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Comparative study on carcass characteristics and meat quality of three Indian goat breeds

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ABSTRACT

Barbari (10), Jamnapari (6) and Marwari (4) male goat kids were reared under semi-intensive management system and slaughtered at 13 month to study the differences if any, in the carcass and meat quality traits. pH, water holding capacity, cooking loss, shear force value, cholesterol content and sensory attributes of *Longissimus dorsi* (LD) and *Semimembranosus* (SM) muscles were assessed for comparative meat quality evaluation. Study revealed that breed has no significant effect on slaughter weight. All the parameters except dressing percentage and fore cannon were nonsignificant among the 3 breeds. Jamunapari had marginally heavier carcass weight and higher dressing percentage. Marwari had the lowest back fat (1.00 mm) and breast fat (2.17 cm) thickness. Loin eye area was moderately higher in Jamunapari (8.62 cm^2) followed by Barbari (8.45 cm^2) and Marwari (7.38 cm^2). The weight of cut portion of leg, loin, rack and breast and shank was marginally higher in Jamunapari kids. There were no significant differences between breeds and muscles in meat chemical composition among three Indian goat breeds. Marwari goats had marginally higher ultimate pH (5.71, 5.79) values than those from Barbari (5.67, 5.72) and Jamunapari (5.63, 5.69) goats. Cooking loss percentage from the 3 breeds ranged from 36.0 to 38.0% with little differences between the 3 breeds and muscles. Barbari goat muscles had lower mean cholesterol (68.38 mg/100 g) content than Jamunarpari (71.76) and Marwari goats (73.45). No significant difference was found between the breeds and muscles with regard to meat tenderness, juiciness and flavour. Barbari received better overall acceptability scores over other two breeds.

Key words: Barbari, Carcass traits, Goats, Jamunapari, Marwari, Meat quality

Marwari is a medium-sized and duel-purpose (meat/milk) goat breed of the northwestern arid region of Rajasthan. Jamunarpari is a large sized and duel-purpose breed whereas, Barbari is the most promising meat goat in India after Black Bengal breed. Extensive studies have been conducted on effect of feeding, management, age on growth, carcass traits and meat quality of Jamunapari (Saini *et al.* 1988, Amin *et al.* 2000) and Barbari kids (Agnihotri *et al*. 2006, Dutta *et al.* 2009). Distribution of carcass tissues is important in determining carcass quality and amount and site of fat in the carcass also influences its quality. The slaughter traits are modulated by heredity, breed, feeding regimen and prevailing rearing environment. Dressing percentage, which is an important trait for carcass evaluation is influenced by age, breed, sex, plane of nutrition, management system etc. Goat meat being high quality protein source is the choicest meat in domestic market. It is leaner than other red meats and its fat has desirable fatty acids. Information on the cholesterol content, tenderness and the eating quality of meat from different goat breeds especially Marwari kids in India is scarce. Therefore, the present study was designed to study the carcass traits, physiochemical properties and sensory attributes of meat from Barbari, Jamunapari and Marwari goats.

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MATERIALS AND METHODS

Barbari (10), Jamunapari (6) and Marwari (4) weaned (at 90 days) male kids, reared under semi-intensive system of management at the institute's farm were used for the study. Kids under the above management system were sent for grazing 4–5 h daily and were supplemented with concentrate @100 g/head/day and *ad lib.* dry roughages. Kids weighing 20–23 kg were slaughtered at 13 months of age.

Carcass characteristics: Kids were fasted for 16–18 h with free access to water and were slaughtered by standard method. The weights of all the non-carcass parts were recorded separately. Post fasted live animal and carcass measurements after dressing were taken (Das *et al*. 2008). Empty live weight (ELW) was calculated as the difference between slaughter weight and weight of digestive content

(ingesta). Immediately after dressing, chest and leg circumferences of the carcass hanging with Achilles tendon were recorded. The hot carcass was spilt into fore and hind quarters and loin eye area was recorded on the cut surface of the *Longissimus dorsi* muscle between 12th and 13th ribs on both sides of the carcass and was expressed as cm^2. Back fat thickness was the average of 2 measurements at the mid length of the *L. dorsi* muscle on either side of the midline. The dressed carcasses were split along the midline manually and left halves were jointed into 5 primal cuts as reported by Das *et al.* (2008).

Analysis of meat sample: Longissimus dorsi (LD) and *Semimembranosus* (SM) muscles of either side from the carcasses were separated and kept in a polyethylene bag at 4±1°C for 24 h for further analysis of moisture, protein, fat and ash (AOAC 1995). pH of muscle was determined blending 10 g of sample with 50 ml of distilled water by a digital pH meter. Water-holding capacity (WHC) of meat was estimated by a centrifugation method (Wardlaw *et al.* 1973). Cooking loss was evaluated by heating meat samples, individually inside polyethylene bag in a water bath at 80ºC for 20 min (Das *et al.* 2008). After measurement of cooking loss, samples were stored in a refrigerator for objective tenderness determinations. The shear force was recorded using shear press. Cholesterol content of minced meat was determined using cholesterol test kit. Coded and heated samples were evaluated for sensory attributes using a nine point hedonic scale, in which score 1 indicated extremely poor and the score 9 as excellent.

The data were analyzed using statistical software following the standard procedure for analysis of variance (Snedecor and Cochran 1995) and Duncan's multiple range tests for comparing the means to determine the effect of breed on carcass traits and meat quality variables.

RESULTS AND DISCUSSION

Live animal, carcass and meat quality: Breed has no significant effect (Table 1) on slaughter weight at 13 months of age. Johnson *et al*. (1995) reported that breed type had no (P>0.05) apparent influence on the yield of dressing percentage. All the parameters except dressing percentage and fore cannon were nonsignificant (P<0.05) among Barbari, Marwari and Jamunapari breeds. Among the indicators of body frame size, all measurements were marginally higher in Jamunapari breed except, the height at withers. In the present study Marwari pure bred goats had moderately (P>0.05) higher height than Jamunapari. Saini *et al*. (1988) reported that the growth rate of Barbari and Jamunapari goats during 6–9 months of age, under semi-intensive system of management was moderately lower than intensively reared kids. Paramasivam *et al*. (2002) reported that the heart girth (51 cm) and paunch girth (62 cm) were significantly higher (P<0.01) in 11-month-old Barbari kids reared under semi-intensive system than in the intensive system.

Table 1. Slaughter and carcass characteristics of three Indian goat breeds

Traits	Barbari	Marwari	Jamunapari
Slaughter weight (kg)	25.57±1.73	24.60±0.20	26.84±1.98
Empty body weight (kg)	21.44±1.43	19.86±0.38	22.00±1.64
Body measurements (*cm*)			
Height	63.14±2.46	68.00±1.73	66.71±2.53
Body length	65.43±2.02	65.00±1.15	69.14±2.33
Heart girth	63.14±2.46	68.00±1.73	66.71±2.53
Paunch girth	68.00±2.31	66.33±1.67	68.00±1.54
Loin width	12.79±0.43	13.00±0.00	13.30±0.35
Leg circumference	30.71±0.68	29.33±0.33	31.57±1.33
Carcass weight (kg)	11.54±0.85	10.00±0.36	12.21±1.13
Dressing percentage%	45.11±1.61[a]	40.66±1.60[b]	45.14±1.00[a]
Dressing percentage[a]%	53.70±1.33[ab]	50.31±0.84[b]	55.09±1.27[a]
Fore quarter (kg)	6.70±0.54	5.57±0.22	6.89±0.61
Hind quarter (kg)	4.84±0.33	4.43±0.15	5.31±0.52
Carcass measurements			
Chest circumference (cm)	59.04±1.36	64.00±1.15	62.93±1.23
Loin width (cm)	11.04±0.46	11.17±0.33	11.39±0.37
Leg circumference (cm)	28.57±0.55	26.83±0.33	29.11±1.34
GR measurement[#] (mm)	1.20±0.07	1.10±0.00	1.34±0.10
Loin eye area (cm^2)	8.45±0.17	7.38±0.09	8.62±0.12
Fat thickness[##]			
Back fat thickness (mm)	1.03±0.03[a]	1.00±0.00[a]	1.35±0.14[b]
Breast fat thickness (cm)	2.24±0.11	2.17±0.09	2.49±0.15
Non carcass components			
Blood,% of SW	4.66±0.20	4.37±0.15	4.39±0.07
Head% of SW	6.95±0.23	7.22±0.09	6.51±0.36
Skin% of SW	8.58±0.45	8.01±0.12	8.37±0.25
Fore cannon (g)	0.31±0.02[b]	0.38±0.02[a]	0.39±0.02[a]
Hind cannon (g)	0.25±0.02	0.29±0.01	0.30±0.02
Lung trachea (kg)	0.31±0.06	0.28±0.02	0.38±0.04

Row bearing different superscripts differ significantly (P<0.05); [#]GR measurement is the soft tissue thickness, measured 11 cm from midline on 12th rib of the carcass; [##] fat thickness measured with digital vernier caliper; [a] on empty body weight basis; SW, slaughter weight.

Jamunapari had little heavier (P>0.05) carcass weight and higher (P<0.05) dressing percentage (Table 1). Marwari breed had the lowest among all the breeds. Johnson *et al.* (1995) reported similar results in the goat breeds of United States of America (USA). Breed type had no effect (P>0.05) on carcass measurements and fat thickness. Marwari had the lowest back fat (1.00 mm) and breast fat (2.17 cm) thickness. Johnson *et al*. (1995) reported that breed type had no (P>0.05) influence on many of the quality indicating characteristics of the lean, including skeletal maturity, lean maturity, flank firmness, flank streaking, feathering, marbling, lean texture and firmness. Further, carcass and leg conformation were

Table 2. Variety meats, fat distribution and cut yield of three India goat breeds

Traits	Barbari	Marwari	Jamunapari
Variety meats			
Testes (g)	145.71±24.11	143.33±3.33	148.57±12.42
Pancreas (g)	35.71±4.29	30.00±5.77	32.86±4.20
Spleen (g)	52.14±8.30	43.33±8.82	47.14±3.60
Kidney (g)	137.86±52.98	80.00±5.77	95.00±4.76
Liver (g)	425.71±68.41	400.68±11.23	455.71±23.98
Heart (g)	94.29±13.99^{b}	153.33±5.77^{a}	120.00±10.96^{ab}
Fat distribution			
Cod fat (g)	42.14±7.14	33.33±18.56	74.29±30.09
Omental fat (g)	181.43±39.85	190.00±32.15	220.00±76.03
Kidney fat (g)	135.71±28.86	86.67±6.67	147.14±51.58
Cut-up parts (*kg*) *- left side of the carcass*			
Leg	1.49±0.08	1.47±0.05	1.85±0.17
Loin	0.79±0.05	0.67±0.07	0.82±0.13
Rack	0.83±0.07	0.67±0.02	0.82±0.10
Neck and shoulder	1.55±0.09^{ab}	1.33±0.06^{b}	1.78±0.12^{a}
Breast and shank	1.02±0.02	0.81±0.02	1.13±0.15

Row bearing different superscripts differ significantly (P<0.05).

not affected by breed type. Breed type did not (P>0.05) influence actual or adjusted fat opposite the rib eye or estimated kidney, pelvic and heart fat. Loin eye area indicates better muscle growth in all the kids under semi-intensive management system at month 13. Loin eye area was moderately higher (P>0.05) in Jamunapari (8.62 cm^2) followed by Barbari (8.45 cm^2) and Marwari (7.38 cm^2). Pal and Agnihotri (1999) reported that heavier goat carcass having higher (P<0.05) loin eye area produced significantly higher (P<0.05) lean and carcass components (P<0.05).

Variety meats did not show much difference among different breeds (Table 2). Amin *et al*. (2000) reported that proportionate weights of kidneys, respiratory organs and heart were highest in Random Bred Black Bengal and they were inconsistent in the other two groups (Jamunapari×Black Bengal and Black Bengal). Results in the present studies are in contrast with the findings of Wahid *et al*. (1985) who reported that breed type affected weight of heart, lungs, liver and testis in goats. The cod fat, omental fat and kidney fat weight were moderately higher (P>0.05) in Jamunapari kids. The primal cuts weights were also not significantly different among breeds. However, the weight of cut portion of leg, loin, rack and breast and shank was marginally higher in Jamunapari kids at 13 months age under semi-intensive system. Use of energy intake in terms of different deposits and fat tissues showed that the goat would have a greater tendency to deposit fat tissues in the abdomen and less in muscle. The increase in carcass primal cuts is directly related to carcass weight. Abdullah and Musallam (2007) reported that the shoulder cuts of feedlot Black goats had higher weight, while Limea *et al*. (2009) reported that shoulder cut represent highest portion in the carcass of Caribbean kids fed on concentrate diet.

Chemical composition: There were no significant differences between breeds and muscles in composition of 3 Indian goat breeds (Table 3). Proximate composition in the present study was similar to that reported by Agnihotri *et al*. (2006) in Barbari goat kids. In the present study, LD muscle had lower extractable fat than SM muscle. In general, extractable fat of LD muscle was lower than reported by others for different goat breeds (Rao *et al*. 2003). The protein (19–21 g/100 g) and fat (1.98–2.64 g/100 g) contents recorded were similar to the findings reported by Dutta *et al*. (2009) in Barbari kid and Rao *et al*. (2003) for Indian local breed.

Physicochemical quality of goat meat: The muscles had pH in the range of 5.67 to 5.79 while SM muscle had higher ultimate pH in all the 3 breeds compared to LD muscle (Table 3). Marwari goats had marginally higher ultimate pH values than those from Barbari and Jamunapari goats. Variation in ultimate pH among the 3 muscles might be attributed to pattern of energy metabolism during both antemortem and postmortem (Swatland 1982). The ultimate muscle pH in Barbari, Marwari and Jamunapari male kids is comparable to that reported by other authors for same muscles in Barbari goats (Agnihotri *et al.* 2006, Dutta *et al.* 2009) and in Omani goats (Kadim *et al*. 2003).

There was no significant effect of breeds on water holding capacity. *Semimembranosus* (SM) muscle showed comparatively higher water holding capacity, though the difference was not significant. Water holding capacity values ranged from 22 to 24% among the kids of different breeds and SM muscle had higher water holding capacity than *Longissimus dorsi* (LD). A similar range of water holding capacity for the Barbari breeds was reported by Dutta *et al*. (2009). Mueller *et al*. (1985) did not find any major differences in water holding capacity between kids raised in similar conditions. Increased cooking loss percentage is a reflection of the decreased water-holding capacity (increased expressed juice) associated with meat of high ultimate pH (Bouton *et al.* 1971). Percentage of cooking loss from the 3 breeds ranged from 36.0 to 38.0%. LD muscle showed marginal higher cooking loss than SM. The range of cooking loss reported in the study was in agreement with the range reported by Verma and Sahoo (2000).

In the present study, breed showed no significant effect on Warner–Bratzler shear force (WBSF) values for any of the muscles evaluated. Similar values were reported by Babiker *et al*. (1990) and Smith *et al*. (1978). Shear force values reported in literature vary considerably, depending on factors such as the treatment of the animals prior to slaughter and of the carcass post-mortem, the sampled muscle and method of sample preparation (Webb *et al.* 2005).

Barbari goat muscles had lower mean cholesterol content than Jamunarpari and Marwari goats. LD muscle had lower cholesterol concentration compared to SM muscle in all the 3 breeds. Park *et al.* (1991) reported goat LD and *biceps*

Table 3. Physico-chemical and sensory characteristics* of meat from 3 goat breeds

Parameters	Muscle	Barbari	Marwari	Jamunapari	SEM
Physico-chemical attributes					
Moisture (%)	LD	75.34	74.23	74.76	0.23
	SM	74.08	73.12	72.39	0.21
Protein (%)	LD	19.34	19.21	20.01	0.13
	SM	19.76	19.87	20.23	0.15
Fat (%)	LD	2.01	2.35	1.98	0.08
	SM	2.34	2.64	2.43	0.06
pH	LD	5.67	5.71	5.63	0.02
	SM	5.72	5.79	5.69	0.02
Water holding capacity (%)	LD	23.13	22.87	24.01	0.23
	SM	24.41	23.54	24.78	0.34
Cooking loss (%)	LD	37.99	38.59	36.89	0.54
	SM	36.42	38.02	36.24	0.56
Shear force (kg/cm^2)	LD	5.6	6.2	6.4	1.32
	SM	5.8	6.4	6.5	1.46
Cholesterol (mg/100 g)	LD	68.38	73.45	71.76	0.68
	SM	69.52	75.89	73.06	0.66
Sensory attributes					
Flavour	LD	6.37	6.29	6.01	0.11
	SM	6.42	6.33	6.12	0.12
Juiciness	LD	6.45	6.42	6.17	0.14
	SM	6.56	6.51	6.25	0.12
Tenderness	LD	6.21	6.36	6.46	0.15
	SM	6.32	6.58	6.55	0.21
Overall acceptability	LD	6.66	6.34	6.17	0.10
	SM	6.71	6.38	6.21	0.13

*Based on 9 point scale where 9,extremely desirable; and 1, extremely undesirable; n, 15.

LD, *longissimus dorsi*; SM, *semimembranosus;* n,6; SEM, standard error mean.

femoris muscle had 57.80 and 69.50 mg/100 respectively. Werdi Pratiwi *et al*. (2006) observed that LD muscle had lower total cholesterol compared to *biceps femoris* and *infraspinatous* muscle. The range of cholesterol values in the present study were well within the range of <90 mg/100 gm, which is considered to be moderate and similar values were reported by Agnihotri *et al.* (2006).

Sensory evaluation: Sensory evaluation of the cooked LD and SM muscle is presented in Table 3. No significant difference was found between the breeds and muscles with regard to meat tenderness and flavour. Sensory tenderness score followed the similar trend as shown in instrumental texture measurement. Juiciness was higher in SM muscle compared to LD muscle which might be due to its higher total fat content as fat has positive relationship with juiciness and overall acceptability. Swan *et al*. (1998) reported that breed did not affect flavour and juiciness of cooked goat LD muscle. Sensory evaluation of the 2 muscles of the 3 breeds reared under similar management and feeding condition revealed that meat from Barbari received better overall acceptability scores over other 2 breeds.

Under the explained set of experimental conditions, breed had little influences on carcass traits such as carcass weight, dressing percentage, variety meat and cut yield under semi-intensive management system. All the breeds had comparable dissectible fat from different depot. Meat quality attributes were not significantly influenced by breed and type of muscle. Goat meat is a low-fat, nutritious red meat alternative for health conscious consumers owing to its low cholesterol content. Sensory evaluation showed no significant difference in sensory attributes. Barbari breed received higher overall acceptability scores than other breeds. Goat producers can use this information to improve marketing of goat carcass or meat.

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