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Quality and fatty acid profile of high and low value cuts of Barbari goat meat

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ABSTRACTS

Quality characteristics and fatty acid profile of muscles from high (*Longissimus dorsi*) and low value (*Supra spinatus*) goat meat cuts were investigated followed by comparison of various physicochemical properties and fatty acid profile. Nuggets were prepared with meat from these cuts and their quality and fatty acid profile were also compared. Fat and salt soluble proteins were significantly higher in muscle from low value (LV) cut while in muscle from high value (HV) water soluble proteins were high. Fatty acid profile of both the muscles did not differ significantly, however, saturated fatty acids were relatively high in LV muscle and unsaturated fatty acids in HV muscle. Ash content in emulsion and moisture level in nuggets were higher in nuggets from LV cut. Significant differences were recorded in some fatty acids composition of the products. Sensory evaluation revealed no significant differences in the various attributes of both the products.

Key words: Fatty acid profile, Goat meat, High value cut, Low value cut, Nuggets, Physico-chemical properties

Muscle has unique physical and chemical properties, which when known and understood, can allow the development of value added products in a better way. These properties are relevant to the processing conditions and quality of the finished products like composition, protein matrix for binding of water and fat, cooking yield and texture. The fatty acid composition of fats determines its degree of saturation, and therefore, significantly affects its quality. Fatty acids, especially oleic (C18: 1) and linoleic acid (C18: 3) also influence meat flavour (Crouse *et al*. 1982). Quality evaluation of the muscles from high and low value goat meat cuts could be helpful to understand any biochemical differences between two cuts. There are no reports on the comparison of physico-chemical properties and fatty acid profile of Barbari goat meats from different cuts. Thus the present study was conducted to evaluate the characteristics of 2 muscles from high and low value Barbari goat meat cuts as well as to compare different quality parameters of goat meat nuggets prepared with meat from these cuts.

MATERIALS AND METHODS

Animals, feeding and detail study

Male weaner Barbari kids (34), 5-month old and weighing 10.54 kg were allowed to graze or browse 8 h daily and were provided the concentrate mixture (CP 14%, TDN 60%) @2% of body weight. All the kids had access to clean drinking water twice daily. Goats were slaughtered at the age of 18 months after 16–18 h fasting with *ad lib.* supply of water. Dressed carcasses were weighed within 1 h (hot carcass weight) and then chilled for 24 h at 4°C and weighed again (cold carcass weight). *Longissimus dorsi* from loin cut (high value) and *Supra spinatus* muscle from neck and shoulder cut (low value) were removed from both sides of the carcasses for quality evaluation and product preparation. Goat meat nuggets were prepared with meat from HV and LV cuts.

pH, water holding capacity (WHC), soluble proteins and total pigments: Proximate composition of muscle was evaluated as per AOAC (1995). Muscle and products pH was determined by blending 10 g of sample with 50 ml of distilled water using a digital pH meter. Water-holding capacity was measured as per Sierra (1973). Soluble proteins in meat samples were determined according to Ryu *et al*. (2005). Method used by Hornsey (1956) was adopted for measurement of total pigments.

Calorific value and fatty acid profile: Gross energy of samples was determined by using digital oxygen bomb calorimeter. A direct and simple method of O'Fallon *et al*. (2007) was followed for fat extraction and preparation of fatty acid methyl esters (FAME) of meat and nuggets. The fatty acid composition of the FAME was determined by capillary GC on a CP-6173, 60 m × 0.25 mm × 0.20µm capillary column installed on a gas chromatograph fitted with automatic sampler, integrator and flame ionization detector. The initial oven temperature was 120°C, held for 5 min, subsequently increased to 240°C @ 2°C/min, and then held for 60 min. Nitrogen was used as the carrier gas at a flow rate of 1 ml/min. Both the injector and the detector were set at 260°C. The split ratio was 30: 1. Fatty acids

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Table 1. Effect of different cuts on the physicochemical characteristics of Barbari goat meat (mean ±SE)

Parameters	High value	Low value	Significance
pH	5.67±0.07	5.78±0.06	NS
Moisture (%)	76.43±0.26	74.83±0.30	NS
Protein (%)	20.18±0.26	20.78±0.27	NS
Fat (%)	1.38±0.06[b]	2.05±0.16[a]	*
Ash (%)	1.12±0.06	1.06±0.050	NS
Water soluble proteins (mg/g)	74.23±1.68[a]	62.84±2.04[b]	**
Salt soluble proteins (mg/g)	130.46±3.03[b]	139.31±2.91[a]	*
Total soluble proteins (mg/g)	204.70±3.63	202.15±4.32	NS
Water holding capacity (%)	68.42±1.55	66.53±0.89	NS
Total pigments (ppm)	122.57±6.56	132.82±9.11	NS
Energy (Kcal/100g)	132.62±4.13	145.15±3.86	NS

*P<0.05; n=24; NS, Nonsignificant.

were identified by comparing their retention times with the fatty acid methyl standards and were expressed as percentage of total fatty acids.

Quality evaluation of nuggets: Emulsion stability and cooking yield were determined as per standard procedure. Textural properties of nuggets were evaluated using the texturometer (Bourne 1978) was performed using central cores of 3 pieces of each sample (1.5 cm^3) which were compressed twice to 80% of the original height. A crosshead speed of 2 mm/sec was used to determine different parameters. A 10– member experienced panelists evaluated goat meat nuggets organoleptically using 8 points descriptive scale with slight modification where eight (8) denoted extremely desirable and one (1) denoted extremely poor. The panelists were asked to evaluate the samples on the sensory evaluation proforma for appearance, flavour, juiciness, texture and overall acceptability.

Statistical analysis: Data generated in the present study were subjected to t-test (Snedecor and Cochran 1995) for comparing the means to find the effect between muscles using SPSS ver 14. Three trials were conducted for goat meat nugget preparation from low and high value cuts.

RESULTS AND DISSCUSION

Physicochemcial properties of goat meat: There was no significant difference in the pH value (5.67 to 5.78) of both the muscle (Table 1). Muscle pH revealed a better understanding of protein functionality but higher pH meat was darker in colour, which could affect the consumer acceptability. Dhanda *et al*. (1999) found the ultimate pH of *longissmus* muscle in the range of 5.6 to 5.8. Laskar and Nath (1998) reported no significant differences in pH value of either between sexes or between muscle cuts at 24 and 72 h after slaughter. Proximate principles of the muscles from both cuts did not differ significantly except fat content,

Table 2. Effect of cuts on the fatty acid profile (percentage of total fatty acids) of Barbari goat meat (mean ±SE)

Fatty acids	High value	Low value	Significance
Myristic Acid (C14: 0)	1.44±0.27	1.88±0.27	NS
Palmitic Acid (C16: 0)	18.79±1.82	22.06±1.71	NS
Heptadecanoic Acid (C17: 0)	0.89±0.24	1.04±0.15	NS
Stearic Acid (C18: 0)	21.18±2.33	23.24±3.21	NS
Saturated fatty acids (SFA)	*46.27±3.26*	*49.95±3.24*	*NS*
Cis-10–Pentadecanoic Acid (C15: 1)	0.38±0.14	1.09±0.35	NS
Pamitolic Acid (16: 1)	0.41±0.12	0.53±0.14	NS
Cis-10-Heptadecanoic Acid (C17: 1)	1.36±0.43	1.41±0.45	NS
Oleic acid (18: 1n9c)	28.50±3.33	25.04±3.63	NS
Cis-11-Eicosenoic Acid (C20: 1) n9	1.57±0.59	1.26±0.32	NS
Monounsaturated fatty acids (MUFA)	*32.41±3.07*	*30.49±3.13*	*NS*
Linoleic acid (C18: 2) n 6	10.34±1.07	9.06±1.19	NS
Gama linolenic acid (18: 3n6)	1.05±0.95	0.03±0.03	NS
Linolenic acid (C18: 3) n3	1.61±0.60	0.33±0.19	NS
Eicosadienoic acid (C20: 2n6)	1.05±0.95	0.03±0.03	NS
Eicosatrienoic acid (C20: 3)n3	1.24±0.44	1.14±0.45	NS
Arachidonic acid (C20: 4) n 6	4.58±1.27	0.37±0.27	NS
Eicosapentaenoic acid (C20: 5) n3	0.10±0.06	1.31±0.88	NS
Docosahexaenoic acid (C22: 6) n3	1.14±0.35	7.46±4.36	NS
Polyunsaturated fatty acids (PUFA)	*21.24±2.41*	*19.57±3.89*	*NS*
SFA/MUFA	3.17±0.90	2.44±0.78	NS
SFA/PUFA	3.16±0.46	3.71±0.49	NS
PUFA/SFA	0.46±0.27	0.39±0.16	NS
Omega 6 fatty acids (%n-6 PUFA)	16.15±1.95	10.64±1.25	NS
Omega 3 fatty acids (%n-3 PUFA)	4.09±0.84	9.59±4.50	NS
n-6/n-3 ratio	3.95±0.75	1.11±0.83	NS

n=24; NS, nonsignificant.

where muscle from low value cut had significantly higher (P<0.05) fat content (2.05%) as compared to muscle from high value cut (1.35%). Contrary to our result, Park *et al*. (1991) reported 2 % fat content in *longissimus* and *biceps* muscle obtained from goat meat.

There were significant differences (P<0.05) in the protein solubility between the muscles from HV and LV cuts

(Table 1). Water soluble proteins were significantly (P<0.05) higher in muscle from HV cut whereas amount of salt soluble proteins was higher in muscle from LV cut. This result shows that muscle from LV cut possesses better functional properties than muscle from HV cut and it could be more suitable for product processing because of higher salt soluble proteins. The observation of protein solubility in the present study was well within the range reported by Das *et al*. (2011) in *L.dorsi* muscle of Barbari kids. Salt soluble proteins or myofibrilar proteins include myosin, actin and play major role while preparation of meat emulsion due to higher emulsifying and water binding capacities. Water holding capacity (WHC), total pigments and calorific value between the muscles did not differ significantly. However, muscle from LV cut had nonsignificantly higher total pigments and calorific value and water holding capacity with respect to muscle from HV cut. Since there was no significant difference in the pH values between the muscles, difference in the WHC remained non-significant. Laskar and Nath (1998) found that ultimate pH of meat showed a significant positive correlation with WHC. The relationship between pH and WHC has been well established (Warriss *et al*.1999).Total haemiron can reveal information about a muscle's physical appearance (appearance to the eye), which is a major factor in consumer acceptance. The concentration of these colour pigments is also an important determinant of processed meat colour (Von Seggern and Calkins2005).

Fatty acid profile of goat meat: Fatty acid composition of meat lipids is a major determinant of the meat quality including its nutritive value (Kazala *et al*. 1999). Saturated fatty acids (SFAs) have highest contribution (46.27 to 49.95%) towards total fatty acid of goat meat (Table 2). This is followed by monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) imparting about 30.49 to 32.41 and 19.57 to 21.24 %, respectively. As far as individual fatty acid is concerned, oleic acid contributed highest (25.04–28.50%) followed by stearic acid (21.18–23.24%) and palmitic acid (18.79–22.06%). According to Mahgoub *et al*. (2002) palmitic (C16: 0), stearic (C18: 0) and oleic (C18: 1) acids comprised the largest proportions of FA in the muscle tissue (approximately 80%) with oleic acid being the most abundant. Potchoiba *et al*. (1990) found that these fatty acids constituted 74% in kids fed milk or concentrates with oleic acid (C18: 1) being the most abundant (28 to 50.53%). Johnson *et al*. (1995) found that C: 16, C18 and C: 18: 1 constituted 81–84% in broiled goat leg meat. Similarly, Park and Washington (1993) found 76.7 and 81.4% for the 3 FA in *Biceps femoris* and *Longissimus dorsi* muscle of French Alpine goats.

Fatty acid profile of both the muscle did not show any significant difference (Table 2). Saturated fatty acids in muscle from LV cut were slightly higher than HV counterpart. Among SFAs, palmitic acid (C16: 0) and stearic acid (C18: 0) were higher in LV cut muscle Dhanda *et al*. (1999) reported that oleic acid may reach up to 43% in muscle samples of some goat breeds. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) content in muscle from high value cut were slightly higher in comparison to muscle from LV cut. Among PUFAs linoleic acid (18: 2), linolenic acid (C18: 3), eicosadienoic acid (C20: 2), arachidonic acid (C20: 4) were observed higher in HV cut muscle while in LV cut, percent eicosapentaenoic acid (C20: 5) and docosahexaenoic acid (C22: 6) were high.Mahgoub *et al*. (2002) reported that Jebel Akhdar goat muscle and fat tissue contained around 4% of linoleic (C18: 2) acid. This essential fatty acid has recently been a subject of intensive research as an anti-carcinogenic factor (Banskalieva *et al*. 2000). Linoleic, linolenic and arachidonic (formed in animal tissue from linoleic acid) cannot be synthesized in the body and has to be taken from the diet.

Omega-6 (n-6) and omega-3 (n-3) polyunsaturated fatty acids (PUFA) are precursors of potent lipid mediators, termed eicosanoids and also play an important role in the regulation of inflammation. The percent of omega-3 fatty acids was found higher (P>0.05) in muscle from LV cut whereas, in HV cut, higher amount of omega-6 fatty acids was noticed. The ratio of SFA: MUFA, SFA: PUFA and PUFA: SFA were 2.44–3.17, 3.16–3.71 and 0.39–0.46 and were almost similar for both the muscles. Park and

Table 3. Chemical composition of nuggets prepared with meat from high value and low value cuts (mean ±SE)

Parameters	High value	Low value	Significance
Emulsion			
pH	6.12±0.04	6.18±0.02	NS
Stability (%)	86.71±1.81	86.24±1.62	NS
Moisture (%)	69.27±0.25	68.48±0.36	NS
Protein (%)	13.83±0.37	13.45±0.17	NS
Fat (%)	9.69±0.22	10.41±0.43	NS
Ash (%)	2.18±0.07[b]	2.24±0.06[a]	*
Nuggets			
pH	6.22±0.02	6.30±0.03	NS
Yield (%)	94.15±0.60	93.59±0.74	NS
Moisture (%)	67.11±0.23[b]	68.38±0.44[a]	*
Protein (%)	14.79±0.36	13.85±0.22	NS
Fat (%)	10.89±0.18	11.13±0.39	NS
Ash (%)	2.18±0.03	2.20±0.04	NS

*P<0.05; n=9; NS, nonsignificant.

Table 4. Textural properties of nuggets with meat from high and low value cuts (mean ±SE)

Parameters	High value	Low value	Significance
Hardness	66.80±2.49	69.79±3.24	NS
Fracturability	23.90±4.86	22.98±3.40	NS
Adhesiveness	–0.027±0.009	–0.023±0.006	NS
Springiness	0.75±0.02	0.77±0.01	NS
Cohesiveness	0.33±0.01	0.32±0.02	NS
Gumminess	22.16±1.20	22.38±1.01	NS
Chewiness	16.79±1.22	17.15±0.79	NS

n=9; NS, nonsignificant.

Table 5. Fatty acid profile (percentage of total fatty acids) of goat meat nuggets from high and low value cuts (mean±SE)

Parameters	High value	Low value	Significance
Myristic acid (C14: 0)	0.873±0.05	1.627±0.62	NS
Palmitic acid (C16: 0)	9.946±0.15	10.582±1.00	NS
Heptadecanoic (c17: 0)	0.727±0.04[a]	0.544±0.02[b]	*
Stearic acid (c18: 0)	9.953±0.11	9.392±0.19	NS
Saturated fatty acids (SFA)	24.08±0.48	25.80±1.67	NS
Pentadecanoic acid (C15: 1)	0.103±0.05[b]	0.218±0.07[a]	*
Pamitolic acid (16: 1)	0.656±0.02	0.676±0.07	NS
Cis-10-Heptadecanoic acid (C17: 1)	0.575±0.04[a]	0.349±0.01[b]	*
Oleic acid (18: 1n9c)	20.163±0.19[a]	17.015±0.62[b]	**
Eicosenoic acid (C20: 1) n9	7.758±0.14	7.871±0.31	NS
Monounsaturated fatty acids (MUFA)	29.42±0.24	26.35±0.45	NS
Linoleic acid (C18: 2) n 6	12.797±0.24	12.625±0.66	NS
Linolenic acid (C18: 3) n3	2.591±0.54	2.878±0.34	NS
Arachidonic acid (C20: 4) n 6	28.317±0.36	28.757±1.52	NS
Docosadienoate (C22: 2)	1.037±0.05	1.435±0.31	NS
Eicosapentaenoic acid (C20: 5) n 3	0.122±0.04	0.209±0.02	NS
Docosahexaenoic acid (C22: 6) n 3	0.207±007	0.174±0.06	NS
Polyunsaturated fatty acids (PUFA)	46.50±0.44	47.84±2.07	NS
SFA/ MUFA	0.977±0.05	0.918±0.02	NS
SFA / PUFA	0.548±0.06	0518±0.02	NS
PUFA / SFA	1.89±0.18	1.93±0.05	NS
Omega 6 fatty acids (% n-6 PUFA)	41.19±0.55	41.47±1.73	NS
Omega 3 fatty acids (% n-3 PUFA)	2.92±0.49	3.23±0.27	NS
n6/n3 PUFA	16.27±4.26	13.12±1.32	NS

*p<0.05; n=9; NS, nonsignificant.

Washington (1993) reported that PUFA: SFA ratio in *longissimus dorsi* muscle was in the range of 0.31–0.37. The ruminant meat generally has low PUFA: SFA ratio and average ratio in goat muscle was between 0.16 and 0.49 (Banskalieva *et al*. 2000). Although PUFA may have beneficial effects on blood cholesterol, there is concern that some meats may have an excessively high ratio of n-6: n-3 PUFA (James *et al*. 1992). In accordance, a diet high in such meat could lead to a tissue membrane imbalance in the ratio of n-6: n-3 PUFA. The ratio of omega-6: omega-3 in the goat meat found between 1.11 and 3.95 and this ratio was higher in the muscle from high value cut.

Quality of goat meat nuggets: The chemical composition of goat meat nuggets from HV and LV cuts did not differ significantly except fat and ash content in emulsion and moisture content in nuggets (Table 3) which were higher for the product from LV cut. High fat content in the goat meat nuggets prepared from LV cut could be attributed to significantly high fat content in fresh meat. Significantly high moisture content in the product with LV cut could be due to relatively high batter pH resulting in more water binding capacity in meat batter. According to Qiao *et al*. (2002) higher pH is generally more associated with higher meat moisture content. Judge *et al*. (1989) also positively correlated the muscle pH and water holding capacity. Texture profile analysis of both the products showed almost similar textural properties (Table 4). However, product from LV cut had marginally higher hardness value.

Table 6. Sensory attributes of goat meat nuggets with meat from high and low value cuts (Mean ±SE)

Parameters	High value	Low value	Significance
Appearance	7.18±0.08	6.93±0.15	NS
Flavour	6.98±0.14	6.95±0.17	NS
Juiciness	7.00±0.15	6.97±0.16	NS
Texture	7.10±0.12	6.94±0.18	NS
Overall palatability	7.23±0.13	7.10±0.16	NS

n=30; (1=poor and 8=excellent); NS, nonsignificant.

Fatty acid profile of goat meat nuggets prepared from HV and LV cuts were significantly different for some fatty acids (Table 5). Oleic acid, heptadecanoic acid and its cis-10 form were significantly (P<0.05) high in HV nuggets. Pentadecanoic acid content was significantly (P<0.05) high in LV nuggets and all other fatty acids were nonsignificantly different. PUFA's (46–48 %) contribution is high in the nuggets profile followed by MUFA (26–29 %) and SFA (24–26 %). Comparing the goat muscle fatty acid profile, nuggets profile is in reverse trend. Among the SFA's, arachidic acid is a new entry in the nuggets profile and might be from the vegetable oil source. MUFA content of LV muscle (30 %) is reduced in LV nuggets (26 %) mainly due to the reduction in the oleic acid content. PUFA content are significantly high in nuggets than from the goat meat muscle mainly by the contribution of linoleic and arachidonic acid. Omega 6 fatty acids contents are significantly high (41 %) in the nuggets than from the goat muscle (10–16 %). Therefore, the n6/n3 ratio is also high in goat meat nuggets. The significant changes in the nuggets fatty acid configuration than that of high and low value muscles could be attributed to incorporation of vegetable oil in the products while processing. Organoleptically, both the products behaved similar and no significant differences were observed in the various sensorial parameters of the products (Table 6). Products prepared from HV and LV cuts were rated as very good (score more than 7) by the panelists.

Our results indicated that major physicochemical characteristics of *Longissimus dorsi* and *Supra spinatus* muscle of Barbari goat did not show significant differences. However, fat content and salt soluble proteins are present in significantly higher amount in low value cut while high value cut contains higher value of water soluble proteins.

This indicates that meat from low value cuts is more suitable for product processing. The differences in fatty acid profile of both the muscles were non-significant. However, muscle from low value cut contains slightly higher omega-3 fatty acid while omega-6 fatty acids present in higher amount in muscle from high value cut. High quality of meat nuggets could be prepared by utilizing meat from low value cuts and meat processor may earn high return.

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