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Effect of Different Storage Conditions and Duration on Physico Chemical Characteristics of Chevon

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A B S T R A C T

The properties of fresh goat meat in relation with post-mortem handling conditions were evaluated. There are various factors which affect the freshness of the meat the most important factors are storage temperature, time of exposure of meat to extrinsic factors and handling of carcass during and after slaughter. Hence a study was conducted to compare the physico chemical characteristics of chevon carcass hanged at room temperature for 6 hours and at chiller temperature for 30 hours. Twenty four numbers of 6 months old tellicherry young male goats were selected and they were slaughtered by the standard procedure. The carcass was vertically split into two halves and one half was exposed to room temperature and another half to chiller temperature. On hourly interval the samples were collected and physico chemical parameters like pH, water holding capacity and shear force value was analysed. Under both temperature treatments, as the storage hour increased, pH value, water holding capacity decreased significantly but the shear force value increased significantly ($p \leq 0.05$) up to 5th hour in ambient temperature and up to 9th hour in chiller temperature then shear force value start decreasing. Between treatments, except 0th hour, all the hour showed highly significant ($p<0.01$) difference between storage treatments up to 6 hours of comparison. The pH decline was faster in chevon stored under ambient temperature than under chiller temperature. Higher water holding capacity was also found in chiller temperature storage. The shear force value was higher in ambient temperature. It was concluded that keeping the carcass in the chilling conditions prolongs the shelf life and increase the tenderness of meat.

Introduction

In India, the total meat production is about 7.29 million tones and of which chevon and lamb meat production contributes about 0.95 million tones (DAHD, 2017). India is the second largest goat meat (chevon) producer after China. Goat meat has been recognized as lean meat with positive dietary values and it is one of the main sources of red meat in human diets. Chiller storage is routinely used to preserve meat over extended periods

(Mendiratta *et al.*, 2012).The long-term chiller storage improves meat quality, tenderness and reduce the microbial status of meat. In general, the meat quality was influenced by several ante and post mortem factors. The ante mortem factors comprises animal species, sex, age, muscle groups, gene regulation and nutritional status (Rubio *et al.*, 2013), several post-slaughter factors such as temperature, pH, storage time etc. (Nuss and Wolfe, 1980) play an important role in quality of meat. A high degree of tenderness is associated with holding temperatures around 10 ± 15 while temperatures below and above this range induce cold and heat shortening respectively. The hot carcasses are held at ambient temperature (26 ± 2̊C) for a few hours in India during marketing. Information regarding the textural characteristics of goat meat as influenced by different temperatures of muscles is scanty in the literature. The current investigation compares the tenderness of tellicherry male goat held at ambient temperature (26 ± 2̊C) upto 6 h postmortem and holding at chill temperature (4 ± 1̊C) for 30 h.

This study was aimed to compare physico chemical characteristics of goat carcasses kept at room temperature for 6 hours and chiller temperature for 30 hours.

Materials and Methods

The total of 24 numbers of 6 months old young tellicherry male goats were selected from Instructional Livestock Farm Complex, Veterinary College and Research Institute, Namakkal. The animals were allowed for overnight fasting and in the morning the animals were transported to the Department of Livestock Products Technology (Meat Science), Veterinary College and Research Institute, Namakkal for slaughter. The animals were slaughtered by 'Halal' method. The flaying and evisceration was performed by adopting the standard hygienic procedure. Each carcass was vertically split into two half and exposed to two different post mortem conditions with one half of the carcass hanged at room temperature (T1) for 6 hours and another half of the carcass hanged inside the chiller at chiller temperature (4 ± 1ºC) for 30 hours (T2).

Physico chemical characteristics of meat

The physico chemical characteristics of meat were analyzed hourly for 6 hours in both the halves hanged at room temperature and chiller temperature.

Carcass temperature

The carcass temperature was measured using the digital datalog thermometer by inserting the thermometer probe into the *Biceps femoris* muscle of both the halves of carcass. Simultaneously, the chiller temperature and the room temperature were also monitored.

pH

The pH of thigh muscles samples was determined by AOAC (1995) method. Five g of meat sample was homogenized with 45 ml of distilled water for one minute. The pH of the meat was recorded by immersing combined glass electrode and temperature probe of the digital pH meter (Model 361, Systronics, India) directly into meat suspension.

Water holding capacity (per cent)

The WHC of the *Longissmus dorsi* muscle was estimated by measuring the amount of water released from muscle protein by the application of force. It measures the ability of muscle protein to retain water in excess and under the influence of external force. The WHC of *Longissmus dorsi* muscles was determined with a modified version of the method reported by Grau and Hamm (1953). Around 300 mg of meat sample was placed on a filter paper arranged between two glass slides. On the top of the upper glass slide 100g weight was placed for 3 minutes. The released water from the meat sample was absorbed in the filter paper and leaves an impression. With the sharp pencil the boundary of the impression was clearly demarcated. The area of two resulted impression left on each half of the filter paper on account of oozing of fluid by application force (outer circle) and the area of the meat (inner circle) were measured by using graph and the percentage was calculated using the formula.

$$\text{Per cent WHC} = \frac{\text{Area of inner circle (area of meat)}}{\text{Area of outer circle (impression by oozing of fluid from meat)}} \times 100$$

Shear force value (kg/cm^2)

Shear force is the measure of tenderness of cooked meat by Warner-Bratzler meat shearer (G.R. electrical manufacturing company). A portion of *Longissmus dorsi* muscle from the carcass was cut into uniform 1 cm diameter core to estimate the tenderness value . The cores were cooked to internal temperature of 80°C for one minute and subsequently cooled on ice immediately to arrest the further cooking. From each muscle sample, two cores were obtained and three readings were recorded on each core. The average of these readings was considered as the SFV and the pressure exerted to shear the core as expressed in Kg/cm^2.

Results and Discussion

pH

The least-square mean (± S.E) of pH values of chevon kept under ambient temperature for 0 hour, 1st hour, 2nd hour, 3rd hour, 4th hour, 5th hour and 6th hour (Table 1) were 6.39 ± 0.03, 6.32 ± 0.02, 6.24 ± 0.02, 6.13 ± 0.03, 6.04 ± 0.03, 5.87 ± 0.05 and 5.69 ± 0.03, respectively. A highly significant ($p < 0.01$) difference was noticed between storage hours. As the storage hour increased, pH value decreased significantly from 2nd hour. The least-square mean (± S.E) of pH values of chevon kept under chiller temperature for 0 hour, 1st hour, 2nd hour, 3rd hour, 4th hour, 5th hour, 6th hour, 9th hour, 12th hour, 15th hour, 24th hour and 30th hour (Table 2) were 6.46 ± 0.02, 6.41 ± 0.03, 6.32 ± 0.03, 6.27 ± 0.03, 6.24 ± 0.03, 6.16 ± 0.04, 6.08 ± 0.04, 6.01 ± 0.03, 5.91 ± 0.03, 5.83 ± 0.04, 5.79±0.03 and 5.60±0.03, respectively. As the storage hours increased the pH values were decreased significantly ($p < 0.01$) between hours. Between treatments, except 0th hour, all the hour showed highly significant ($p < 0.01$) difference between storage treatments up to 6 hours of comparison. The pH decline was faster in chevon stored under ambient temperature than under chiller temperature.

The pH decline was much faster in chevon stored at ambient temperature. Similar to our result, Hur *et al.,* (2009) reported that in bovine meat the hanging temperature (surrounding temperature) of the carcass influenced the pH, at higher temperature (35°C) the pH decline was faster than at chiller temperature (4°C). On agreement with this White *et al.,* (2006) stated that the muscle incubated at 15°C had reached the lower pH values very faster than those incubated at 5°C from 1 to 48 hour postmortem. Similar to those Jones *et al.,* (1993) reported that increased the rate of chilling lead to a more rapid temperature decline in carcasses but slower pH decline. Rathina Raj *et al.,* (2000) also reported that delayed chilling (hanging at room temperature for 6 hours then chilled at 2℃) of muscle resulted in faster fall in pH than the direct chilling of muscle. The decreased in pH value of meat was due to formation of lactic acid as a result of anaerobic glycolysis due to long storage periods (Savell *et al.,* 2005). Such a faster fall in pH associated with muscles held at higher temperature was also observed earlier in sheep muscles (Mahendrakar *et al.,* 1988; Mendiratta *et al.,* 2008) and in buffalo muscles (Ziauddin *et al.,* 1994). The pH value and water holding capacity of meat was positively correlated when the pH was low there will be lower water holding capacity (Enfalt *et al.,* 1997). Purslow *et al.,* (2008) reported that only pH measures at 1 and 2 h post-mortem were related to variations in both the water-holding capacity of the raw meat.

Water holding capacity (per cent)

The water holding capacity is defined as the ability of meat to retain its water upon application of external forces (Hedrick *et al.,* 1994). Water holding capacity is a primary indicator of the degree of juiciness of meat. The least-square mean (± S.E) of water holding capacity of chevon kept under ambient temperature for 0 hour, 1st hour, 2nd hour, 3rd hour, 4th hour, 5th hour and 6th hour (Table 1) was 69.16±0.87, 65.02±0.75, 60.36 ± 0.59, 54.57 ± 0.58, 52.73 ± 0.70, 49.86±0.86 and 46.00 ± 0.69, respectively. There was a highly significant ($p < 0.01$) difference between storage hours. As the storage hour increased, water holding capacity decreased significantly. The least-square mean (± S.E) of water holding capacity of chevon kept under chiller temperature for 0 hour, 1st hour, 2nd hour, 3rd hour, 4th hour, 5th hour, 6th hour, 9th hour, 12th hour, 15th hour, 24th hour and 30th hour (Table 2) was 69.45 ± 1.10, 66.85 ± 1.16, 64.01 ± 1.04, 63.01 ± 1.08, 60.11 ± 1.20, 57.79 ± 1.05, 56.19 ± 0.95, 55.29 ± 1.23, 54.01 ± 0.85, 52.43 ± 0.83, 50.83 ± 0.78 and 48.78 ± 0.67, respectively. As the storage hours increased the water holding capacity decreased significantly ($p < 0.01$) between hours. Between 0th hour and 1st hour, highly significant decrease in WHC was noticed but no significant decrease was noticed from 1 hour to 3 hour after that significant ($p < 0.05$) decrease was noticed in water holding capacity of meat. Between treatments, except in 0th hour and 1st hour, all the hour showed highly significant ($p < 0.01$) difference between storage treatments up to 6 hours of comparison. Higher water holding capacity was found in chiller temperature storage.

As the storage hours increased in both the treatments, the water holding capacity was also decreased significantly. Between 0th hour and 1st hour, higher significant decreased in WHC while, after 3 hour significant decrease was noticed in water holding capacity of meat. Between treatments, except in 0th hour and 1st hour, all the hour showed highly significant ($p < 0.01$) difference up to 6 hours of comparison. The water holding capacity decrease was faster in chevon stored at ambient temperature than in chiller temperature. Similar to these Rathina Raj *et al.,* (2000) reported that in buffalo initial (2 h postmortem) values of WHC were 71.5 to 79.6 per cent for loin muscles and gradually decreased to 68.2 to 69.3 per cent during chilling. The post-slaughter storage at ambient temperature caused significantly faster decline in water holding capacity in comparison to post-slaughter storage at refrigerated temperature. Geesink *et al.,* (2000) reported that when the pre-rigor lamb muscle was incubated at 15˚C, it showed slower decrease in water holding capacity than muscle incubated at temperature above 25° C. Hamm (1960) showed that, immediately after slaughter, beef had a very high WHC, which decreased rapidly and reached a minimum in 24 to 48 hours of slaughter. This declined trend in water holding capacity was correlated with decrease in pH (Savell *et al.,* 2005) and rigor state (Hannula and Poulanne, 2004). The difference in water holding capacity in pre-rigor and rigor stage could be due to difference in swelling of myofibrils (Kovacs, 1996) and denaturation of sarcoplasmic and myofibrillar proteins (Scheffler and Gerrard, 2007).

Shear force value

Shear force values is important in predicting the tenderness of the meat. The least-square mean (± S.E) of shear force values of chevon kept under ambient temperature for 0 hour, 1st hour, 2nd hour, 3rd hour, 4th hour, 5th hour and 6th hour (Table 1) were 3.28 ± 0.15, 3.62 ± 0.15, 4.88 ± 0.20, 5.60 ± 0.22, 6.21 ± 0.27, 7.07 ± 0.34 and 5.65 ± 0.31, respectively. Highly significant ($p < 0.01$) difference was noticed between storage hours. As the storage hour increased, shear force value increased significantly ($p \leq 0.05$) up to 5th hour then shear force value start decreasing.

The least-square mean (± S.E) of shear force values of chevon kept under chiller temperature for 0 hour, 1st hour, 2nd hour, 3rd hour, 4th hour, 5th hour, 6th hour, 9th hour, 12th hour, 15th hour, 24th hour and 30th hour (Table 2) were 3.24 ± 0.15, 3.56 ± 0.21, 3.98 ± 0.23, 4.58±0.25, 5.07 ± 0.23, 5.55 ± 0.19, 6.19 ± 0.18, 7.20 ± 0.11, 6.94 ± 0.07, 6.57 ± 0.09, 5.99 ± 0.09 and 5.40 ± 0.13, respectively. As the storage hours increased, the shear force value increased significantly ($p < 0.01$) up to 9th hour then it decreased significantly. Between treatments, except in 0th hour and 1st hour, all hours showed significant ($p < 0.05$) difference between storage treatments up to 6 hours of comparison. Except in 6th hour, the shear force value was higher in T1.

Under ambient temperature, there was a highly significant ($p < 0.01$) difference between storage hours. As the storage hour increased, shear force value increased significantly up to 5th hour of storage then shear force value decreased. Under chiller temperature, as the storage hours increased, the shear force value increased significantly up to 9th hour then it started to decrease significantly. Between treatments, except in 0th hour and 1st hour, all hours showed significant ($p < 0.05$) difference between storage treatments up to 6 hours of comparison. Except in 6th hour, the shear force value was high in T 1. In room temperature, the toughness is due to the higher rigor temperature (38℃) because of earlier activation of µ- calpine. Initially the toughness occurs because of sarcomere length shortening later the tenderness was depend upon the start of proteolysis which is also indicated by tyrosine value of meat. Similar to our result, Hwang and Thompson (2001) reported a gradual increase in Warner–Bratzler shear force value as a result of the low temperature treatment. Starkey *et al.,* (2015) reported that in lamb *Longissmus dorsi* muscle ageing had a significant effect on shear force value of meat stored at 3-48°C for 14 days. The shear force value were higher (tougher- 21.7 to 57.6 kg/cm^2) on day 1 and lowest (more tender- 16.3 to 37.4 kg/cm^2) on day 14. Abdullah and Qudsieh (2009) found that ageing of Awassi ram lamb meat for 7 days reduced the shear force from 28.3 kg/cm^2 in day 1 to 20.7 kg/cm^2 in day 7, a reduction of 26%. Dunn *et al.,* (2000) found a strong negative correlation between shear force and sarcomere length in chicken breast meat, the sarcomere shortening was a major contributor to toughness when the carcasses were chilled at −12 and 0°C.

Table.1 Mean (±S.E) values of physico chemical parameters of chevon kept under different storage conditions and duration

Parameters	Treatments	Storage time (hours)						
		0	1	2	3	4	5	6
pH	T1	6.39^{aA} ± 0.03	6.32^{bAB} ± 0.02	6.24^{bB} ± 0.02	6.13^{bC} ± 0.03	6.04^{bD} ± 0.03	5.87^{bE} ± 0.05	5.69^{bF} ± 0.03
	T2	6.46^{aA} ± 0.02	6.41^{aAB} ± 0.03	6.32^{aBC} ± 0.03	6.27^{aC} ± 0.03	6.24^{aCD} ± 0.03	6.16^{aDE} ± 0.04	6.08^{aE} ± 0.04
Carcass temperature (℃)	T1	32.47^{aA} ± 0.37	27.70^{aB} ± 0.44	26.15^{aC} ± 0.53	24.64^{aD} ± 0.27	24.00^{aDE} ± 0.27	23.30^{aEF} ± 0.38	22.64^{a} ± 0.57
	T2	32.05^{aA} ± 0.76	20.56^{bB} ± 1.15	12.99^{bC} ± 1.16	6.57^{bD} ± 0.69	4.11^{bE} ± 0.28	2.83^{bEF} ± 0.25	2.10^{bF} ± 0.23
Water holding capacity (per cent)	T1	69.16^{aA} ± 0.87	65.02^{aB} ± 0.75	60.36^{bC} ± 0.59	54.57^{bD} ± 0.58	52.73^{bD} ± 0.70	49.86^{bE} ± 0.86	46.00^{bF} ± 0.69
	T2	69.45^{aA} ± 1.10	66.85^{aB} ± 1.16	64.01^{aB} ± 1.04	63.01^{aB} ± 1.08	60.11^{aC} ± 1.20	57.79^{aCD} ± 1.06	56.19^{aE} ± 0.96
Shear force value (kg/cm^2)	T1	3.28^{aE} ± 0.15	3.62^{aE} ± 0.15	4.88^{aD} ± 0.20	5.60^{aC} ± 0.22	6.21^{aB} ± 0.27	7.07^{aA} ± 0.34	5.65^{bC} ± 0.31
	T2	3.24^{aA} ± 0.16	3.56^{aB} ± 0.22	3.98^{bBC} ± 0.24	4.58^{bBCD} ± 0.25	5.07^{bCDE} ± 0.23	5.55^{bDE} ± 0.19	6.19^{aF} ± 0.18

T1 – Room temperature storage, T2 – Chiller temperature.

[ab] Means bearing different superscript in a column differ significantly (P<0.05) for treatments,

[A-F] Means bearing different superscript in a row differ significantly (P<0.05) for storage hours.

n= 24 for each treatment

Table 2 Mean (± S.E) values of physico chemical parameters of chevon kept under chiller temperature (4 ± 1℃)

Parameters	Storage time (hours)											
	0	1	2	3	4	5	6	9	12	15	24	30
pH	6.46^{A} ± 0.02	6.41^{AB} ± 0.03	6.32^{BC} ± 0.03	6.27^{C} ± 0.02	6.24^{CD} ± 0.03	6.16^{DE} ± 0.04	6.08^{EF} ± 0.04	6.01^{F} ± 0.03	5.91^{G} ± 0.03	5.83^{GH} ± 0.04	5.79^{H} ± 0.03	5.60^{I} ± 0.03
Carcass temperature(℃)	32.05^{A} ± 0.76	20.56^{B} ± 1.15	12.99^{C} ± 1.16	6.57^{D} ± 0.69	4.11^{E} ± 0.28	2.83^{EF} ± 0.25	2.10^{FG} ± 0.23	1.63^{FG} ± 0.18	1.28^{FG} ± 0.19	1.10^{FG} ± 0.16	1.32^{FG} ± 0.56	0.82^{G} ± 0.19
Water holding capacity (per cent)	69.45^{A} ± 1.10	66.85^{B} ± 1.16	64.01^{B} ± 1.04	63.01^{B} ± 1.08	60.11^{C} ± 1.20	57.79^{CD} ± 1.05	56.19^{DE} ± 0.95	55.29^{DEF} ± 1.23	54.01^{EF} ± 0.85	52.43^{FG} ± 0.83	50.83^{GH} ± 0.78	48.76^{G} ± 0.67
Shear force value (kg/cm^2)	3.24^{A} ± 0.15	3.56^{B} ± 0.21	3.98^{BC} ± 0.23	4.58^{BCD} ± 0.25	5.07^{CDE} ± 0.23	5.55^{DEF} ± 0.19	6.19^{EF} ± 0.18	7.20^{FG} ± 0.11	6.94^{GH} ± 0.07	6.57^{HI} ± 0.09	5.99^{I} ± 0.09	5.40^{I} ± 0.13
Means bearing different superscripts in a row differs significantly (P<0.01).												

Greater shear values for directly chilled muscles are explained as due to cold shortening in bovine muscles (Bouton *et al.*, 1975) and in sheep muscles (Mahendrakar *et al.*, 1990). Delayed chilled muscles were markedly tender as indicated by 10.3 ± 33.6 per cent.

The storage temperature influenced meat quality. Exposure of meat to ambient temperature for 6 hours resulted in faster pH decline, significant tenderization effect and protein denaturation started after 5 hours of slaughter. While 30 hours of exposure of carcass to chiller temperature resulted in slower pH decline and slower protein denaturation and tenderization started after 12 hours of slaughter. Hence, it could be concluded that the initial increase and later decrease in shear force value indicate the increase in tenderness indicated conversion of muscle to meat during storage. It could also be concluded that the exposure of goat carcass to ambient temperature up to 6 hours and chiller temperature up to 30 hours influence the physico-chemical of the meat significantly.

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