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Comparisons of Handling Practices of Culled Sheep Meat for Production of Mutton Curry

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ABSTRACT : In most developing countries consumers purchase retail cuts from hot carcasses and prepare traditional meat products as per their convenience and requirements. In this study, effects of different *post mortem* handling practices on quality of meat curry from culled sheep meat have been studied. After slaughter, leg cuts were subjected to nine commonly prevalent handling conditions in India viz. deboning (boning out) and cooking within 2-3 h (1), deboning immediately and cooking after 5-6 h (2), deboning after 5-6 h and cooking (3), deboning immediately, storage at 4°C for 24 h and cooking (4), chilling for 24 h at 4°C, deboning and cooking (5), deboning after 5-6 h, storage for 24 h at 4°C, and cooking (6), deboning after 5-6 h, storage for 48 h at 4°C and cooking (7), deboning after 5-6 h, freezing and cooking (8), deboning after 5-6 h, storage for 24 h at 4°C, freezing and cooking (9). Significant differences were observed in pH, water-holding capacity, cooking loss and shear force values. Sensory scores were significantly higher in conditions (1), (5) and (9), and significantly lower in conditions (4) and (6). From the results, it was concluded that, to have the best quality product, meat should be cooked either immediately after slaughter or should be deboned just before cooking. Storage of deboned meat at refrigerated temperature must be avoided. (**Key Words :** Sheep Meat, Mutton Curry, Handling Practices, Hot Boning, Tenderness, Sensory Qualities)

INTRODUCTION

India is the richest country in the world in livestock wealth. However, meat production is largely a by-product system of livestock production. More than 40% of the total meat is produced from spent (culled) animals at the end of their productive economic life. Sheep are also usually reared for wool and are slaughtered at the end of their productive economic life. Meat from such aged sheep is usually tough and fibrous and is not liked by the consumers. Improper post-mortem handling conditions further deteriorate the quality of product prepared from such low quality meat.

Meat retailers in India slaughter their animals in nearby slaughter house or procure dressed carcasses for their daily requirements. These retailers hang the hot carcasses and sold retail cuts to the consumers. Consumers bring meat cuts to their home and cook these chunks immediately or store in refrigerator and cook as per their requirements. Thus, from slaughter of animal till preparation of meat curry, cuts are subjected to different handling and processing conditions.

Meat curry is a traditional, one of the most popular and most relished meat preparations in India. For preparation of meat curry, meat chunks are first partially fried and then cooked under pressure in pressure cooker. Although the pressure cooking improve tenderness in comparison to normal cooking (Raj et al., 2000), but the products from tough meat have very low sensory attributes even after cooking under pressure for long time. Greater tenderization of pressure-cooked muscle occurs due to thermal shrinkage of muscle and greater solubilization of collagen at higher temperature (Mahendrakar et al., 1989).

Several biochemical processes and structural changes take place during first 24 h after slaughter. Post mortem factors such as holding time and temperature after slaughter, time of boning, chilling before cooking, time and temperature of cooking play very important role in determining quality of meat products. Dransfield and Rhodes (1975) studied effect of heating beef M. semitendinosus muscle before, during and after development of rigor mortis and reported that rapid heating soon after slaughter produced normal shear values for

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Table 1. Ingredients used for preparation of meat curry

Sl. No	Ingredients	Level
1	Meat chunks	1,000 g
2	Refined vegetable oil	100 g
3	Condiment paste (onion and garlic in 3:1 ratio)	200 g
4	Table salt	25 g
5	Coriander powder	10 g
6	Red pepper powder	5 g
7	Dried spices (mixture of common spices)	10 g
8	Water	700 ml

cooked meat but slow heating gave very tough meat. At later times, shear values were unaffected by heating rate and decreased with increasing time after slaughter. Loucks et al. (1984) indicated that cold boned beef roasts were superior in tenderness than hot boned products. Sharma et al. (1988) reported that tenderness of goat meat was adversely affected by hot boning, this trait was further exacerbated by freezing. Raj et al. (2000) have indicated definite improvement in the textural quality of buffalo muscles subjected to delayed chilling (keeping carcass at 26±2°C for 6 h followed by chilling at 2-3°C for 18 h) in comparison to direct chilling (keeping carcass at 2-3°C for 24 h). Mahendrakar et al. (1990) also reported greater shear value of sheep muscles subjected to direct chilling. Generally rapid chilling of meat produce cold shortening, but if meat is boned out then shortening can occur both due to rapid chilling or elevated temperature conditions and affect tenderness. Devine et al. (2002) showed that at rigor temperature of 18°C, lamb meat that has been excised pre-rigor, will be as tender as meat remaining on the carcass. Wrapping was shown to mimic meat left intact on the carcass, as it prevented significant prerigor shortening. Scheffler and Gerrard (2007) reported that the rate and extend of pH decline during the conversion of muscle to meat had significant impact on development of fresh meat quality attributes. Park et al. (2007) revealed that chilling temperature during the first 90 minutes had a significant effect on PSE incidences.

Cooking of tender meats do not require precise conditions, however, improper post mortem handling conditions further deteriorate the quality of products from spent animals meat. In spite of most popular meat preparation in India, meat curry has not received required attention of meat researchers. Considering all these, the present study was conducted to investigate the effects of different handling practices on quality of meat curry from adult sheep meat.

MATERIALS AND METHODS

Meat source

Adult sheep (about 2 and half years old) of non-descript breeds were slaughtered at an ambient temperature of 20-25°C. Hind leg cut was separated from the carcass immediately after slaughter and subjected to different handling conditions commonly prevalent in Indian market. A total of 27 animals (54 hind leg cuts) were used in this study. Thus each handling condition was evaluated six times. Generally, at one time 4 hind leg cuts were randomly subjected to different handling conditions and evaluated.

The post-mortem conditions evaluated were: deboning (boning out) and cooking of meat within 2-3 h of slaughter (1), deboning immediately after slaughter, storage of muscle pieces at 20-25°C and cooking after 5-6 h of storage (2), holding of hind leg cuts at 20-25°C for 5-6 h, deboning and cooking (3), deboning immediately after slaughter, storage of muscle pieces at 4°C for 24 h and cooking (4), chilling of hind leg cut for 24 h at 4°C, deboning and cooking (5), holding of hind leg cuts at 20-25°C for 5-6 h, deboning, storage of muscle pieces for 24 h at 4°C and cooking (6), holding of hind leg cuts at 20-25°C for 5-6 h, deboning, storage of muscle pieces for 48 h at 4°C and cooking (7), holding of hind leg cuts at 20-25°C for 5-6 h, deboning, freezing of muscle pieces at -18°C for 24 h, thawing at 20-25°C and cooking (8), holding of hind leg cuts at 20-25°C for 5-6 h, deboning, storage of muscle pieces for 24 h at 4°C, freezing at -18°C for 24 h, thawing at 20-25°C and cooking (9).

During deboning (boning out) care was taken to remove muscle pieces as large as possible. These muscle pieces were aerobically packed in polyethylene bags and treated as per requirement of experiments.

Preparation of mutton curry

Meat collected after different handling conditions was cut into chunk size of approximately 2.5 cm×2.5 cm×2.5 cm in size and used for preparation of meat curry.

Series of preliminary trials were conducted to standardize chunks size, spice, oil and water levels, time of cooking etc. for preparation of meat curry from spent sheep meat. For preparation of meat curry, first gravy mixture was prepared by frying condiments (fine paste of onion and garlic) in refined vegetable oil. Salt, red pepper, turmeric, coriander powder were added during frying as per details given in Table 1. After about 5 minutes, meat chunks were added in the gravy mix and mixture was again fried for about 10 minutes. After frying, dried spice mix and water was added and fried chunks were cooked under pressure (1 kg/cm^2 steam pressure) in kitchen pressure cooker (Hawkings make) of 6 L capacity for 20 min. After cooking, pressure cooker was removed from the flame and steam was released. Content (meat chunks and slurry) was transferred to glass jar, cooled at room temperature and kept at refrigerated temperature (4°C) till evaluation.

pH

The pH of raw (just before cooking) and cooked chunks

Table 2. Effect of different handling conditions on physico-chemical characteristics of raw sheep meat

Conditions*	pH	Water holding capacity	Moisture content (%)
1	6.83±0.02^{f}	0.361±0.007^{d}	75.55±0.48^{b}
2	6.37±0.02^{d}	0.383±0.007^{e}	74.98±0.59^{ab}
3	6.47±0.02^{e}	0.369±0.008^{de}	74.99±0.51^{ab}
4	5.60±0.03^{b}	0.278±0.003^{bc}	75.45±0.52^{ab}
5	5.65±0.02^{b}	0.260±0.007^{b}	75.83±0.63^{b}
6	5.60±0.03^{b}	0.295±0.005^{c}	74.88±0.49^{ab}
7	5.48±0.02^{a}	0.289±0.007^{c}	74.68±0.39^{ab}
8	5.80±0.03^{c}	0.230±0.007^{a}	75.94±0.51^{b}
9	5.48±0.02^{a}	0.228±0.002^{a}	74.08±0.30^{a}
F value	366.21	66.71	1.42

Means values bearing same superscripts column-wise do not differ significantly ($p<0.05$).

* Conditions :

1: deboning and cooking of meat within 2-3 h of slaughter; 2: deboning immediately after slaughter and cooking after 5-6 h of storage;
3: deboning after 5-6 h of slaughter and cooking; 4: deboning immediately after slaughter, storage at 4°C for 24 h and cooking;
5: chilling for 24 h at 4°C, deboning and cooking; 6: deboning after 5-6 h of slaughter, storage for 24 h at 4°C, and cooking;
7: deboning after 5-6 h of slaughter, storage for 48 h at 4°C and cooking; 8: deboning after 5-6 h of slaughter, freezing and cooking;
9: deboning after 5-6 h of slaughter, storage for 24 h at 4°C, freezing and cooking.

Table 3. Effect of different handling conditions on physico-chemical characteristics of cooked sheep meat

Conditions*	Cooking yield (%)	pH	Moisture content (%)	Shear force value (kg/cm^2)
1	70.12±0.50^{e}	6.32±0.03^{d}	54.78±0.32^{e}	2.83±0.12^{bc}
2	65.85±0.60^{cd}	6.15±0.03^{c}	53.65±0.47^{de}	3.66±0.12^{d}
3	65.43±0.82^{cd}	6.25±0.04^{d}	53.50±0.39^{cd}	2.79±0.11^{b}
4	65.83±0.78^{cd}	5.79±0.02^{a}	52.73±0.40^{abcd}	3.69±0.08^{d}
5	63.74±0.77^{bc}	5.75±0.02^{a}	52.78±0.40^{bcd}	2.40±0.08^{a}
6	63.52±0.99^{bc}	5.83±0.03^{a}	52.45±0.41^{abc}	3.48±0.09^{d}
7	65.07±0.54^{cd}	5.87±0.02^{b}	52.20±0.46^{ab}	3.10±0.13^{c}
8	62.04±0.57^{ab}	6.10±0.02^{c}	51.60±0.38^{a}	3.04±0.10^{bc}
9	61.25±0.48^{a}	5.81±0.01^{a}	51.66±0.34^{a}	2.27±0.08^{a}
F value	14.06	66.97	6.60	25.65

* Same as given in Table 2.

Means values bearing same superscripts column-wise do not differ significantly ($p<0.05$).

was determined by homogenizing ten gram of sample with 50 ml distilled water with the help of Ultra Turrex T25 tissue homogenizer (IKA labor Technik, Germany) for 1 min. The pH of the suspension was recorded by immersing combined glass electrode of digital pH meter (Model CP-901, Century Instruments Ltd., India).

Water holding capacity (WHC)

WHC of raw meat (just before cooking) was estimated by following the method of Hamm and Honikel (1994). About 0.3 g of minced meat was placed on a piece of Whatman filter paper No. 42. The filter paper containing meat was then pressed between plaxi-plates (by tightening the screws fixed in plates) for 5 minutes. After pressing, the piece of filter paper along with pressed meat was taken out of plaxi-plates and area of meat film and total area (including area of released juice) were calculated by measuring diameters at two places. WHC was calculated as:

$$\mathrm{WHC} = \frac{\text{Area of meat film } (\mathrm{Am} \times \mathrm{Bm})}{\text{Total area } (\mathrm{At} \times \mathrm{Bt})}$$

Am and Bm = Diameters of meat film

At and Bt = Total diameters (meat film+juice released)

Cooking yield

The weight of chunks before and after cooking was noted and percent-cooking yield was calculated.

$$\text{Cooking yield } (\%) = \frac{\text{Weight of cooked chunks}}{\text{Weight of raw chunks}} \times 100$$

Moisture content

The moisture content of raw and cooked mutton chunks was estimated by following gravimetrically procedure (AOAC, 1995).

Shear force value

The cooked chunks were allowed to set by keeping at refrigerated temperature for overnight. After setting, chunks were cut into size of 1 cm^3 and then sheared in a Warner-Bratzler Shear Press (Model: 81031307, G.R. Elect. Mfg. Co., USA) with the fibres parallel to the longitudinal axis.

The results were expressed in kg/cm^2.

Sensory evaluation

A sensory panel consisting of seven meat scientists evaluated the products for appearance and colour, flavour, juiciness, tenderness and the overall acceptability by using 8 point scales (Keeton, 1983; Baker and Scottkline, 1988; Okumura et al., 2007), where 8 denoted extremely desirable and 1 denoted extremely poor. Samples stored at refrigerated temperature were warmed in microwave oven just before serving.

Statistical analysis

Each experiment was replicated six times. Thus a minimum of six observations was recorded for parameters like cooking yield. Minimum 12 observations were recorded for moisture, pH, WHC and 30 for shear force. 21 observations were recorded for different sensory attributes for each condition/treatment. The data obtained was analyzed by SPSS statistical software package using standard procedures (Snedecor and Cochran, 1989). Duncan’s multiple range tests was used to determine significant differences among means for different treatments. The results of the storage studies were analyzed by two-way analysis of variance (ANOVA) to determine the effect of treatment and storage period.

RESULTS AND DISCUSSION

Physico-chemical characteristics

Results related to physico-chemical characteristics of raw and cooked meat curry prepared from tough sheep meat is presented in Table 2 and 3.

pH, WHC and moisture content of raw meat

pH values of raw meat decreased with increasing storage period after slaughter. Highest values were observed immediately after slaughter in condition 1 and lowest values were observed after 48 h of slaughter i.e. in conditions 7 and 9. Significant difference in pH values after 5 to 6 h of slaughter in conditions 2 and 3 indicate that faster decline in pH occurred when meat was deboned immediately after slaughter. However, non-significant difference in conditions 4, 5 and 6 revealed that time of deboning did not affect pH values after 24 h of slaughter. Significant differences between conditions 8 and 6 revealed that freezing delayed the development of ultimate pH value. These results indicated significant affect of deboning time and storage temperature on rate of pH fall. Kovacs (1996) also observed significant interaction of pH, temperature and storage time. Raj et al. (2000) also reported that delayed chilling of buffalo muscle resulted in faster fall in pH. In the present study, deboning time seems to have more affected the rate of pH fall than temperature of storage after slaughter.

Water Holding Capacity (WHC) values were significantly higher in meat samples evaluated after 5-6 h of slaughter (in conditions 1, 2 and 3) and significantly lower in frozen and thawed samples (in conditions 8 and 9). Higher WHC in hot meat samples could be due to higher pH values and larger space between the myofilaments and less denaturation of the meat proteins (Louck et al., 1984). The differences in WHC in pre-rigor and rigor stage could also be due to difference in swelling of myofibrils (Kovacs, 1996) and denaturation of sarcoplasmic and myofibrillar proteins (Scheffler and Gerrard, 2007). Raj et al. (2000) also reported that initial (2 h post mortem) values of WHC of buffalo loin muscles gradually decreased during chilling. They further reported that direct or delayed chilling of muscle did not influence WHC markedly.

Moisture contents of raw meat did not differ significantly in most of the conditions. Moisture content value in condition 9 was significantly lower than conditions 1, 5 and 8. This could be due to loss of fluid during thawing of frozen samples.

Cooking yield, pH and moisture content of cooked meat

Cooking yield was significantly higher when meat was cooked within 2 to 3 h of slaughter (condition 1). Values of yield were significantly lower in frozen and thawed samples (in conditions 8 and 9). Non-significant differences were noticed in cooking yields of other conditions. Higher and lower cooking yield values could be related to pH and WHC. Higher cooking loss for post rigor than pre rigor beef roasts was also reported by Loucks et al. (1984). Similarly, Sharma et al. (1988) reported less cooking loss in goat meat chunks cooked after hot boning than cold deboned cuts and the trends was reversed after freezing. Reduction in drip loss was also reported in pork after hot-boning (Schwegele et al., 1991).

Devine et al. (2002) reported almost similar cook loss in sheep muscles subjected to different conditions like restraining, deboning, electrical stimulation and wrapping. The cook loss during cooking upon internal temperature of 75°C ranged from 21 to 25 per cent. However, value decreased with longer ageing duration. In contrast to these, Bekhit et al. (2007) showed no clearly established trends of the effect of rigor temperature and time on the cooking and drip losses of venison muscles.

pH values of cooked samples were significantly higher in conditions 1 and 3. The results also revealed that pH decreased during cooking when initial pH values were higher (in conditions 1, 2 and 3). However, in all other conditions, pH values increased during cooking. In other words, pH values decreased when meat was cooked within 5-6 h of slaughter, but increased when meat was cooked

Table 4. Effect of different handling conditions* on sensory scores** of cooked sheep meat curry chunks

Conditions*	Appearance	Flavour	Juiciness	Tenderness	Overall acceptability
1	7.07±0.07[c]	6.98±0.07[de]	7.17±0.06[e]	7.21±0.06[c]	7.32±0.05[e]
2	6.83±0.07[a]	6.87±0.07[bcd]	6.75±0.07[bc]	6.73±0.07[b]	6.82±0.08[c]
3	6.87±0.08[ab]	6.92±0.07[bcde]	6.72±0.07[b]	6.77±0.07[b]	6.75±0.07[c]
4	7.00±0.05[ab]	6.65±0.07[a]	6.53±0.07[a]	6.37±0.08 [a]	6.21±0.06[a]
5	6.93±0.07[abc]	6.77±0.07[abc]	6.88±0.05[bcd]	7.10±0.08[c]	7.08±0.01[d]
6	6.91±0.05[abc]	6.73±0.07[ab]	6.72±0.07[b]	6.48±0.08[a]	6.43±0.07[b]
7	7.03±0.03[bc]	7.07±0.07[e]	7.00±0.03[de]	6.73±0.06[b]	6.65±0.07[c]
8	6.98±0.06[abc]	6.93±0.07[cde]	6.92±0.07[cd]	6.78±0.07[b]	6.70±0.07[c]
9	7.01±0.04[bc]	7.10±0.07[e]	7.03±0.06[de]	7.05±0.09[c]	7.07±0.09[d]
F value	1.74	5.09	9.24	14.10	23.85

* Same as given in Table 2.
** Sensory scores, 1 = Extremely undesirable, 8 = Extremely desirable.
Means values bearing same superscripts column-wise do not differ significantly ($p<0.05$).

after 24 h of slaughter.

Almost same trend was noticed for moisture content of cooked meat as that for raw meat i.e. significantly higher values were observed in meat chunks cooked immediately after slaughter (condition 1) and lower values in frozen and thawed samples (conditions 8 and 9).

Shear force value

Shear force values (SFV) results revealed significant effects of time of deboning, duration of chilling and freezing. Values were significantly higher in conditions 2, 4 and 6, and significantly lower in conditions 5 and 9. These Significant higher values in conditions 2 than 3, and in conditions 4 than 5, suggests that meat should always be cooked immediately after deboning. Storage of deboned meat at refrigeration temperature may lead to toughening. Significant lower SFV in conditions 1 and 2 indicate start or setting of rigor stage within 5-6 h of slaughter. Significant lower SFV in condition 9 than 8 also indicate that chilling before freezing further decreased the SFV.

Dransfield and Rhodes (1975) showed that variation in shear values of meat heated within 18 h after slaughter was largely due to combined influences of shortening and of muscle and pH after heating. Higher shear values were also observed for directly chilled sheep muscles by Mahendrakar et al. (1990). Scwaegele et al. (1991) also compared qualities of hot and cold boned pork and reported that hot boned cuts cooled more rapidly than intact carcass side and hot boning need not result in cold shortening. Koohmaraie et al. (1996) experimentally proved that the shear force values do not increase during rigor development when lamb muscles were prevented from shortening. Thus the toughening that occurs during 24 h of slaughter is most likely due to sarcomere shortening. Savell et al. (2005) also demonstrated that minimizing cold shortening is of greatest importance in lamb and can be best addressed by ensuring that muscle temperatures are not below 10°C before pH reaches to 6.2. Devine et al. (2002) reported significant effect of temperature during rigor on shear force values of sheep meat. Although shear force value for 18 and 35°C rigor were similar at zero ageing, but as ageing progressed, the 18°C rigor meat aged faster and become more tender than meat that went into rigor at 35°C.

Sensory characteristics

Results related to sensory evaluation of meat curry prepared from tough sheep meat are presented in Table 4.

Appearance and flavour scores

Only marginal differences were observed in appearance scores of different samples. Score in condition 1 was significantly higher than condition 2. Flavor scores were significantly higher in samples that were chilled for 48 h before cooking (condition 7) and in samples that were chilled for 24 h and then frozen and thawed (condition 9). This improvement in flavour score could be due to development or release of flavouring components during ageing or chilling of meat. Significantly lower score in condition 4 could be due to shortening of muscles occurred due to storage of hot deboned meat.

Juiciness, tenderness and overall acceptability scores

Juiciness scores were significantly higher for samples that were cooked immediately after slaughter (condition 1) or chilled/frozen for 48 h (conditions 7 and 9). Juiciness score was lowest in samples that were deboned immediately after slaughter and stored for 24 h before cooking.

Tenderness scores were significantly higher in samples that were cooked immediately after slaughter (condition 1), chilled for 24 h and then deboned (condition 5) or frozen after chilling (condition 9). Scores were significantly lower in samples that were deboned immediately or after 5-6 h of slaughter and chilled for 24 h before cooking (conditions 4 and 6). Almost same trend was observed for overall acceptability as that for tenderness i.e. scores were significantly higher in conditions 1, 5 and 9, and significantly lower in condition 4 and 6.

Loucks et al. (1984) evaluated pre-rigor (hot-boned and cooked 1h post exsanguinations) and post-rigor (cold-boned and cooked 48 h post exsanguinations) bovine semimembranous muscles and reported that although cold boned roasts were superior to hot boned in tenderness but juiciness was consistently higher in hot boned roasts. The relative superiority of deboning just before cooking in terms of tenderness could be due to formation of limited number of rigor bonds, in contrast to large number of rigor bonds and complete overlap of myofilaments during storage of deboned meat (Kovacs, 1996).

Jaime et al. (1992) studies the effect of rapid drop of post mortem temperature to 0, 4, 10, 15, 20 or 36°C during rigor followed by ageing at 4°C and reported high sensory scores after rigor at 0°C possibly due to higher pH and rapid increase of sarcoplasmic Ca++ level. Significant differences between sensory scores of conditions 4 and 5, could also be due to rapid increase of sarcoplasmic Ca++ level during chilling of hot deboned meat than intact meat cuts (with bone). However, Ali et al. (2007) showed no significant effects of chilling temperature on ultimate pH, protein solubility and shear force value for duck breast and leg meat.

Freezing of hot carcasses was also not recommended by Toohey and Hopkins (2006). They studied the eating quality of electrically stimulated, hot boned (within 2 h) and frozen sheep meat and showed that all samples exceeded the recommended threshold value of 49 N for shear force. Thus even effective electrical stimulation was not found to be sufficient to ensure freezing of hot boned sheep meat as table meat. The differences in quality attributes of different handling conditions could also be due to difference in rate and extend of pH fall (Scheffler and Gerrard, 2007).

CONCLUSIONS

In the present study cooking of tough mutton within 2-3 h of slaughter produced good quality of meat curry in comparison to cooking after 5-6 h of slaughter. Deboning after 24 h of chilling also produced good quality meat curry then deboning immediately after slaughter and storage at 4°C before cooking. Chilling for 48 h or freezing after chilling also improved the sensory qualities of meat curry from tough sheep meat. Thus, it can be concluded that to have best quality product, meat should be cooked either immediately after slaughter or should be deboned just before cooking. Hot deboned meat chunks should not be subjected to freezing or storage at refrigerated temperature.

The present study shows that how different handling conditions affect the quality of meat curry. Although the development of rigor mortis and cold shortening were not evaluated but the differences observed in pH, WHC, shear force value and sensory characteristics clearly correlates these changes with the rigor stage. However, more detailed studies are required to evaluate the sequences of changes that are taking place due to different handling conditions.

REFERENCES

Ali, M. S., H. S. Yang, J. Y. Jeong, S. H. Moon, Y. H. Hwang, G. B. Park and S. T. Joo. 2007. Quality of duck breast and leg meat after chilling carcasses in water at 0, 10 or 20°C. Asian-Aust. J. Anim. Sci. 20(12):1895-1900.

AOAC. 1995. Official Methods of Analysis. 16th edn. Association of Official Analytical Chemists, Washington, DC, USA.

Baker, R. C. and D. Scottkline. 1988. Development of high protein coating batter using egg albumen. Poult. Sci. 67:557-564.

Bekhit, A. E. D., M. M. Farouk, L. Cassidy and K. V. Gilbert. 2007. Effect of rigor temperature and electrical stimulation on venison quality. Meat Sci. 75(4):564-574.

Devine, C. E., S. R. Payne and R. W. Wells. 2002. Effect of muscle restraint on sheep meat tenderness with rigor mortis at 18°C. Meat Sci. 60:155-159.

Devine, C. E., S. R. Payne, B. M. Peachey, T. E. Lowe, J. R. Ingram and C. J. Cook. 2002. High and low rigor temperature effects on sheep meat tenderness and ageing. Meat Sci. 60: 141-146.

Dransfield, E. and D. N. Rhodes. 1975. Texture of beef M. semitendinosus heated before, during and after development of rigor mortis. J. Sci. Food Agric. 26(4):483-491.

Hamm, R. and K. O. Honikel. 1994. Determination of the water-holding capacity of meat: history of the filter-paper press method and critical review. Meat past and present: research, production, consumption. Selected topics in retrospection on the occasion of 40th Inter. Conf. Meat Sci. Tech., The Hague, Netherlands, 28th Aug.-2nd Sept. TNO Topics in Nutr. Food Res. (Ed. W. Sybesma, P. A. Koolmees and D. G. van der Heij). TNO Nutrition and Food Research Institute, Zeist, Netherlands.

Jaime, I., J. A. Beltrain, P. Cena, P. Lopez-Lorenzo and P. Roncales. 1992. Tenderization of lamb meat: Effect of rapid postmortem drop on muscle conditioning and ageing. Meat Sci. 32(4):357-366.

Keeton, J. T. 1983. Effect of fat and sodium chloride/phosphate level on chemical and sensory properties of pork patties. J. Food Sci. 48:878-881.

Koohmaraie, M., M. E. Doumit and T. L. Wheeler. 1996. Meat toughening does not occur when rigor shortening is prevented. J. Anim. Sci. 74(12):2935-2942.

Kovacs, M. V. 1996. Effect of pre rigor stretch and various constant temperatures on the rate of post-mortem pH fall, rigor mortis and some quality traits of excised Porcine Biceps femoris strips. Meat Sci. 42(1):49-66.

Loucks, L. J., E. E. Ray, B. W. Berry, E. A. Leighton and D. G. Gray. 1984. Effects of mechanical tenderization and cooking treatments upon products attributes of pre- and post-rigor beef roasts. J. Am. Sci. 58(3):626-630.

Mahendrakar, N. S., N. P. Dani, B. S. Ramesh and B. L. Amla. 1989. Studies on influence of age of sheep and postmortem carcass conditioning treatments on muscular collagen and its thermolability. J. Food Sci. Technol. 26:102-105.

Mahendrakar, N. S., N. P. Dani, B. S. Ramesh and B. L. Amla.

1990. Effect of postmortem conditioning of ewe carcasses on instrument texture profile of cooked thigh muscles. Meat Sci. 28:195-202.

Okumura, T., K. Saito, T. Nade, S. Misumi, Y. Masuda, H. Sakuma, S. Nakayama, K. Fujita and T. Kawamura. 2007. Effects of intramuscular fat on the sensory characteristics of *M. longissimus* in Japanese Black Steers as judged by a trained analytical panel. Asian-Aust. J. Anim. Sci. 20(4):577-581.

Park, B. Y., J. H. Kim, S. H. Cho, K. H. Hah, S. H. Lee, C. H. Choi, D. H. Kim, J. M. Lee, Y. K. Kim, J. N. Ahn and I. H. Hwang. 2007. Evidence of significant effects of stunning and chilling methods on PSE incidences. Asian-Aust. J. Anim. Sci. 20(4):257-262.

Raj, K. R., J. R. Rao, N. D. Rao and N. S. Mahendrakar. 2000. Influence of direct and delayed chilling of excised female buffalo muscles on their textural quality. Meat Sci. 56:95-99.

Savell, J. W., S. L. Mueller and B. E. Baird. 2005. The chilling of carcasses - A review. Meat Sci. 70(3):449-459.

Scheffler, T. L. and D. E. Gerrard. 2007. Mechanisms controlling pork quality development: the biochemistry controlling postmortem energy metabolism. Meat Sci. 77(1):7-16.

Schwegele, F., F. K. Luecke and K. O. Honikel. 1991. Practical way of improving meat quality. Fleischwirtschaft, 71(6):684-688.

Sharma, N., R .C Keshri, G. S. Padda and B. D. Sharma. 1988. Influence of hot boning on meat yield and physical characteristics of goat carcass. Indian J. Anim. Sci. 58(9): 1122-1124.

Snedecor, G. W. and W. G. Cochran. 1989. Statistical methods. 8^{th} edn. Oxford and IBH Pub. Co., New Delhi.

Toohey, E. S. and D. L. Hopkins. 2006. Eating quality of commercially processed hot boned sheep meat. Meat Sci. 72(4):660-665.