B-4864
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RESEARCH ARTICLE Indian Journal of Animal Research

Age and Sex Affect Carcass Traits and Meat Quality in Malpura Sheep

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10.18805/IJAR.B-4864

ABSTRACT

Background: Small ruminants play a vital role in livelihood and nutritional security in India. The sheep population in the country is showing positive growth. Malpura sheep from the semi-arid region of India is an important mutton purpose breed.

Methods: Twenty-four animals *viz*., ram lamb ($G\text{-}_{Rl}$), ewe lamb ($G\text{-}_{El}$) (10-12 months each), ram ($G\text{-}_{Ra}$) and ewe ($G\text{-}_{Ea}$) (20-24 months each) were slaughtered to assess carcass traits and meat quality.

Result: The average pre-slaughter weight and dressing yield on an empty live weight basis for $G\text{-}_{Rl,}$ $G\text{-}_{El,}$ $G\text{-}_{Ra}$ and $G\text{-}_{Ea}$ groups were 23.83, 17.00, 35.82 and 28.08 kg; 52.35, 51.26, 53.70 and 52.93% respectively. The loin eye area (cm^2) differed significantly. The weights of edible and inedible offals were significantly higher (P<0.001) in males in the same age group. The average lean content in different cut-up parts was higher (P<0.05) in G-3($G\text{-}_{Ra}$). The shear force values and other meat quality attributes were significantly different among the groups. It is concluded that age and sex had a significant effect on carcass traits and meat quality in Malpura sheep.

Key words: Age, Carcass traits, Malpura sheep, Meat quality, Sex.

INTRODUCTION

Meat is an awesome wellspring of supplements. Amino acids are significant for the growth and repair of body tissues in humans (Lawrie and Ledward, 2006). Of late, leaner carcasses are in demand due to better consumer awareness for healthy meat, with a focus on the quantity and quality of fat. Meat quality and carcass characteristics vary among animal species (Muela *et al*., 2012). With increasing slaughter body weight in lambs, the carcass becomes darker, fattier and less tender (Abdullah and Qudsieh, 2008). Purchaser favors meat with more lean and less fat and steady quality (Gadekar *et al*., 2015). Recently, global demand for low-fat, high-protein lean meat has increased to satisfy the protein requirements (Shauyenov *et al.,* 2016).

Malpura is one of the main sheep of the semi-arid region of Indian state Rajasthan, notable for its hardiness, versatility to unforgiving climate and considered as an incredible mutton breed (Gowane *et al*., 2015). The carcass traits of intensively fed lambs (3 to 6 months of age) were studied. The dressing yield (%) on live weight and empty body weight basis was 51 and 59, respectively (Prasad *et al.,* 1981). The Malpura lambs maintained on suckling with *ad-lib* creep ration and tree leaves accomplished 14.6 kg body weight at 3 months of age with ADG of 134 g and FCR of 2.00 (Tripathi *et al*., 2011). For improved weight gain and thus higher carcass weight in Malpura lambs, *Lactobacillus acidophilus* culture @ 1.5 ml/kg body weight can be used as a probiotic (Gadekar *et al.,* 2014). Malpura ram lambs with an adequate dressing yield, loin eye area, desirable commercial cuts and lean, fat and bone content when slaughtered at 6 months of age and weighed 24.49 kg body weight (Shinde *et al.,* 2018). The information about carcass attributes of Malpura sheep has been documented in the literature (Karim *et al.,* 2000; 2002; Sen and Karim, 2010; Sureshkumar *et al.,* 2010); However, the detailed studies on the effect of age and sex on meat qualities in Malpura sheep is lacking.

Therefore, the present study was undertaken to study the effect of age and sex on carcass traits and meat quality of Malpura sheep in depth.

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How to cite this article: Meel, S.K., Pandey, A., Gadekar, Y.P., Soni, A., Meena, P., Gurjar, A.S. and Chauhan, V.K. (2022). Age and Sex Affect Carcass Traits and Meat Quality in Malpura Sheep. Indian Journal of Animal Research. DOI: 10.18805/IJAR.B-4864.

Submitted: 14-01-2022 **Accepted:** 02-05-2022 **Online:** 28-05-2022

MATERIALS AND METHODS

The study was undertaken at ICAR-Central Sheep and Wool Research Institute, Avikanagar, Rajasthan during 2018-2019. Twenty-four Malpura sheep were divided into four groups *viz*., ram lamb ($G\text{-}_{Rl}$), ewe lamb ($G\text{-}_{El}$) (10-12 months each), ram ($G\text{-}_{Ra}$) and ewe ($G\text{-}_{Ea}$) (20-24 months each). The animals fasted overnight with free access to water were slaughtered by the Halal method. Sticking, legging, dressing and evisceration were done. The carcass was portioned along the midline and the left half was split into the leg, loin, rack, neck and shoulder, breast and foreshank (ISI, 1963). The *Longissimus dorsi* muscle was collected from each carcass for meat quality evaluation. The meat pH was estimated according to Trout *et al.* (1992). The moisture, protein, fat and ash contents were determined as per AOAC (2000). Total meat pigments were determined by Hornsey (1956). The procedure of Knipe *et al.* (1985) was used for the estimation of salt soluble proteins. The muscle fibre diameter was evaluated according to Jeremiah and Martin (1982). The muscle fibre diameter was measured as the mean diameter of the middle and the two extremities of the 25 randomly selected muscle fibres and expressed in micrometer.

The hydroxyproline (HP) content was determined using a procedure by Neuman and Logan (1950). The collagen content was estimated using a conversion factor of 7.25 (Goll *et al*., 1963). A soluble fraction of hydroxyproline was prepared by slightly modifying the procedure of Okonkwo *et al*., (1992). The percentage of soluble hydroxyproline was calculated as follows:

$$\text{Per cent soluble hydroxyproline} = \frac{\text{Soluble hydroxyproline of supernatant fraction}}{\text{Soluble hydroxyproline of residue fraction} + \text{Insoluble hydroxyl proline of supernatant}} \times 100$$

$$\text{Collagen solubility (\%)} = \frac{\text{Soluble collagen}}{\text{Soluble collagen} + \text{Insoluble collagen}} \times 100$$

The shear force values (N) were estimated with a texture analyzer (TA.HD plus), Stable Micro System Ltd., England. The myofibrillar fragmentation index (MFI) was estimated as per Davis *et al.* (1980). The water holding capacity was determined according to Wardlaw *et al.* (1973). The method of Swift *et al.* (1961) was used for determining emulsifying capacity.

The data obtained were analyzed using the SPSS v. 16.0. The variations in carcass traits and meat quality parameters between age groups and sex were compared by one-way ANOVA and test of significance.

RESULTS AND DISCUSSION

Body length, height, heart girth, paunch girth, pre-slaughter weight varied significantly (P<0.001) with age and sex of animals (Table 1). It increased with the advancement of age and was higher for males than females for identical age groups. Pre-slaughter weight, empty live weight, hot carcass weight were highest in ram and lowest in ewe lamb. These might be ascribed to the size differences in males and females. Dressing percentage based on pre-slaughter weight, the weight of reproductive organs, weight of caul fat, kidney fat, the weight of total edible, the weight of different type fat and fat percentage were higher in female than male in same age groups. The hot carcass weight was in accordance with Kumar *et al.* (2017). The loin eye area differed significantly (P<0.001) in all the groups. Our study results are in agreement with earlier findings (Das *et al*., 2008).

Yields of edible and inedible offals (Table 1) differed significantly (P<0.001). It increased with the advancement of age and was higher for males than females. The weight of testis and testis fat increased with age. Weights of the spleen, caul fat, kidney fat, kidney, heart, liver, lungs, total edible offal, differed significantly (P<0.05).

The primal cut yield was affected significantly (P>0.05) by age and sex (Table 2). Shinde *et al.* (2018) reported that half carcass weight increased significantly with age in Malpura sheep. Leg cut was the major portion of half carcass followed by neck and shoulder cut (Fig 1). Pena *et al.* (2005) reported that sex affected the amount and type of fat deposited. The lean fat ratio was highest for G-1($G\text{-}_{Rl}$). A higher lean fat ratio is always desirable. The meat bone ratio was highest for G-4($G\text{-}_{Ea}$) while meat bone ratios in G-1 ($G\text{-}_{Rl}$) and G-2($G\text{-}_{El}$) were comparable. With an increase in the animal age, the growth rate of muscles is unchanged while the growth rate of bone tissue reduces (Koyuncu *et al.* 2007). Santos-Silva and Portugal (2001) observed that the meat/bone ratio increases with an increase in slaughter weight.

The meat quality was also affected due to age and sex in Malpura sheep. Markedly higher protein content was observed in the ewe lamb group. A significantly (P<0.001)

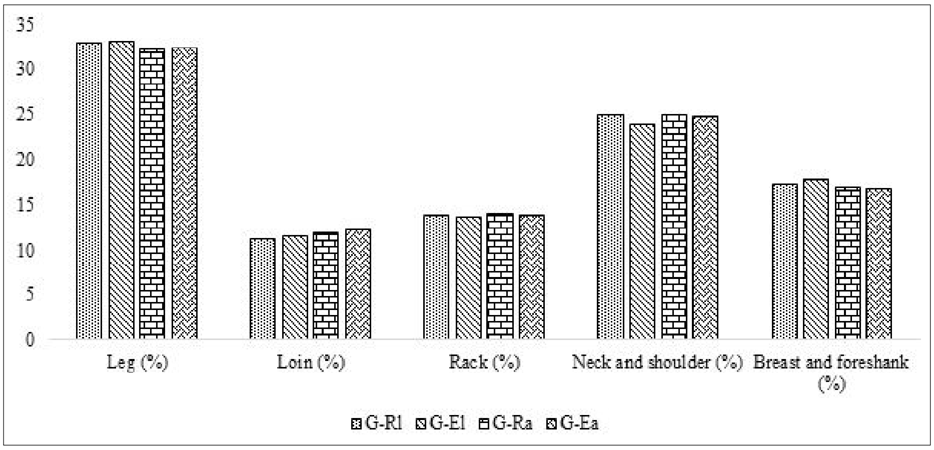

Fig 1: Effect of age and sex on commercial cuts in Malpura sheep.

higher fat content was recorded in the female group for the same age group. With the progression of slaughter age, fat and protein levels increased whereas moisture content declined (Madruga *et al.* 1999). Tejeda *et al.* (2008) also found a non-significant effect of sex on moisture content. A muscle composition varies with increasing animal age irrespective of species, breed, or sex and in most cases; younger animals are considered to have less myoglobin, less intramuscular fat and more moisture (Lawrie, 1998). Fat is the last tissue to mature and older animals tend to be fatter. The inter-muscular fat content of *Longissimus dorsi* increased and moisture content decreased with increasing slaughter weight. Lipids are major components of the muscle structure that give the meat the sensory characteristics

Table 1: Effect of age and sex on pre-slaughter parameters in Malpura sheep (Mean±SE).

Parameters	G_{-Rl}	G_{-El}	G_{-Ra}	G_{-Ea}
Length (cm)	55.67±0.67[bc]	51.83±1.54[c]	63.50±1.06[a]	58.50±2.35[b]
Height (cm)	61.33±0.88[c]	56.00±0.73[d]	69.00±0.93[a]	64.50±0.96[b]
Heart girth (cm)	71.67±2.59[b]	65.50±1.48[c]	84.00±1.24[a]	79.17±1.40[a]
Paunch girth (cm)	86.33±1.38[b]	73.50±2.69[c]	98.17±1.66[a]	87.67±1.38[b]
Pre Slaughter weight (kg)	23.83±1.07[c]	17.00±1.21[d]	35.82±1.24[a]	28.08±1.26[b]
Empty Live weight (kg)	19.43±1.01[c]	13.93±1.02[d]	29.38±1.18[a]	23.67±0.93[b]
Hot carcass weight (kg)	10.19±0.63[c]	7.15±0.54[d]	15.76±0.60[a]	12.63±0.51[b]
Dressing yield (%) PSW	42.61±0.81[b]	41.99±0.83[b]	43.99±0.45[ab]	44.98±0.55[a]
Dressing yield (%) ELW	52.35±0.71	51.26±0.57	53.70±0.88	52.93±0.62
Weight of forequarter (kg)	5.47±0.36[c]	3.75±0.27[d]	8.50±0.31[a]	6.49±0.23[b]
Weight hindquarter (kg)	4.59±0.26[c]	3.28±0.27[d]	7.01±0.31[a]	5.65±0.24[b]
Loin eye area (cm^2)	12.26±0.79[bc]	9.91±0.66[c]	17.81±1.61[a]	13.11±0.36[b]
Blood (kg)	1.31±0.06[b]	0.87±0.06[c]	1.76±0.16[a]	1.46±0.05[b]
Head (kg)	1.47±0.04[c]	1.13±0.05[d]	2.21±0.08[a]	1.73±0.03[b]
Skin (kg)	2.03±0.14[b]	1.43±0.10[c]	3.05±0.15[a]	2.17±0.10[b]
Fore canon (kg)	0.33±0.01[b]	0.23±0.01[c]	0.45±0.02[a]	0.30±0.01[b]
Hind canon (kg)	0.28±0.01[b]	0.20±0.01[c]	0.38±0.01[a]	0.25±0.00[b]
Gallbladder (kg)	0.03±0.00	0.02±0.00	0.04±0.01	0.03±0.01
Total inedible offal(kg)	5.49±0.23[b]	3.93±0.23[c]	7.95±0.33[a]	6.17±0.29[b]
Inedible Offal (%) on PSW	23.12±0.66	23.2±0.37	22.24±0.73	22.18±0.53
Gastrointestinal tract (filled) (kg)	6.63±0.28[b]	4.77±0.37[c]	9.64±0.53[a]	7.34±0.43[b]
Gastro-intestinal tract (empty) (kg)	2.22±0.17[bc]	1.71±0.16[c]	3.20±0.39[a]	2.80±0.13[ab]
Testis fat (kg)	0.03±0.00	NA	0.04±0.00	NA
Testis (kg)	0.16±0.02[b]	NA	0.35±0.04[a]	NA
Spleen (kg)	0.05±0.00[b]	0.04±0.00[b]	0.10±0.01[a]	0.06±0.01[b]
Pancreas (kg)	0.03±0.0	0.02±0.0	0.04±0.0	0.04±0.0
Caul Fat (kg)	0.06±0.03[c]	0.10±0.05[bc]	0.20±0.03[b]	0.50±0.06[a]
Kidney Fat (kg)	0.07±0.02[b]	0.07±0.02[b]	0.15±0.03[b]	0.37±0.08[a]
Kidney (kg)	0.06±0.0[b]	0.05±0.0[c]	0.10±0.01[a]	0.07±0.0[b]
Heart (kg)	0.10±0.0[c]	0.08±0.01[d]	0.15±0.01[a]	0.12±0.01[b]
Liver (kg)	0.44±0.02[b]	0.31±0.01[c]	0.67±0.05[a]	0.51±0.01[b]
Lungs (kg)	0.46±0.02[c]	0.38±0.03[d]	0.67±0.02[a]	0.56±0.03[b]
Total edible offal (kg)	1.27±0.08[b]	1.06±0.11[b]	2.09±0.11[a]	2.21±0.15[a]
Total inedible offal (%) on PSW	5.49±0.23[b]	3.93±0.23[c]	7.95±0.33[a]	6.17±0.29[b]
Chilling loss (%)	2.91±0.28[a]	2.07±0.25[b]	3.23±0.16[a]	2.67±0.13[ab]
Lean yield (%)	56.98±1.52[b]	56.24±0.70[b]	60.24±0.54[a]	57.68±0.83[ab]
Subcutaneous fat (%)	3.91±0.31[b]	4.44±0.65[b]	4.14±0.46[b]	6.47±0.58[a]
Intermuscular fat (%)	3.41±0.70	3.89±0.88	4.01±0.22	5.82±0.78
Separable fat (%)	7.32±0.99[b]	8.33±1.5[b]	8.15±0.67[b]	12.4±1.35[a]
Dissected bone (%)	31.64±1.20[a]	31.26±1.26[a]	28.94±0.57[ab]	26.48±1.50[b]
Lean fat ratio	8.45±1.02	7.96±1.46	7.66±0.64	5.29±0.57
Meat Bone ratio	1.82±0.11[b]	1.82±0.08[b]	2.09±0.05[ab]	2.16±0.12[a]

N=6 in each group; Means bearing different superscripts differ significantly (*-P<0.05, **-P<0.01, ***-P<0.001), NS- Non-significant (P>0.05). G_{-Rl} = Ram lamb, G_{-El} = Ewe lamb, G_{-Ra} = Ram and G_{-Ea} = Ewe, NA= Not applicable.

Table 2: Effect of age and sex on meat quality in Malpura sheep (Mean±SE).

Parameter	$G\text{-}_{Rl}$	$G\text{-}_{El}$	$G\text{-}_{Ra}$	$G\text{-}_{Ea}$
Moisture (%)	76.80±0.92	75.14±1.30	74.94±1.01	73.11±1.18
Protein (%)	20.83±0.94	21.70±1.18	20.72±0.84	20.54±1.4
Fat (%)	1.20±0.02[d]	2.02±0.15[c]	3.22±0.34[b]	4.83±0.21[a]
Ash (%)	1.17±0.05	1.14±0.05	1.13±0.04	1.52±0.21
pH 45min.	6.89±0.09	7.03±0.09	6.87±0.09	6.65±0.18
Ultimate pH	5.78±0.14	5.81±0.12	5.95±0.13	5.96±0.15
Cooking loss (%)	26.87±1.67[a]	26.24±0.65[ab]	22.8±1.67[b]	23.18±0.71[ab]
Firmness (N)	51.31±2.06[a]	41.56±0.52[b]	53.67±1.42[a]	44.2±0.54[b]
Work of shear (N*sec.)	284.42±14.11[b]	183.05±5.18[d]	324.52±4.74[a]	222.06±2.34[c]
Heme iron content (µg/gm)	11.41±1.01[b]	11.72±0.59[b]	14.56±1.15[ab]	17.27±1.25[a]
Total meat pigment (ppm)	129.35±11.46[b]	132.84±6.67[b]	165.08±12.98[ab]	195.77±14.18[a]
Salt soluble protein (%)	5.68±0.65	5.90±0.39	6.16±0.37	7.15±0.72
Collagen content (%)	2.47±0.09[c]	2.39±0.08[c]	2.95±0.04[b]	3.20±0.03[a]
Collagen solubility (%)	24.70±0.49[b]	28.06±0.76[a]	20.84±0.52[c]	22.23±0.62[c]
Water holding capacity (ml/100 gm)	52.86±4.88	50.67±3.63	51.47±1.57	47.71±7.85
Muscle fiber diameter (µm)	30.78±0.33[b]	31.35±1.04[b]	39.78±0.85[a]	38.79±0.78[a]
Myofibrillar fragmentation index (%)	76.76±0.89	77.34±0.81	74.67±3.03	75.54±1.14

N=12 in each group (N= 300 for muscle fibre diameter); Means bearing different superscripts differ significantly (*-P<0.05, **-P<0.01, ***-P<0.001), NS- Non-significant (P>0.05) $G\text{-}_{Rl}$ = Ram lamb, $G\text{-}_{El}$ = Ewe lamb, $G\text{-}_{Ra}$= Ram and $G\text{-}_{Ea}$= Ewe.

desired by the consumer such as juiciness, flavour and aroma (Zorzi *et al.*, 2013).

The pH of the meat is very important as it has a definite impact on meat quality and shelf life. The meat pH recorded after 45 minutes of slaughter was found to be comparatively higher in ewe lamb than others. The meat pH variation might be due to variations in animal age, pre-slaughter handling of animals, slaughter condition and handling of meat. Tejeda *et al*. (2008) reported that animal sex did not affect meat pH. The cooking loss differed (P<0.05) significantly between the groups with comparatively higher values in ram lambs. Yarali *et al.* (2014) recorded cooking losses of 26.80, 28.76 and 24.10 percent in *Longissimus thoracis et lumborum*, *Longissimus thoracis* and *Semitendinosus* muscle, respectively. The firmness (N) and work of shear (N*sec.) differed significantly (P<0.001) between the groups with significantly higher in ram. The fibre diameter, hydroxyproline content and toughness of the meat had a positive correlation with the shear force value of meat while it has a negative correlation with the sarcomere length (Biswas *et al.* 1989). The value obtained in the present study is in concurrence with the reports of Sen *et al.* (2004) in yearling sheep reared under a semi-arid region. The heme iron content (µg/gm) and total meat pigment (ppm) differed significantly (P<0.001) with sex and age. A significantly higher total meat pigment was observed in ewes and increased with increasing age. The greater meat pigment concentration in aged sheep groups was attributed to the more heme pigment and myoglobin pigment (Mamino and Horn, 1996). As animal age increases the myoglobin concentration increases which in turn improves red color intensity (Warner *et al.*, 2007). Advancement in sheep age leads to increased aerobic muscle fibres which raise myoglobin pigment leading to better red colour of meat. Nevertheless, the degree differs according to the breed and nutrition (Warner *et al*., 2007). The salt soluble protein content was comparable (P>0.05) between the groups. Ahmed *et al*. (2015) observed a non-significant effect of age on salt soluble protein content in goatmeat. The collagen content of meat in ewes was significantly higher compared to in other groups. Significantly higher collagen solubility was observed in ewe lambs ($G\text{-}_{El}$). Collagen content and muscle fiber diameter increased while collagen solubility decreased with age. Intra-muscular collagen and cross-link formation depends upon the age of the animal and is directly proportional to age. Polidori *et al*. (2017) observed a significant effect of age on collagen content in lambs. The collagen has a low rate of metabolic turnover which leads to the permanent formation of cross-linkages (Purslow *et al*., 2012). The water holding capacity in ram lambs was comparatively higher than in other groups. Stankov *et al*. (2002) observed a non-significant effect of age on water holding capacity in the young goat of Bulgarian breeds and crossbreeds of goats. A significantly larger muscle fibre diameter was observed in the ewes group. The myofibrillar fragmentation index was comparatively higher for ewe lambs. The myofibrillar fragmentation index is a measure of myofibrillar protein degradation (Seideman *et al*., 1987). This was highly related to shear force and sensory tenderness ratings (Calkins and Davis, 1980).

CONCLUSION

The findings of the study indicated that pre-slaughter weight, loin eye area, a yield of different edible offals and lean yield in primal cuts were higher in ewes and rams compared to the ewe lambs and ram lambs, while the above parameters were higher in rams and ram lambs compared to their female counterparts in same age groups. Fat content and total meat pigment were found higher in females compared to males in the same age groups. Collagen content and muscle fiber diameter were higher in the adult animal while collagen solubility was higher in the young animal. The age and sex of animal affected carcass traits and meat quality.

ACKNOWLEDGEMENT

The first author thanks to the Director, ICAR-CSWRI, Avikanagar and Incharge LPT section for providing facilities to carry out work. Author is also grateful to RAJUVAS, Bikaner for providing financial support in form of stipend.

Conflict of interest: None.

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