EFFECT OF ELECTRICAL STIMULATION IN DIFFERENT CUTS OF BLACK BENGAL GOAT CARCASSES

S. Biswas[1], A. K. Samanta[1] and B. K. Biswas[1] and Arun K Das[2]
[2]Directorate of Research, Extension and Farms,
West Bengal University of Animal and Fishery Sciences, Kolkata, India
[1]Eastern Regional Station, ICAR-Indian Veterinary Research Institute, Kolkata, India

Abstract- A study was undertaken to evaluate the effect of electrical stimulation (ES) on different muscles of Black Bengal (BB) goats for meat quality improvement. ES of goat carcasses improved the rate of pH decline, altered to a very small extent the sarcomere length and collagen content. It also slightly influenced the proximate composition as ES primarily decreased moisture percentage leading to a total change of other dependent quality parameters. The shear force value was decreased in stimulated cuts and all the muscles though apparently received the same electrical stimuli but reacted differently in terms of tenderness improvement is concerned. The sensory attributes of the stimulated part seemed to be always act positive direction for tenderness but leg, loin and rack part reacted more better way than that of neck-shoulder and breast-shank substantiating the views that identifying effective means for tenderizing all the muscles in the carcass appeared to be an important area for future electrical stimulation research. The present study hinted towards this direction for researcher to take up this issue in their future endeavour.

Key words- Electrical stimulation, goat, meat quality]

I. INTRODUCTION

Among 20 well defined breeds of goat in India, the Black Bengal (BB) goat is a dwarf breed, highly prolific and famous for its superior quality of meat and skin. It is considered as “poor man’s cow” and regarded as the “National meat animal” of India. With an annual growth rate of 2.4%, this animal has a very good contribution to a tune of approximately 230 thousand millions to livestock GDP of India. The animals are generally put for slaughter when these lose utility of life and considered as the spent ones. Obviously the meat of such animal is tough and suffers consumers disdain [1]. To overcome this use, electrical stimulation soon after the exsanguinations is general practiced and adopted widely in abattoirs. Literature is plentiful on the effect of electrical stimulation on muscle and changes in physicochemical, sensory and proximate composition of the meat, but mapping of the different carcass muscles based on electrically stimulated and non-stimulated condition on Black Bengal goat meat is a new area of study. Hence, in the present study attempt has been made to evaluate the effect of electrical stimulation on different muscles of the carcass of BB goat comparatively to controlled group by using electrical inputs of volt, hartz and pulses.

II. MATERIALS & METHODS

In the present study, carcasses of male BB goats (*Capra hircus bengalensis*) between two and three years of age were used. A total 10 goats weighing from 19 to 21 kg were slaughtered and were randomly allotted to each of the two treatment groups where one group was exposed to electrical stimulation with a voltages of 330V with fixed 50 Hz and 10 pulses/s for a total duration of 3 min. The other group remained as control. The selection of present voltage that 330V was on the basis of experimentation on efficacy of different voltage treatments where 330V was found to be ideal and best for improving quality of chevon [1]. The pre-slaughter care, slaughter and dressing of the goats were conducted as per standard procedures. The dressed carcasses were halved by splitting through the vertebral column. One half received the electrical stimulation and the other half remained as a control.

The following parameters were estimated to evaluate the effect of electric stimulation in different muscles of the stimulated carcass. Moisture, crude fat, ash and protein of muscles were determined as per standard procedures of AOAC [2]. pH of meat sample was measured by digital pH meter. Water-holding capacity (WHC) of meat was estimated by a centrifugation method [3]. Cooking loss was determined per the procedure outlined by Das et al. [4]. Collagen solubility assay was performed according to the procedure of Hill [5]. Fibre diameter and sarcomere length were measured using the methods outlined by Jeremiah & Martin [6] and Cross et al. [7]. Warner-Bratzler (WB) Shear force was estimated by using a WB shear machine. For each sample, 10 observations were recorded and values were expressed in kg/cm^2.

Ten member trained taste panelists evaluated the coded and heated samples from each carcass cuts using a nine point hedonic score card, in which score 1 indicated extremely tough and the score 9 extremely tender meat. The other traits of sensory attributes i.e. flavor, juiciness and overall acceptability were also studied with same 9 point hedonic score card. Statistical Analysis of data was done using SPSS (Version 16.0) software.

III. RESULTS AND DISCUSSION

ES on proximate composition of goat meat

The chemical composition of stimulated and control of different cuts of BB goat carcasses were presented in Table 1. Results show that the moisture content in all the stimulated cuts were decreased as compared to their corresponding control part substantially but values were statistically found to be insignificant. The lower moisture percentage in electrical stimulated cuts can be explained with the observation of Bendall [8] where he noted that the loss of moisture due to ES might be due to the elevation of muscle temperature during stimulation even upto 12°C. This enhancement of temperature causes evaporation and reduce the ability of the muscle to retain moisture to certain extend in stimulated muscle as it was also evident in the present study. In regard to protein, there was a very less diminution of the values between control and stimulated part of the carcass where stimulated part showed a less of protein than that of corresponding control. The similar observation in deduction in the protein content was also reported by McKeith et al. [9], Biswas et al. [1], where they were in opinion that this deduction in value might be due to denaturation and hydrolysis of myofibrillar and lysosomal structure as well as connective tissue proteins as application of electrical stimulation substantially caused a muscle disruption and certain co-aggulation of microstructure within the protein due to raising of muscle temperature.

While analyzing fat content of stimulated and control groups of different cut up parts of BB goat carcass, it was noted that in all the cut up parts in stimulated part, the fat percentage decreased but not significantly. This reduction in value has been observed also by Cross and Tennent [10] also where they also noted a clear decrease in raw fat percentage in electrical stimulated beef Longissimus muscle. Several factors such as chilling rate, outside fat cover, initial pH, rate of pH decline and initial muscle temperature were responsible to influence the traits like status of fat within a carcass. The effect of electrical stimulation could be helpful to explain the observation in the present study in regard to the results of fat percentage.

The WHC and pH of the muscle sample of different wholesale cuts were electrically stimulated (ES) and found to be insignificant than those of control cuts (Table 2). ES effectively accelerated post-mortem glycolysis as evidenced by low pH values post-mortem. The attainment of low pH and WHC in the present study was in agreement with the results of Hwang and Thompson [11] and Strydom et al. [12]. Conditions of low pH and high temperature in post-mortem muscle reduce the WHC of meat, an effect attributed to the denaturation of muscle proteins, particularly myosin [13]. The pH declines due to ES also contribute to a reduced WHC, though the magnitude of the effect depends on the chilling rate [14, 15, 12]. Fiber diameter and sarcomere length which serve as indices for evaluating tenderness are related to tenderization process and are influenced by the degree of tension on the skeletal muscles by their skeletal attachment. This can be substantiated in the present study where improvement of tenderness in different muscle happened differently (Table 2).

The total collagen and soluble collagen as studied in the control and stimulated carcass parts showed that there was no significant difference ($p>0.05$) between the values of stimulated and control parts both in total collagen and soluble collagen. But results showed that total collagen decreased to certain extent in all the stimulated part whereas there was an enhancement of the soluble collagen content in the stimulated part than that of control in all the parts in the present study. The result of the present study was in agreement of McKeith et al. [9], Dutson et al. [16] and Judge et al. [17] where these researchers also found that diminution of collagen content in the ES meat compared to the control.

Cooking loss was analysed in both control and stimulated parts of the carcasses and the results showed that the cooking loss was always less in the stimulated parts than that of corresponding control parts of the different carcass cuts. The results were insignificant but lower values in the treated part could be explained with the values of moisture content of the stimulated parts and control parts of the carcasses. As in stimulated parts, there was lower content of total moisture which may be reflected through the observation of lower cooking loss in treated parts of the carcasses than that of control parts.

Sensory attributes of control and electrical stimulated cuts of black Bengal goat

The different traits of sensory attribute namely tenderness, flavor, juiciness and overall acceptability of control and electrical stimulated cuts of black Bengal goat carcasses were assessed. After analyzing the results, there was a reasonable improvement in quality by electrical stimulation irrespective of cuts and all the cuts received the electrical stimuli more or less uniformly and an improvement was also noticed. These observations were in agreement with the observation of Gadiyaram et al. [18] and Cetin and Topcu [19], where they also worked on the effect of ES on sensory attributes of goat carcasses

IV. CONCLUSION

On critical analysis of the tables it could be concluded that the improvement in tenderness score were not the same in all the cuts of the carcass. Better improvement in tenderness scores (>8%) were observed in leg, loin and rack, whereas neck-shoulder and breast-shank cuts, the improvement were comparatively less (<4%). Such observation in goat carcasses was not available in the literature, however, in a similar study Smith [20] noted that ES did not ensure that all the muscles of the carcass be effected by ES uniformly. ES appeared to be most effective for improving tenderness of the *Longissimus dorsi thoracis* muscle, partially effective in improving the tenderness of some of the muscles of sirloin and round, and relatively ineffective for improving the tenderness for almost all the muscles in chuck. This work was based on beef carcass, found to be pertaining in the present context of the study in goat carcasses. Smith [20] also hinted that identifying the effective means for tenderizing of all the muscles in the carcass appear to be an important area for future ES research.

ACKNOWLEDGEMENTS

The authors would like to thank the Vice-Chancellor, West Bengal University of Animal and Fishery Sciences, Kolkata, India for extending the facilities to carry out this work.

REFERENCES

1. Biswas, S., Das, A. K., Banerjee, R. and Sharma, N. 2007. Effect of electrical stimulation on quality of tender stretched chevon sides. Meat Science 75: 332-336.
2. AOAC 1995. Official methods of analysis, 16th edn. Association of Official Analytical Chemists, Washington DC.
3. Wardlow, F. B., McCaskill, L. H., and Acton, J. C. 1973. Effect of postmortem muscle changes of poultry loaf properties. Journal of Food Science 38: 421.
4. Das, A.K. and Singh, N.P. 2006 .A comparative study on meat quality of three Indian goat breeds. Indian Journal of Animal Sciences
5. Hill, F. 1966. The Solubility of intramuscular Collagen in Meat Animals of Various Ages. Journal of Food Science 31 (2):161-166
6. Jeremiah, L.E. and Martin, A.H. 1977. The influence of sex within breed of sire groups upon histological properties of bovine Longissimus dorsi muscle during post-mortem aging. Canadian Journal of Animal Science 57: 7.
7. Cross H.R., West, R.L. and Dutson T. R. 1981. Comparison of methods for measuring sarcomere length in beef semitendinosus muscle. Meat Science 5: 216
8. Bendall, J. R. 1976. Electrical stimulation of rabbit and lamb carcasses. Journal of the Science of Food and Agriculture 27: 819-826.
9. McKeith, F., Smith, C., Dutson, T., Savell, J., Hostetler, R. and Carpenter, Z. 1980. Electrical stimulation of intact or split steer or cow carcasses [Increases tenderness]. Journal of Food Protection 43: 795.
10. Cross, H. and Tennent, I. 1980.Accelerated processing systems for USDA choice and good beef carcasses. Journal of Food Science 45: 765-768.
11. Hwang, I. and Thompson, J. 2001.The effect of time and type of electrical stimulation on the calpain system and meat tenderness in beef longissimusdorsi muscle. Meat Science 58: 135-144.
12. Strydom, P., Frylinck, L. and Smith, M. 2005. Should electrical stimulation be applied when cold shortening is not a risk? Meat Science, 70, 733-742.
13. Offer, G. (1991). Modelling of the formation of pale, soft and exudative meat: Effects of chilling regime and rate and extent of glycolysis. Meat Science 30(2): 157-184.
14. Babiker, S. A. and Lawrie, R. A. 1983. Post-mortem electrical stimulation and high temperature ageing of hot-deboned beef. Meat Science 8: 1-20.
15. DenHertog-Meischke, M., Smulders, F., Van Logtestijn, J. and Van Knapen, F. 1997. The effect of electrical stimulation on the water-holding, capacity and protein denaturation of

two bovine muscles. Journal of Animal Science 75: 118-124.

16. Dutson, T., Smith, G. and Carpenter, Z. 1980. Lysosomal enzyme distribution in electrically stimulated ovine muscle. Journal of Food Science 45: 1097-1098.
17. Judge, M., Reeves, E. and Aberle, E. 1981. Effect of electrical stimulation on thermal shrinkage temperature of bovine muscle collagen. Journal of Animal Science 52: 530.
18. Gadiyaram, K., Kannan, G., Pringle, T., Kouakou, B., McMillin, K. and Park, Y. 2008. Effects of postmortem carcass electrical stimulation on goat meat quality characteristics. Small Ruminant Research 78: 106-114.
19. Cetin, O. and Topcu, T. 2009. Effects of electrical stimulation on meat quality in goat carcasses. Journal of Food, Agriculture and Environment 7: 101-105.
20. Smith, G. 1985. Effects of electrical stimulation on meat quality, color, grade, heat ring, and palatability. Advances in meat research. Springer.

Table 1: Chemical composition of control and electrical stimulated cuts of BB goats.

Traits	Carcass cut up parts/ Components									
	Leg		Loin		Rack		Neck and Shoulder		Breast and Shank	
	Control	stimulated	Control	stimulated	Control	stimulated	Control	stimulated	Control	stimulated
Moisture	74.89 ±0.12^{a}	73.29 ±0.08^{a}	74.23 ±0.15^{a}	73.24 ±0.16^{a}	75.09 ±0.11^{a}	74.16 ±0.34^{a}	73.25 ±0.08^{a}	73.94 ±0.12^{a}	74.01 ±0.13^{a}	73.15 ±0.09^{a}
Protein	20.13 ±0.09^{a}	20.06 ±0.16^{a}	19.54 ±0.08^{a}	19.42 ±0.14^{a}	20.43 ±0.10^{a}	20.16 ±0.25^{a}	19.08 ±0.11^{a}	19.26 ±0.06^{a}	19.22 ±0.09^{a}	19.76 ±0.04^{a}
fat	1.31 ±0.15^{a}	1.28 ±0.08^{a}	1.42 ±0.07^{a}	1.38 ±0.10^{a}	1.39 ±0.08^{a}	1.34 ±0.17^{a}	1.41 ±0.14^{a}	1.36 ±0.19^{a}	1.31 ±0.09^{a}	1.26 ±0.11^{a}
Ash	1.02 ±0.03^{a}	0.97 ±0.13^{a}	1.05 ±0.02^{a}	0.94 ±0.15^{a}	1.07 ±0.01^{a}	0.94 ±0.24^{a}	1.10 ±0.03^{a}	0.98 ±0.14^{a}	1.11 ±0.02^{a}	0.97 ±0.16^{a}

Means bearing different superscripts in a row (a,b,c etc.) differ significantly ($p<0.05$).
Means bearing same or common superscripts in a row do not differ significantly ($p>0.05$).

Table 2: Physico-chemical and meat quality of control and electrical stimulated cuts of BB goats.

Traits	Carcass cut up parts/ Components									
	Leg		Loin		Rack		Neck and Shoulder		Breast and Shank	
	Control	stimulated	Control	stimulated	Control	stimulated	Control	stimulated	Control	stimulated
pH 24 hr	5.59±0.05^{a}	5.31±0.16^{a}	5.60±0.06^{a}	5.52±0.09^{a}	5.63±0.02^{a}	5.59±0.05^{a}	5.72±0.07^{a}	5.64±0.18^{a}	5.68±0.02^{a}	5.49±0.18^{a}
WHC	27.12 ± 0.43^{a}	27.08 ±0.07^{a}	28.01±0.52^{a}	27.94±0.13^{a}	28.14±0.48^{a}	28.03±0.08^{a}	29.36±0.44^{a}	29.17±0.16^{a}	28.56±0.41^{a}	28.27±0.13^{a}
Total Collagen (mg/g)	5.56±0.25^{a}	5.50±0.06^{a}	5.88±0.37^{a}	5.85±0.24^{a}	6.43±0.24^{b}	6.52±0.28^{b}	8.82±0.22^{d}	8.76±0.16^{d}	7.02±0.45^{c}	7.10±0.18^{c}
Soluble collagen (%)	0.56±0.21^{a}	0.61±0.13^{a}	0.58±0.19^{a}	0.59±0.04^{a}	0.61±0.22^{a}	0.64±0.06^{a}	0.66±0.26^{a}	0.68±0.19^{a}	0.57±0.21^{a}	0.60±0.13^{a}
Fibre diameter (µm)	41.54 ± 0.17^{a}	40.36 ± 0.17^{a}	39.42 ± 0.11^{a}	38.29± 0.16^{a}	41.37± 0.16^{a}	40.17±0.15^{a}	42.06±0.14^{a}	41.97± 0.26^{a}	38.98±0.12^{ab}	37.28±0.19^{b}
Sarcomere length (µm)	2.18 ±0.08^{a}	2.14± 0.28^{a}	2.13±0.07^{a}	2.19±0.38^{a}	2.21±0.11^{a}	2.26±0.16^{a}	2.09±0.09^{a}	2.16±0.18^{a}	2.18±0.10^{a}	2.27±0.16^{a}
Cooking loss (%)	37.34 ± 0.32^{a}	36.41 ±0.18^{a}	36.63 ±0.36^{a}	35.28 ±0.16^{ab}	36.09 ±0.29^{a}	35.49 ±0.06^{ab}	35.62 ±0.34^{ab}	34.86 ±0.09^{b}	35.76 ±0.33^{ab}	35.09 ±0.13^{ab}
Shear force (kg/cm^{2})	5.68±0.49^{a}	5.53±0.17^{a}	5.84±0.42^{a}	5.64±0.19^{a}	6.02±0.50^{b}	5.90±0.08^{b}	7.54±0.53^{d}	7.42±0.18^{d}	7.21±0.47^{c}	7.13±0.24^{c}

Means bearing different superscripts in a row (a,b,c etc.) differ significantly ($p<0.05$).
Means bearing same or common superscripts in a row do not differ significantly ($p>0.05$).