to have higher percentages of retail cuts compared to younger animals. This suggests that age is an important factor to consider in the production of goat meat and may have implications for farmers and producers seeking to maximize meat yield. This finding highlights the importance of considering age when assessing the quality and value of goat carcasses for meat production. At the retail level, younger goats are preferred due to their lower fat and higher muscle percentage. Carcass composition, bone, fat, and muscle percentage are all influenced by the weight and age of the goat. Moreover, research shows that as the carcass weight increases by 1 kg with the progression of age, the external fat increases by 0.10 kg and internal fat by 0.18 kg. The findings of the present study indicate that sex did not have a significant effect on retail cuts percentage. The results are similar with the findings of Kawęcka and Pasternak (2022). This may be attributed to the fact that at similar age, female goats tend to have a higher fat content than male goats (Sebsibe, 2011). Previous studies have also shown that carcasses of male goats have less marbling and softer flank firmness compared to those of female goats, but generally have greater muscularity (Ash and Norton, 1987). These results are consistent with the findings of Benevent *et al.* (1971), who reported that carcasses of female goats had a significantly higher proportion of fat than those of male goats, while the male goat carcasses had a heavier skeleton and a similar percentage of muscle mass as compared to females.

Effect of age and sex on offal

The present study found that the offal percentage decreased with increasing age in goats, resulting in lower values in two teeth animals as compared to milk teeth animals. This can be attributed to the increase in muscle and fat percentages with age, which leads to a decrease in offal percentage. Mourad *et al.* (2001) reported that for each kilogram increase in body weight, the edible offal percentage increased by 20.4%. Furthermore, a 1.9% increase in offal was observed for each kilogram increase in carcass weight. Non-carcass components, or offal, make up approximately 35% of the body weight of an animal, and the offal percentage decreases with increasing weight or age (Pena *et al.*, 2005). Offal plays a significant role in the carcass yield and can provide better returns to farmers. Offal is often referred to as the 'Fifth Quarter' of the carcass based on its economic value. Research by Ruiz de Huidobro *et al.* (1993) demonstrated that the percentage of offal is higher in male goats compared to females, and female goats have a higher fat content and lower weight of offal. This is because the fast rate of fat deposition in females reduces the growth rate of offal and other tissues. Studies by Wood *et al.* (1983) and Johnson *et al.* (1995) have also shown that female goats have a lower percentage of feet, heart, pelt, liver, and kidney compared to male goats.

Effect of age and sex on killing out percentage

The dressing percentage of goat carcasses is an important factor that affects the revenue and profitability of the goat production. The weight of stomach contents and skin can affect the dressing percentage. Research conducted by Kirton *et al.* (1995) has shown that stomach content and skin weight can affect the dressing percentage.

Sex does not have a significant effect on dressing percentage in goat carcasses of similar weight, according to studies conducted by Mehjabin *et al.* (2016), Ruvuna *et al.* (1992) and Cloete *et al.* (2004). Furthermore, Warmington and Kirton (1990) found no significant effect of sex on dressing percentage in various goat breeds.

The present study found that age and live weight had a significant impact on the dressing percentage of goats. Consistent with previous research by Kawęcka and Pasternak (2022), our results showed that as age increased, the dressing percentage also increased. Specifically, the dressing percentage for two teeth male and female goats (older animals) was observed to be higher than that of milk teeth male and female goats (younger animals). The Effect of slaughter age on meat quality of male kids of the Polish carpathian native goat breed. Animals, 12(6), p.702. as the age of the goat increases and live weight increases, the dressing percentage also increases, as reported by Wood *et al.* (1983). If the weight of a live goat increases by 1 kg, the carcass weight increases by 0.48 kg. Mourad *et al.* (2001) found that dressing percentage increased by 0.1% with an increase in each kilogram of body weight and by 0.6% with an increase in each kilogram of carcass weight.

It is important for the goat farming industry in Pakistan to focus on breeding and fattening practices to improve carcass weight and fatness. By determining the appropriate time for slaughter, producers can increase their returns. However, it is recommended that slaughtering of female and young animals be banned in order to improve goat production in Pakistan. It is suggested that goats should be raised for at least one to two years before slaughter, which can ultimately increase yield and profitability for farmers and processors.

In addition to improving breeding and fattening practices, there is a need to focus on the value cuts of goat carcasses. Exporters can obtain higher profits by exporting high-value cuts, such as hind leg and loin, which contain less associated fat and connective tissue. However, there is currently limited data available on the standard value

cuts of goat breeds in Pakistan. It is therefore important to collect baseline data on retail cuts of goat, which can help establish standards for specific sex and slaughtering age, and maximize revenue from carcasses.

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Not applicable.

Availability of data and materials

Available on request to corresponding author.

Consent for publication

The authors give their consent to publish.

Ethics approval consent to participate

Not applicable.

Conflict of interest

The authors have declared no conflict of interest.

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