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Effect of Age on Physico-Chemical and Nutritional Composition of Indigenous Kodiadu Goat Meat

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ABSTRACT

The study was conducted to study the effect of age *viz.*, young (6-9 months) and adult (2 years) on physico-chemical characteristics, proximate composition, amino acid, fatty acid and cholesterol content of Kodiadu goat meat. The *Longissimus dorsi* muscle was collected from these animals and the physico-chemical characteristics *viz.*, pH, water holding capacity, instrumental colour, muscle fibre diameter, myofibrillar fragmentation index and nutritional composition *viz.*, proximate composition, amino acid, fatty acid and cholesterol content of two different age groups were studied. The results obtained in this study indicated that the meat of young goat had higher water holding capacity, Lightness (L*), moisture, threonine, glutamic acid, linoleic acid, linolenic acid, ecosapentaenoic acid, docosohexanoic acid, total poly unsaturated fatty acids and total P/S than adult. Based on the quality and nutritional composition it was concluded that meat of young animal (6-9 months) had superior meat quality than the meat of adult animals.

Keywords: Physico-chemical characteristics, Kodiadu goat meat, *Longissimus dorsi*, meat quality, nutritional composition.

Meat is an excellent source of good quality animal protein which provides all the essential amino acids and various micronutrients in proper proportion to human being (National Health and Medical Research council, 2006). It is also a valuable source of B-complex vitamins including thiamin, riboflavin, niacin, biotin, pyridoxine, pantothenic and cyanocobalamine and minerals like iron, zinc, selenium and phosphorus (Pereira and Vicente, 2013). Consumers are now more focused on the quality and nutritional characteristics of foods including meat and meat products and they are increasingly focusing on their eating habits and nutrient intake as well as food safety (Garnier *et al.*, 2003).

Detailed knowledge on the composition of meats is necessary to understand the nutrients in meat. Goat meats are used for the consumption since very beginning of human civilization. Goat meat has a species-specific flavour and aroma, which differs from that of sheep meat and is a good source of desirable fatty acids. Goat deposits

moderate amounts of polyunsaturated fatty acids than other ruminants (Webb *et al.*, 2005).

So far several studies on the nutrient content of meat from different livestock had been made in the Western countries. In tropical country like India where the meat is known for its leanness, specific studies on the nutrient content of the indigenous breeds are meagre. Meat obtained from indigenous breeds also contains omega-6 and omega-3 fatty acids in the proper ratio, along with higher amount of antioxidants. However, there is not much of research to substantiate the claims and there exists a wide gap in the knowledge on various aspects of nutritional composition of meat from these animals. Among the different goat breeds of Tamil Nadu the Kodiadu breed is distributed in southern agro climatic zone of the state and are generally grazed and not stall fed. Hence the present study was undertaken to study the various meat quality characteristics of Kodiadu goat at different ages, so as to determine the optimum age



for marketing thereby making the farming of these animal economically sustainable.

MATERIALS AND METHODS

Experimental Design

A total number of twelve male Kodiadu goats of two different age groups *viz.*, young (6 - 9 month) and adult (2 years) were selected based on the dentition from the native tract, Vilathikulam and Tuticorin of Tamil Nadu and meat from these animals were collected from the municipal slaughter houses for this study. The ante mortem inspection of animals was carried out by municipal veterinary officer. Each age group consisted of 6 animals.

Meat samples

Samples were taken from the *longissimus dorsi* muscle at the level of 13th rib (Alonso *et al.*, 2009). The collected meat samples were packed in clean polyethylene bag and placed in the thermocole box with ice and immediately transported to the Department of Meat Science and Technology, Madras Veterinary College, Chennai.

Analytical procedures

The pH was measured using a digital pH meter (Digisun electronic system, model: 2001) as per the method outlined by Troutt *et al.* (1992b) and the Water holding capacity was assessed by adopting the filter paper press method with certain modifications (Grau and Hamm, 1957). Muscle fibre diameter was measured according to the method outlined by Jeremiah and Martin (1982). Myofibrillar fragmentation index (MFI) was determined by "Virtis homogeniser 45" (Virtis Company, Gardinar, New York, USA) with slight modifications (Davis *et al.*, 1980). Colour of the sample was tested using Hunter lab Mini scan XE plus Spectro colorimeter (Model No. 45/O-L, Reston Virgenia, USA) with geometry of diffuse/80 (sphere - 8mm view) and an illuminant of D₆₅ and 10° observer (Bindu *et al.*, 2007). Proximate composition *viz.*, moisture, protein, fat and total ash content of meat samples were analyzed by following the standard procedure (AOAC, 1995). Amino acid and fatty acid content of meat was estimated by Chromatography (Bruckner *et al.*, 1991) and by Standard hydrolysis procedure (Fountoulakis and

Lahm, 1998; Palmquist and Jenkins, 2003) with slight modifications respectively. Cholesterol content was determined using cholesterol test kit (Recombigen Pvt Ltd., India) except that instead of blood serum, lipid extract was prepared (Folch *et al.*, 1957) and the cholesterol content was estimated as per the method described by Wybenga *et al.* (1970).

Statistical analysis

The data obtained in the present study on young and adult age groups of Kodi adu goat meat was analysed by unpaired t-test using IBM® statistical package for social sciences 20.0 for MS-Windows®.

RESULTS AND DISCUSSION

Physico-chemical characteristics

The physico-chemical characteristics of young and adult age groups of Kodiadu goat meat are summarized in Table 1 and it revealed that there was highly significant difference (P<0.01) in the pH, muscle fibre diameter, myofibrillar fragmentation index and redness and a significant difference (P<0.05) in the yellowness scores between two age groups of Kodiadu goat meat. It was evident that with the increase in the age, the mean pH value also increased, which was in concurrence with results of Marichal *et al.* (2003) in goats and Boni *et al.* (2010) in quail.

Table 1. Physico-chemical properties of young and adult age groups of Kodiadu goat meat (Mean ± SE)

Parameters	Young	Adult	t- value
pH	6.41 ± 0.02	6.59 ± 0.02	6.42**
WHC (cm ²)	2.03 ± 0.06	2.17 ± 0.06	1.53NS
Muscle fibre Diameter (µm)	70.43 ± 0.50	85.33 ± 1.11	6.62**
MFI	869.17 ± 1.54	986.17 ± 1.54	53.84**
Instrumental colour			
Lightness (L*)	46.55 ± 1.59	43.80 ± 0.78	1.55NS
Redness (a*)	10.98 ± 0.17	13.18 ± 0.44	4.69**
Yellowness (b*)	11.84 ± 0.46	13.69 ± 0.45	2.87*

n = 6, means bearing different superscripts differ significantly. * = significant (P<0.05), ** = highly significant (P<0.01), NS = Non - significant (P>0.05).

However, contrary to the findings of this study a non-significant decrease in pH with increase body weight in Kanniadu goat has been reported (Sivakumar, 2003).

Water holding capacity of meat samples decreased non significantly with the increase in the age of the animals suggesting that animals slaughtered at 6-9 months of age have better juiciness compared to older animals since water holding capacity of meat is closely related to tenderness and juiciness (Lawrie, 1985). Similarly a decrease in WHC with increase in age has been reported in buffaloes (Kandeepan *et al.*, 2009a) and in goat (Sivakumar, 2003).

Muscle fiber diameter was significantly ($P<0.01$) higher in adult goat meat than young goat meat and it could be due to increased age and maturity. Negative correlation has been established between muscle fiber diameter and tenderness of meat (Kandeepan *et al.*, 2009a). The results are in agreement with the findings of Romans *et al.* (1965) in beef and Appa Rao *et al.* (2009) in carabeef.

Myofibrillar fragmentation index (MFI) is an accurate index for tenderness and is a useful indicator of the extent of proteolysis (Olson *et al.*, 1976). The results revealed that there was a highly significant ($P<0.01$) increase in myofibrillar fragmentation index with higher values in adult goat meat as compared to young goat meat. Similar results were observed in carabeef (Kandeepan *et al.*, 2009) and they opined that animal age has shown to have more influence on tenderness attributes than sex of the animal (Huff and Parrish, 1993).

The meat of adult goat had significantly lower lightness (L^*) value ($P>0.05$), higher redness (a^*) value ($P<0.01$) and yellowness (b^*) value ($P<0.05$) than young. This phenomenon indicates that goat meat, just like other red meats, becomes darker and redder with increase in age, which is mainly due increase in concentration of myoglobin pigment with age (Lawrie, 1991). Similar to the findings of this study an inverse correlation was observed in lightness and myoglobin content with increasing age in the meat of goats (Dhanda *et al.*, 1999b) and sheep (Gardner *et al.*, 2007). The muscle pH and meat colour are correlated, higher the muscle pH darker the meat whereas lower muscle pH values are associated with lighter color of meat (Richardson and Mead, 1999) and the results obtained in this study also indicated higher pH and redness (a^*) in adult goat meat.

Nutritional composition

The proximate composition of young and adult age groups of Kodiadu goat meat are summarized as mean \pm S.E in Table 2 and it revealed that the meat of adult goat had significantly ($P<0.01$) lower moisture and higher protein,

Table 2. Proximate composition (%) of young and adult age groups of Kodiadu goat meat (Mean \pm SE)

Parameters	Young	Adult	t- value
Moisture	75.85 \pm 0.11	74.63 \pm 0.15	6.73**
Protein	20.71 \pm 0.13	21.48 \pm 0.11	4.56**
Fat	2.48 \pm 0.12	2.79 \pm 0.04	2.41**
Total Ash	0.96 \pm 0.01	1.10 \pm 0.02	6.07**

n = 6, means bearing different superscripts differ significantly.
** = highly significant ($P<0.01$).

Table 3. Amino acid content (g/100 g of meat) of two age groups of Kodiadu goat meat (Wet basis) (Mean \pm SE)

Amino acid (g/100 g of meat)	Young	Adult	t- value
Essential amino acids			
Arginine	0.92 \pm 0.02	1.18 \pm 0.03	7.15**
Histidine	0.46 \pm 0.02	0.72 \pm 0.02	9.91**
Isoleucine	0.81 \pm 0.03	0.89 \pm 0.03	1.85 ^{NS}
Leucine	1.34 \pm 0.03	1.62 \pm 0.03	6.38**
Lysine	1.06 \pm 0.04	1.49 \pm 0.02	9.46**
Methionine	0.22 \pm 0.01	0.25 \pm 0.02	1.32 ^{NS}
Phenylalanine	0.72 \pm 0.03	0.77 \pm 0.02	1.72 ^{NS}
Threonine	1.18 \pm 0.03	0.87 \pm 0.02	8.02**
Valine	0.80 \pm 0.03	0.91 \pm 0.03	2.72*
Non-essential amino acids			
Alanine	1.11 \pm 0.05	1.23 \pm 0.04	1.61 ^{NS}
Aspartic acid	1.27 \pm 0.03	1.64 \pm 0.03	8.79**
Glutamic acid	2.85 \pm 0.03	2.48 \pm 0.03	8.64**
Glycine	0.71 \pm 0.03	0.92 \pm 0.01	6.53**
Serine	0.70 \pm 0.02	0.74 \pm 0.02	0.94 ^{NS}
Tyrosine	0.61 \pm 0.02	0.64 \pm 0.02	1.18 ^{NS}

n = 6, means bearing different superscripts differ significantly.
* = significant ($P<0.05$), ** = highly significant ($P<0.01$), ^{NS} = Non - significant ($P>0.05$).

**Table 4.** Fatty acid analysis (%) and cholesterol content (mg/100 g) of young and adult age groups of Kodiadu goat meat (Mean \pm SE)

Fatty acid type	Fatty acid (Per cent)	Young	Adult	t - value
(SFA)	Myristic Acid (C14:0)	1.59 \pm 0.08	2.67 \pm 0.12	7.50**
	Palmitic Acid (C16:0)	18.76 \pm 0.40	19.37 \pm 0.04	5.71**
	Stearic Acid (C18:0)	13.05 \pm 0.40	14.61 \pm 0.63	2.09 ^{NS}
	Arachidic Acid (C20:0)	0.65 \pm 0.06	0.74 \pm 0.09	0.76 ^{NS}
	Behenic Acid (C22:0)	3.64 \pm 0.31	4.92 \pm 0.49	2.22 ^{NS}
(MUFA)	Palmitoleic Acid (C16:1)	2.03 \pm 0.25	2.09 \pm 0.18	0.17 ^{NS}
	Oleic Acid (C18:1)	37.35 \pm 0.63	40.77 \pm 0.46	4.38**
(PUFA)	Linoleic Acid (C18:2)	14.99 \pm 0.54	13.15 \pm 0.67	2.13 ^{NS}
	Linolenic Acid (C18:3)	0.54 \pm 0.09	0.20 \pm 0.03	3.63**
	Ecosapentaenoic Acid (C20:5)	0.96 \pm 0.18	0.75 \pm 0.16	0.86 ^{NS}
	Docosahexanoic Acid (C22:6)	1.17 \pm 0.16	0.36 \pm 0.04	5.07**
Total saturated fatty acids (SFA)	37.68 \pm 1.06	42.31 \pm 0.59	3.78**	
Total mono unsaturated fatty acids (MUFA)	39.39 \pm 0.54	42.86 \pm 0.58	4.39**	
Total poly unsaturated fatty acids (PUFA)	17.67 \pm 0.39	14.46 \pm 0.72	3.87**	
Total unsaturated fatty acids (UFA)	57.06 \pm 0.52	57.32 \pm 0.75	0.29 ^{NS}	
Total P/S	0.47 \pm 0.01	0.34 \pm 0.01	5.22**	
Cholesterol (mg/100 g)	50.89 \pm 0.28	53.25 \pm 0.25	6.24**	

n = 6, means bearing different superscripts differ significantly.
 ** = highly significant (P<0.01), ^{NS} = Non - significant (P>0.05).

fat and total ash content than young. The moisture content of goat meat decreased with increase in the age of the animal, which is probably associated with an increase in fat content (Lawrie, 1998). Similar results were obtained in buffalo (Kandeean *et al.*, 2009) and goat meat (Sivakumar, 2003). The fat content of Kodiadu goat was much lower (2.48 - 2.79%) as compared with exotic Boer goat (10.5%) (Tshabalala *et al.*, 2003).

The amino acid content of young and adult age groups of Kodiadu goat meat are summarized in Table 3 and it revealed a significant difference (P<0.05) in valine and highly significant difference (P<0.01) in arginine, histidine, isoleucine, leucine, lysine, threonine, aspartic acid, glutamic acid and glycine content of young and adult Kodiadu goat meat. Similar amino acid profiles have been reported in goat meat (Webb *et al.*, 2005; Aristoy and Toldra, 1998). The results of this study revealed that Kodiadu meat is a rich source of all essential and non-essential amino acids.

The fatty acid content of young and adult age groups of Kodiadu goat meat are summarized in Table 4 and it revealed that a highly significant difference (P<0.01) was observed in myristic acid, palmitic acid, oleic acid, linolenic acid and docosohexanoic acid content between two age groups of Kodiadu goat meat. Palmitic acid was the predominant saturated fatty acid followed by stearic and oleic acid (Madruga *et al.*, 2001). The meat of young goat had significantly lesser total saturated (P<0.01) and unsaturated fatty acids (P>0.05) and higher total poly unsaturated fatty acid (P<0.01) content than adult. Kodiadu, an indigenous goat had lower total saturated fatty acid (37.68 - 42.31%) and higher poly unsaturated fatty acid (17.67 - 14.46%) compared to exotic Boer goat which had 54.7% saturated fatty acids and 3.4% poly unsaturated fatty acids (Tshabalala *et al.*, 2003). The higher poly unsaturated fatty acid content in indigenous breeds could be due to extensive system of rearing animals wherein the animals are allowed for free access to pasture (Enser, 2000; Yang *et al.*, 2002; Williams, 2007).

The recommended poly unsaturated to saturated (P/S) ratio in the human food is 0.45-0.65 (Department of Health, 1984) and lower ratios in the diets may increase the occurrence of cardiovascular disease. The meat of young goat had P/S ratio within this range. The young goat had significantly (P<0.01) lower cholesterol content than

adult and the cholesterol content increased with advance in slaughter age and higher the fat content, the higher will be the cholesterol content (Madruga, 2001; Dorado *et al.*, 1999). Indian goat had lower cholesterol content than Boer goat (Pratiwi *et al.*, 2007). The differences may be attributed to climate, soil content, water composition and breeding policies of the various regions, which affect the nutrient content of the animal feed and thus the nutrient content of the animal's meat (Greenfield and Southgate, 2003; Okeudo and Moss, 2005).

CONCLUSION

Based on the physico-chemical and nutritional composition it was observed that Kodiadu goat slaughtered at 6-9 months of age had better meat quality as well as balanced nutritional composition.

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