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Original article

Physical and Organoleptic Characteristics of Pre-Rigor Leg-Twisted Red Sokoto Goat Carcasses

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Abstract

The efficiency of leg-twisting treatment as a method of improving goat muscle tenderness and eating qualities were determined. Twelve matured good grade Red Sokoto does were dressed conventionally with the hind hoofs retained on a randomly selected side of each carcass. Leg twisting was effected by inserting one hoof into a slit made anterior to the flank muscle. Both sides were suspended by the Achilles tendon and moved into the cold room within 30 min post-mortem and chilled for 48 hours. The semimembranosus (SM), the semitendinosus (ST) and the biceps femoris (BF) were excised from each half and used for the study. The result of the study showed that the sarcomere increased in all the three muscles as a result of leg-twisting. The treatment also improved tenderness by 1.4, 6.17 and 32.71 percent for SM, ST and BF muscles respectively. Except in the SM, where the water holding capacity (WHC) increased (P>0.05) there was a reduction in the WHC of the other two muscles while the drip loss increased as a result of leg-twisting in the three muscles. The sensory score for SM improved significantly (P<0.05) in all the parameter measured while the improvement in other muscles were not significant (P>0.05).

Key words: Pre-rigor, leg-twisting, organoleptic, muscles, carcass

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Introduction

There is an increasing demand for leaner meat in order to safeguard consumer's health from heart related diseases. Goat meat has unique attributes which will be beneficial to the present day consumers. Goat has 10 and 19% more lean carcass than cattle and lamb respectively. Casey (1982) reported that goat has fat content that is lower by 47 and 54% than beef and mutton respectively. The future of goat meat as an important nutrient source to a large part of the world population is indisputable but unfortunately it has not been researched as extensively as beef, pork and mutton. Although, goat meat have some unique characteristics but several studies have indicated that goat meat is inherently less tender than sheep. They have higher collagen content with lower solubility than sheep, (Heinze *et al.*, 1986).

In an attempt to improve tenderness, some researchers focused on the use of tenderizers while some focused on the use of electrical stimulations (Derbyshire *et al.,* 2007), some however centered their research on physical stretching or controlling the shortening of sarcomere during rigor development. The methods of pre-rigor muscle stretching that have been considered and investigated include alternative suspension of carcasses (Hostetler *et. al.,* 1970) and applying tension to muscles with weights or mechanical devices (Sonaiya and Stouffer, 1982) even, hind leg twisting (Odusanya and Okubanjo, 1983) has been attempted. However, these practices have not been thoroughly investigated on goats, especially the Maradi breed (Red Sokoto) with their attendant tough meat. This present study therefore aimed at investigating the effect of leg twisting on tenderness and eating qualities of red Sokoto goats.

Materials and Methods

Slaughtering and dressing

Twelve matured Red Sokoto does of good grade with live weight ranging between 15 and 17kg were slaughtered on the same day following stunning. The slaughtered goats were conventionally dressed and split into halves. One side of each carcass was randomly assigned to the control (conventional) or to the leg-twisting method of suspension (treatment). The distal portion of the hind leg of the control sides were removed at the tarsal joint while that of the treated sides were not removed but thoroughly washed and rinsed with fresh cool water without contaminating other parts of the carcass (Fapohunda and Okubanjo, 1987). The leg twisting treatment was accomplished by making a slit in the flank at the level of the cranio-ventral tip of the rectus abominis. One hoof of the leg was tucked into the slit such that the thin part of the flank formed a sling in the crevice between the hoofs (Okubanjo, 1978). Both sides of the carcasses were suspended by the Achilles tendon. The carcasses were then moved into the cold room maintained at 1^0C within 30 minutes post-mortem (Okubanjo, 1978).

Dissection and Sampling

Following a 48 hour chill period, the semitendinosus (ST), semimembranosus (SM) and biceps femoris (BF) were excised from the thigh of each side. The excised muscles samples were tightly wrapped in polythene bags and frozen for further use.

Water holding capacity

This was determined by the press method described by Wierbicki and Deatherage (1958) as modified by Tsai and Ockerman (1981). Duplicate samples of each muscle from each group (control and leg - twisted) were used. Approximately 0.5g of sample was weighed onto a 9cm Whatman No 1 filter paper (Model C, Carver, Inc, Wabash, IN, USA) and pressed between two 10.2X 10.2 cm plexi glasses at approximately 35.2 $kgkm^3$ for 1 min. the area of free water was measure using a compensatory planimeter (Plannix 5000, Tamaya Technics, Inc, Tokyo, Japan) and percent free water was calculated based on sample weight and moisture content. Percent bound water (WHC) was calculated as 100% minus free water %.

Drip loss

This was measured by the method of Barton-Gade et al. (1993) with some modifications. Steaks from each muscle were weighed immediately after

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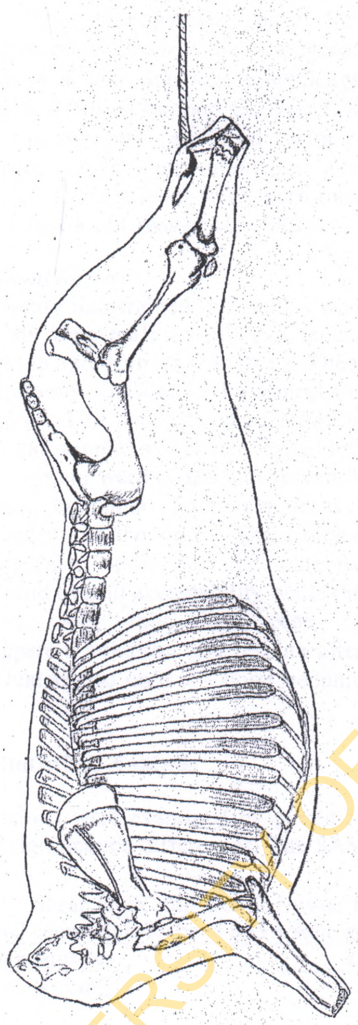
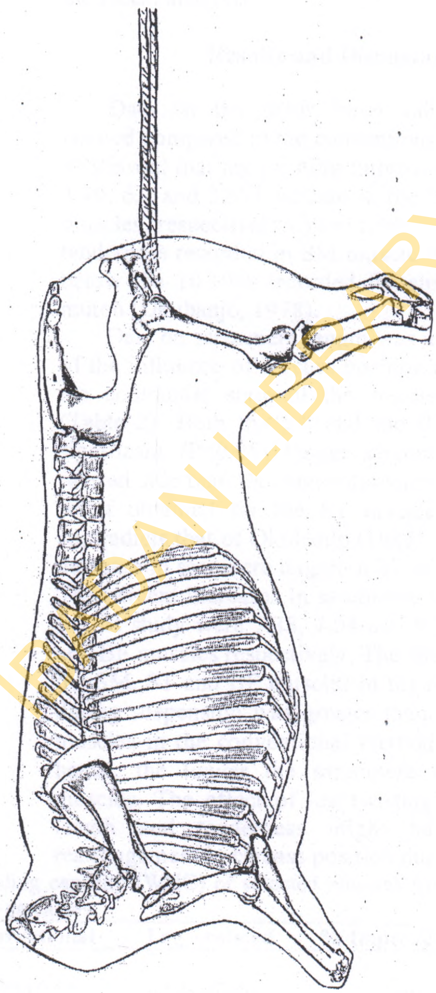
removal, hung in a laminate bag, closed tightly with strings. The meat samples were weighed again after 48 hrs at 4^0C and the drip loss calculated.



Conventional



Leg twisting

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Shear force measurement

The objective evaluation of tenderness was performed using the modified Warner Bratzler shear force procedure (Bouton and Harris (1978). Meat samples from each muscle type were cooked to an internal temperature of 72^0C. The cooked samples were allowed to equilibrate to room temperature. Three cores of 1.0 cm diameter were removed from each cooked meat sample using an electric coring machine. The coring was done parallel to the orientation of muscle fibre and each core was sheared at three locations with Warner Bratzler shear force instrument.

Sarcomere length measurement

Approximately 4g of tissue was cut from each frozen sample, placed into 15-20 ml of cold solution containing 0.25 M sucrose and 0.002 M potassium chloride (KCl), and homogenized until fibre separation was noticed. A drop of the homogenate was then placed on a slide and sarcomere length was measured with a Nikon Nippon Kokagu K.K. phase contrast microscope equipped with a calibrated eye-piece. Nine measurements were taken per sample. Calculations were performed according to the formula of Cross *et al.* (1980).

Taste panel evaluations

A total of twenty four trained individuals were used. The panelists were male (n=10) and female (n=14) and ranged in age from 25 – 35 years. These panelists were randomly allocated to the control and leg twisted samples. The panelists were made to rate each of the meat sample in triplicate. Equal bite size from each treatment were coded and served in an odorless plastic container. Each sample was evaluated independent of the other. The panelist rated the samples on a 9-point hedonic scale for flavour, juiciness and overall acceptability while the tenderness rating was split into ease of fragmentation, apparent adhesion and residue after chewing and evaluated also on a 9 – point hedonic scale.

Statistical Analysis

All data obtained were examined by paired t-test to determine significance differences. The SAS (1999) computer software package was used for all statistical analysis.

Results and Discussion

Data on the shear force values of the leg twisted compared to the conventionally hung (Table 1) showed that leg twisting improved tenderness by 1.40, 6.7 and 32.71 percent in the SM, ST and BF muscles respectively. The 1.4% improvement in tenderness recorded in SM muscle in this study fell below the 10.10% recorded for similar muscle in muton (Okubanjo, 1978).

Data on sarcomere length was used as an index of the influence of carcass position during rigor on the contractile state of the selected leg muscles (Table 2). Both the ST and the BF muscles had significant ($P<0.05$) longer sarcomere in the leg twisted side than the conventionally hung side. The result obtained for the ST muscle in this study contradicts that of Okubanjo (1985) who recorded a decrease in sacomere length in ST of beef carcasses. The percent increases in sarcomere length obtained in this study were 1.38, 7.04 and 8.76 for SM, ST and BF muscles respectively. The strain imposed on the SM, ST and BF muscles in the leg twisted side during suspension was greater than that of similar muscles in the conventional method of suspension hence, the longer the sarcomere of the treated muscles. The effect of leg twisting on sarcomere length and tenderness might be due to the rearrangement in carcass position during rigor.

Table 1: Shear force, drip loss and water holding capacity (WHC) of selected muscles from leg twisted and conventionally hung Red Sokoto goat carcasses

Parameter/ muscles	Conventional	Leg - twisted	% Improvement
Shear force (kg/cm^3)			
SM	5.73±0.64	5.65±0.46	1.40
ST	6.32±0.41	5.93±0.15	6.17
BF	7.52±1.10^a	5.06±0.85^b	32.71
Water holding capacity (%)			
SM	46.69±4.18	50.40±6.09	7.36
ST	41.48±6.54	37.79±14.39	-9.79
BF	46.54±5.60	41.13±5.57	-13.15
Drip loss %			
SM	1.92±0.82	1.98±0.81	-3.13
ST	3.07±0.24	3.16±0.28	-2.93
BF	2.22±0.46^b	3.06±0.17^a	-37.84

^{ab} Means on the same row with similar superscripts are not significantly different ($P>0.05$).
SM: Semimembranosus
ST: Semitendernosus

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BF: Biceps femoris

Table 2: Effect of leg twisting on sarcomere length of selected muscles of Red Sokoto goat carcasses

Muscles	Conventional	Leg twisted	% Improvement
SM	1.45±0.14	1.47±0.10	1.38
ST	1.42±0.21[b]	1.52±0.36[a]	7.04
BF	1.37±0.19[b]	1.49±0.16[a]	8.76

[ab] Means on the same row with similar superscript are not significantly different (P>0.05).

The source of drip loss is generally accepted as intracellular water which is lost from the muscle fiber post-mortem, driven by pH and calcium induced shrinkage of myofibrils during rigor development (Honikel *et. al*., (1986) and Offer *et al*.,1998) The rate and quality of drip formation in fresh meat is believed to be influenced by the extent of rigor shrinkage and permeability of the cell membrane to water as well as other factors, such as the extent of protein denaturation (Offer and Knight, 1988). The drip loss percent recorded in this study ranged from 1.92 to 3.16. Apart from the BF muscle of the leg-twisted that gave a higher (P<0.05) percent drip loss, the SM and the ST of the leg twisted gave values that were statistically similar (P>0.05) to the conventionally hung carcasses. The three muscles exhibited negative improvement in drip loss as a result of leg twisting with values of –3.13, -2.93 and –37.84 percent for SM, ST and BF respectively. It was observed that the muscles with highest water holding capacity gave the least drip loss. This relationship between drip loss and water holding capacity was expected since water holding capacity is the ability of meat to hold on to its water upon the application of an external force.

Apart from SM where leg twisting imposed an improvement of 7.36 % on WHC over their conventionally hung counterparts there was a decrease in WHC of ST and BF by -9.77 and -13.15% respectively. The observed differences in the WHC as a result of leg twisting were however not statistically different (P>0.05) from that of the control.

The sensory score for tenderness was evaluated based on the ease of fragmentation, apparent adhesion and residue after chewing (Table 3). The result obtained on ease of fragmentation ranged between 4.40 and 5.72 when expressed on a 9-point hedonic scale. There were no significant differences (P>0.05) in all the muscles when the control and the treatment were compared. It was however noted that leg twisted muscles gave higher ratings in the SM and BF when compared with that of conventionally hung sides. Ease of fragmentation is one of the parameters of tenderness; it is an expression of the ability of the teeth to cut across the fibers.

Table 3: Sensory score for tenderness of selected muscles from leg twisted and conventionally hung goat carcasses

Parameter/muscles	Conventional	Leg - twisted
Ease of fragmentation		
SM	5.39±0.56	5.72±0.47
ST	5.11±0.91	5.05±0.35
BF	4.40±0.57	4.70±1.87
Apparent adhesion		
SM	4.94±0.73[b]	5.58±0.29[a]
ST	5.02±0.71	5.22±0.47
BF	4.75±0.74	4.50±1.66
Residue after chewing		
SM	5.05±0.47[b]	5.37±0.70[a]
ST	4.67±0.65[b]	5.24±0.62[a]
BF	4.32±0.55	4.44±1.76

[ab]Means on the same row with different superscripts are significantly different (P<0.05).

The values obtained for apparent adhesion were only significant in the SM of the leg twisted sample where a value of 5.58 was obtained as against the value of 4.94 in the conventionally hung side. The result of the residue after chewing showed that leg twisting significantly (P<0.05) improved this parameter in the SM and ST muscles. Although, the values obtained in the BF muscle were not

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significantly affected by the treatment however, a higher rating was obtained for the leg twisted muscles. Residue after chewing is detected as the connective tissue remaining after mastication. The coarse strands of the connective tissue in the perimysium and epimysium might probably be responsible for this component.

The sensory evaluation result for flavor indicated that leg twisting imposed positive improvement on the flavour perception by 4.52, 9.50 and 11.76 % for BF, ST and SM muscles over their counterparts in the conventionally hung sides (Table 4). The flavour rating was however only significant in the SM muscles. In a similar manner, juiciness was improved by leg-twisting. The percent improvement ranged from 1.50 to 8.48 while the SM was the only muscle that was significantly affected ($P<0.05$) in terms of juiciness by leg-twisting.

The meat from the SM muscle of the leg twisted side was preferred ($P<0.05$) by the taste panel. Leg-twisting improved the overall acceptability of the SM muscle by 21.58 percent over that of the control. Although, the differences between the overall acceptability of ST and BF muscles of the leg-twisted and the control were not significant ($P>0.05$) however, it was observed that leg twisting improved the overall acceptability by 1.24 and 1.16 percent in the two muscles over their counterpart in the control. Apart from SM where the panelist gave higher ($P<0.05$) values for flavour, juiciness and overall acceptability for leg twisted samples over the control, the other two muscles (ST and BF) were equally ($P>0.05$) rated for these parameters.

Table 4: Sensory score for flavour, juiciness and overall acceptability of selected muscles from leg twisted and conventionally hung Red Sokoto goat carcasses

Flavour	Conventional	Leg - twisted	%Improvement
SM	5.78±0.26[b]	6.55±1.05[a]	11.76
ST	4.86±0.93	5.37±0.58	9.50
BF	5.49±0.95	5.75±1.73	4.52
Juiciness			
SM	5.29±1.20[b]	5.78±0.59[a]	8.48
ST	4.89±0.40	5.08±0.75	3.74
BF	5.27±0.68	5.35±1.27	1.50
Overall acceptability			
SM	5.05±0.72[b]	6.44±0.69[a]	21.58
ST	4.80±0.37	4.86±0.53	1.24
BF	5.13±0.92	5.19±1.72	1.16

[ab] Means on the same row with similar superscripts are not significantly different ($P>0.05$).

Conclusion

Leg twisting has remarkable effect on shear force values and the organoleptic characteristics such as flavour, juiciness and the overall acceptability. Leg-twisting however increased the rate of drip loss in all the muscles studied while the WHC was only improved ($P>0.05$) in the SM muscle. The sarcomere length increased significantly ($P<0.05$) in the ST and BF muscles as a result of leg-twisting while the improvement recorded in SM sarcomere length was not significant ($P>0.05$).

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