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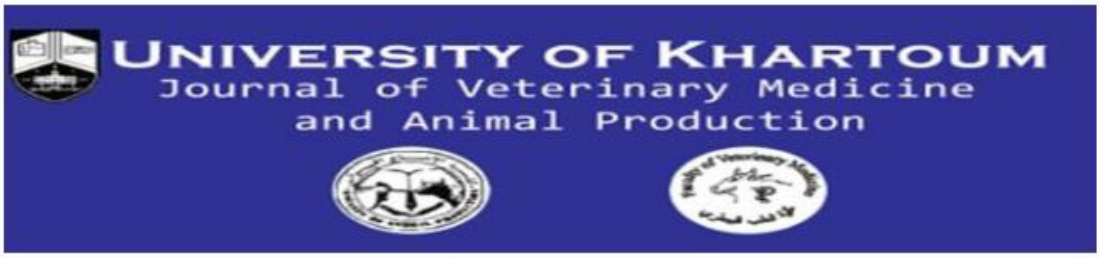

Effect of Postmortem Aging Period on the Meat Quality, Sensory Properties and Total Bacterial Count of Western Baggara Bulls Meat

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Abstract: A study was conducted to investigate the effect of postmortem aging period (1, 5, 10, and 15 days) on meat quality of bovine muscles, Longissimus dorsi, Semimembranosus and Semitendinosus, held at 2°C. Fourteen western Baggara bulls were used. The hindquarters were immediately chilled at 2°C for 24 hours, Longissimus dorsi, Semimembranosus and Semitendinosus were cold deboned, each one was divided into four parts and aged immediately after deboning for 1, 5, 10 and 15 days at 2°C, chemical composition, bacterial load and muscle eating quality were determined. Extractable myofibrillar proteins, non-protein nitrogen and water holding capacity were increased ($P<0.001$), while the extractable sarcoplasmic proteins significantly ($P\leq0.001$) decreased; cooking loss and colour rating scores decreased and tenderness increased numerically with increasing aging period to 15 days. Increasing aging period from 5 to 15 days resulted in low flavour rating and increased juiciness but non-significantly for the three muscles studied. The total bacterial counts values increased slightly with increasing the aging period but the differences between days 1 (control), 5 and 10 were not significant ($P>0.05$) it was only significant between day 15 of aging and the other aging times for all the muscles. SDS polyacrylamide gel electrophoresis revealed a gradual decrease and disappearance of the troponin-T and a built up of a 30 kd component seems to be the major changes during postmortem aging. Complete disappearance of toponin-T and appearance of a 30 kd component at day 10 of aging and continue to be observed at day 15. Aging of Baggara bulls carcasses for 10 days at 2°C is recommended.

Key words: Bovine muscles; quality, sensory properties; aging

المستخاص: أجريت هذه الدراسة للتحقيق في تأثير تأثير طول مدة الانضاج بعد الذبح (1، 5، 10، 15 يوما) على جودة لحوم عضلات Longissimus dorsi, Semimembranosus and Semitendinosus, الأبقار، م . تم °2 التي حفظت في درجة حراره م مئوية لمدة 24 ساعة، °2استخدام أربعة عشر من عجول ابقار البقارة الغربية. تم تبريد الارباع الخلفية على الفور في درجة حراره ، تم تقسيم كل واحده إلى Longissimus dorsi, Semimembranosus and Semitendinosus ثم تمت التشفيه البارده للعضلات م لمدة 1، 5، 10، 15 يوما .تم تحديد كل من التركيب الكيميائي، °2أربعة أجزاء و انضجت اي حفظت مباشرة في درجة حراره قابلية حمل الحمل أ لميكروبي ، وعناصر جودة اللحم المأكول . وجد أن استخلاص البروتينيات الليفية و النيتروجين ألا بروتيني و

بينما استخلاص البروتينيات الساركوبلازمية يقل معنويا ويقل فاقد الطهي ودرجات تقييم اللون ,(P<0.001) الماء يزداد معنويا بينما تزداد الطراة زيادة عدديه بازدياد زمن الإنضاج إلى 15 يوم . زيادة زمن الإنضاج من 5 إلى 15 يوما أسفر عنه انخفاض في درجات تفييم النكهة وزيادة في العصيرية غير معنوية للعضلات الثلاثة التي تمت دراستها . زادت قيم التعداد البكتيرية الكلية بشكل طفيف مع زيادة فترة الانضاج، ولكن الفروق بين الأيام 1 (الشاهد) و 5 و 10 لم تكن معنوية (0.05 >P) كانت معنوية فقط بين اليوم 15 من الانضاج وأوقات الانضاج الأخرى لجميع العضلات. كشف استخدام الترحيل الكهربائي عن انخفاض تدريجي ومن ثم اختفاء وبناء المكون ذو الوزن الجزيئي 30 كيلودالتون ويبدو أنها التغييرات الرئيسية خلال الانضاج بعد الذبح. حيث كان هنالك Tالتروبونين- وظهور مكون 30 كيلودالتون في اليوم 10 من االانضاج وتستمر ملاحظتها في اليوم 15.توصي الدراسه Tاختفاء كامل للتروبونين- بانضاج ذبائح عجول ابقار البقارة لمدة 10 ايام في درجة حراره 2° م .

Introduction

Sudanese beef animals were generally raised on grass till finished and ready for slaughter at 4-5 years of age, depend mainly on the natural grazing system which affects meat production in term of quantity and quality. Both basic and applied research is necessary to improve its quality, preservation and utilization to meet the current marketing trends. Pasture finished beef in general, as compared to grain-finished beef, has a much lower amount of fat, thus has the potential to meet the demand of today's consumer for leaner, high-value meats (Yong *et al.*, 2007). Consumer satisfaction is the most important factor influencing beef consumption which is based on overall palatability of the meat tenderness, juiciness and flavour. Among these palatability traits, tenderness is the most important factor influencing consumer satisfaction, (Miller *et al.*, 2004). Tenderization of meat can be carried out chemically or physically. Aging is a process whereby beef carcasses, are stored, without protective packaging, at refrigeration temperatures for one to more weeks. Meat is aged in order to increase the tenderness over time and to develop the flavors so as to enhance the palatability of the product. Postmortem aging of carcasses after slaughter for varying periods, up to 14 days at 0 - 4°C to improve their tenderness has been practiced for many years and still remains an important procedure for producing tender meat. It is well known that aging has a decisive effect on the quality of the product (Jayasooriya *et al.*, 2007; Sañudo *et al.*, 2004,). Meat tenderness is determined by postmortem proteolysis of myofibrillar and myofibrillar-associated proteins (Koohmaraie and Geesink, 2006 and Troy and Kerry, 2010). There is general agreement that proteolysis of myofibrillar proteins, accelerated by the calpain's proteolytic system, is the major contributor to tenderization of meat during postmortem storage (Bowker *et al.*, 2008; Huang *et al.*., 2011). Caplain plays an important role in meat tenderization by weekening the structural integrity of the myofibrillar protein (Koohmaraie and Geesink, 2006). The degradation of the skeleton proteins plays an important role in the tenderization process .Ho *et al.*, (1996) reported that desmin and troponinT are two of the major cytoskeletal proteins that degrade during postmortem aging. Troponin-T is degraded mainly into the 30 kDa products during postmortem aging. Many researchers have repeatedly shown that a 30 kDa degradation product of troponin-T increases with muscle aging and is associated with tenderization ((Rhee *et al.*, 2000 and Lametsch et al.2003).The aims of the present study were to determine the optimum postmortem aging period required to produce high quality meat from Sudanese Western Baggara bulls.

Materials and methods

Samples preparation: The study was carried out on 14 Western Baggara bulls of 4 years average age and slaughter weight ranged from 320-360 kg (animals were obtained from the Fattening Research Unit of the Department of Meat Production, Faculty of Animal Production;Universityof Khartoum). Hindquarters were obtained immediately after dressing, splitting and washing. They were moved into the meat-cutting laboratory; weights were obtained and kept at 2˚C for 24h. After 24 postmortem, Longissimus dorsi (LD), Semimembranosus (SM) and Semitemdinosus (ST) muscles were dissected. Each muscle was divided into 4 portions, weighed and placed in a polythene bag then assigned at random to one of the 4 aging treatments (1, 5,10 and 15 days) at 2˚C. On completion of the aging period, the sample was dried with a paper towel to determine weep, then sub sampled for quality and chemical analysis.

Colour measurements

Samples were taken from the experimental muscles (LD, SM., and ST) and Hunter colour components lightness (L*) redness (a*) and yellowness (b*) were recorded using Hunter Lab Tristimulus colorimeter model D25 m-2. Subsequently these samples were frozen and stored for cooking loss and shear force determinations.

Water parameters:

Water holding capacity (WHC) was determined according to the procedure of Grau and Hamm (1953). The samples prepared for different aging period were dried by paper towel and weighed, then placed into polyethylene bags and aged at 2°C. After the completion of the aging period, removed from the bags, dried again and reweighed. The difference between the initial and final weights was expressed as a percentage of the initial weight and considered as weep (Follet *et al.*., 1974). Samples (5x5x14 cm) were cut from each muscle after aging, dried by paper towel, weighed and frozen at –18˚C for 5 days. They were then thawed at 2˚C for 50 hours, excess exudates were removed by paper towel and samples were reweighed. The difference in weights before and after freezing and thawing was taken as drip and was expressed as a percentage of weight before freezing. Cooking loss was determined according to the procedure described by (Bouton *et al*.., 1978).

Shear force：Samples 5x5x7 cm cut with the fibre direction parallel to the long axis, each was placed in a polyethylene bag and totally immersed in a water bath at 80ºC for 90 minutes (internal temperature at the centre of sample was 80ºC). After cooking, it was cooled in running tap water for 20 minutes in its exuded fluids and then removed and dried with paper towel. Rectangular meat samples having across sectional of 1cm were shorn across the muscle fibres to give shear force values of the muscle fibers using Instron Universal Testing Machine (Model 1000) fitted with a Warner Bratzler shear device.

Protein fractionation

The samples for protein fractionation were trimmed of excessive subcutaneous fat and connective tissues before mincing. A 5 gm sample was weighed and fractionated into sarcoplasmic and myofibrillar proteins according to the procedure described by Babiker and Lawrie (1983). All fractionation procedures were carried at 4˚C.

Non-protein Nitrogen (N.P.N.): Thirty ml sample from the combined filtrate (containing both sarcoplasmic proteins and N.P.N. fractions) was obtained from the protein fractionation and homogenized with 10 ml of trichloroacetic acid 20% (w/v), for 15 minute and filtered through filter paper (Whatman No. 1) to obtain non-protein nitrogen content of this fraction, which was expressed as a percentage of fresh sample weight.

Electrophoresis

Electrophoresis was conducted on slab gels according to the procedure of Babiker and Lawrie (1983) using a linear gradient of playacrylamide. Gels were prepared as a slab, 21cm long and 0.2cm thick. It consisted of: A stacking polyacrylamide gel solution (Tris/H2So4 buffer 50% mM, pH 6.1; SDS 0.1% polyacrylamide 6%; bisacrylamide 0.156%, temed 0.05% and ammonium persulphate 0.08%), upper part, 5 cm in length with a castellated superior part providing 15 slots for loading of samples. A running polyacrylamide gel, lower part (about 13cm high) consisting of a mixer of the original 10% and 15% gel solution to prepare a linear gradient of polyacylaride (54 ml), and myofibrillar proteins were run in both gels.

Microbiological evaluation

The samples were obtained from the surface of the muscles LD, SM and ST that were excised immediately after 24 hours postmortem (day one) and 5, 10 and 15 days of aging. Duplicate samples were taken from 10 cm2 area by swabbing the area with a sterile cotton swab. The swabs were broken in 10 ml ¼ strength ringers solution. Serial dilutions were made for each sample and each dilution was plated in standard plate-count agar. Duplicates of each sample were incubated at 37˚C for 48 h or at 4˚C for 14 days. Bacterial colony count was expressed as log 10 colony count per 10 cm2.

Sensory evaluation

The muscles samples were overnight thawed at 4ºC, wrapped in aluminum foil, and roasted in an electric oven at 175˚C to an internal temperature of 75˚C.A thermocouples were inserted into the centre of two randomly selected samples and the temperature was recorded every 15 minutes throughout the cooking time (Griffin et al., 1985). Semi-trained panelists,10-members,evaluated warm meat samples in individual booths, for tenderness, flavour, juiciness and acceptability on the basis of a hedonic seale of 5-1, with 5 being extremely tender, desirable flavour, extremely juicy and acceptable and 1 being extremely tough, undesirable flavour, dry or unacceptable.

Statistical analysis

The data of the experiment were analyzed as a completely randomized design with a 3^x4 factorial arrangement of treatments using analysis of variance. Tests were computed for treatments main effects and any interactions among treatments by using SPSS version 10.05- computer program.

Results

Protein fractionation

Table (1) gives means and standard error of the means for percentage myofibrillar, sarcoplasmic proteins and N.P.N. extracted from SM, ST and LD muscles aged for 1,5,10 and 15 days at 2ºC. The amount of extractable myofibrillar proteins increased significantly (P<0.001) from day 1 to days 15 of aging for all the three muscles studied. Most of the increase in the extactability of myofibrillar proteins occurred at day 10 and 15. The amount of extractable sarcoplasmic proteins leptin, serum insulin, and glucose) were calculated using correlation procedure of the statistix8.0.

decreased significantly (P<0.001) with progress of aging time; the least extractable amount of sarcoplasmic proteins was at day 15 from all the 3 muscles. Day one gave the highest extractable amount of sarcoplasmic proteins. This result revealed that LD muscle had the lowest amount of extractable myofibrillar proteins, followed by SM and ST muscles respectively. Soluble non-protein nitrogen (NPN) showed a reverse trend to that of sarcoplasmic proteins and it increased significantly (P<0.001) during postmortem aging time from 1 to 15 days in all the muscles studied. ST muscle exhibited the greater increase followed by SM and LD, respectively. Most of the increase in non protein nitrogen occurred during the 15th day of aging.

50 µl of stop solution was added to each well and mixed well.

The optical density was immediately read at 450 nm.

The mean blank value was subtracted from each sample or standard value and the mean for duplicate (or greater) wells was calculated.

The standard curve was constructed on graph paper.

Statistical analysis

The data obtained from feed intake, insulin, glucose and leptin were subjected to Statistical analysis of variance (ANOVA) for completely randomized design, using computerized program known as statistix[8.0.] . A least significant difference (LSD) was carried out to test significant difference between the treatment means. Pearson product moment correlations between the variables (feed intake,plasma,

Table 1: Means and standard error of the means for myofibrillar , sarcoplasmic proteins and N.P.N. of beef carcass hind quarter muscles as affected by aging time

Parameters	Aging days				SE	LS
	1	5	10	15		
Myofibrillar proteins(%)						
SM	9.49[a]	10.28[b]	11.22[c]	11.99[d]	0.06	***
ST	9.54[a]	10.46[b]	11.36[c]	12.03[d]	0.05	***
LD	9.69[a]	10.28[b]	11.46[c]	12.23[d]	0.05	***
Sarcoplasmic proteins (%)						
SM	6.34[a]	5.91[b]	5.44[c]	5.21[d]	0.059	***
ST	6.32[a]	5.98[b]	5.48[c]	5.30[d]	0.047	***
LD	6.19[a]	5.67[b]	5.45[c]	5.14[d]	0.057	***
Non-protein nitrogen (%)						
SM	0.437[a]	0.448[a]	0.465[b]	0.477[b]	0.003	***
ST	0.439[a]	0.449[a]	0.466[b]	0.478[b]	0.003	***
LD	0.429[a]	0.44 [a]	0.456[bc]	0.467[c]	0.004	***

a – d = means in the same raw bearing different superscript are significantly different (P<0.001).

SDS polyacrylamide gel electrophoresis

Figures 1 and 2 respectively, show the SDS polyacrylamide gels of beef LD and SM muscles respectively, after 1, 5, 10 and 15 days postmortem aging at 2ºC. The two muscles show the same band pattern on SDS electrophoresis gels. A gradual decreased and disappearance of the troponin–T and a build-up of a 30.000 dalton component seems to be the major changes during postmortem aging. A complete disappearance of troponin-T and appearance of a 30 kd component took place at day 10 of aging and continued to be observed at day 15 of aging. Also degradation and alteration of myosin heavy chains was noticed with increase of aging time

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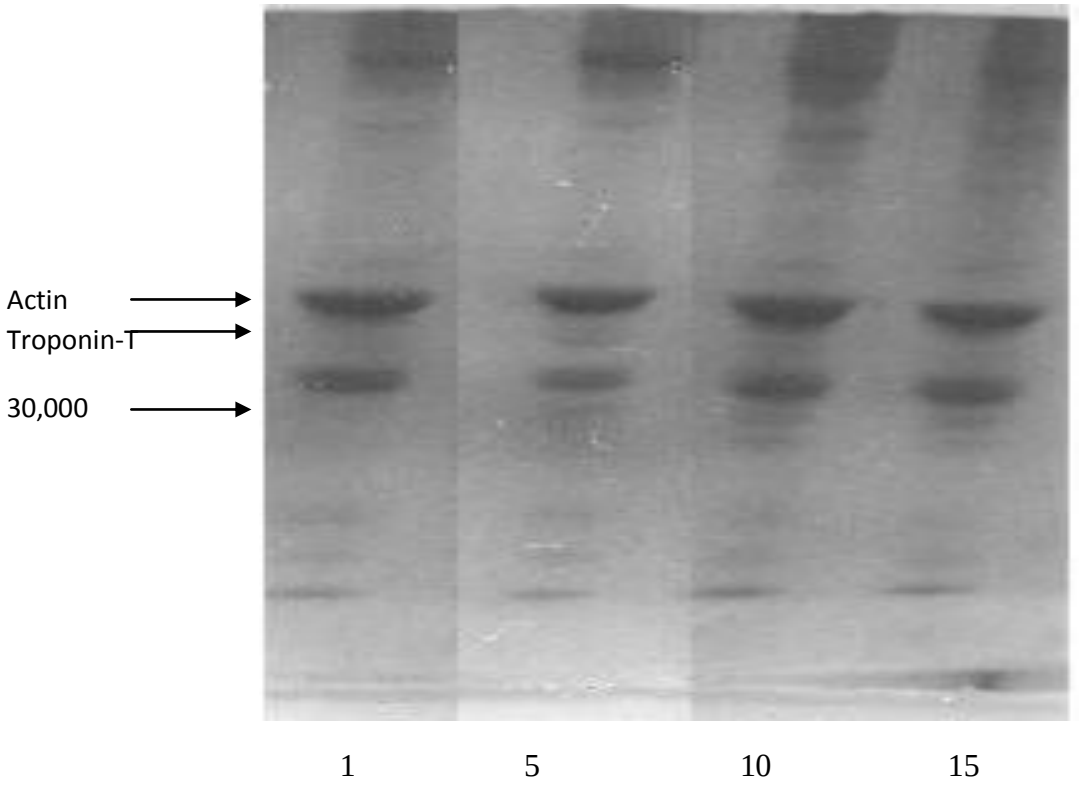

Figure 1: SDS 15% Polyacrylamide gels of myofibrils prepared from Longissimus dorsi muscle aged for various postmortemtimes (1, 5, 10 and 15 days PM) at 2ºC

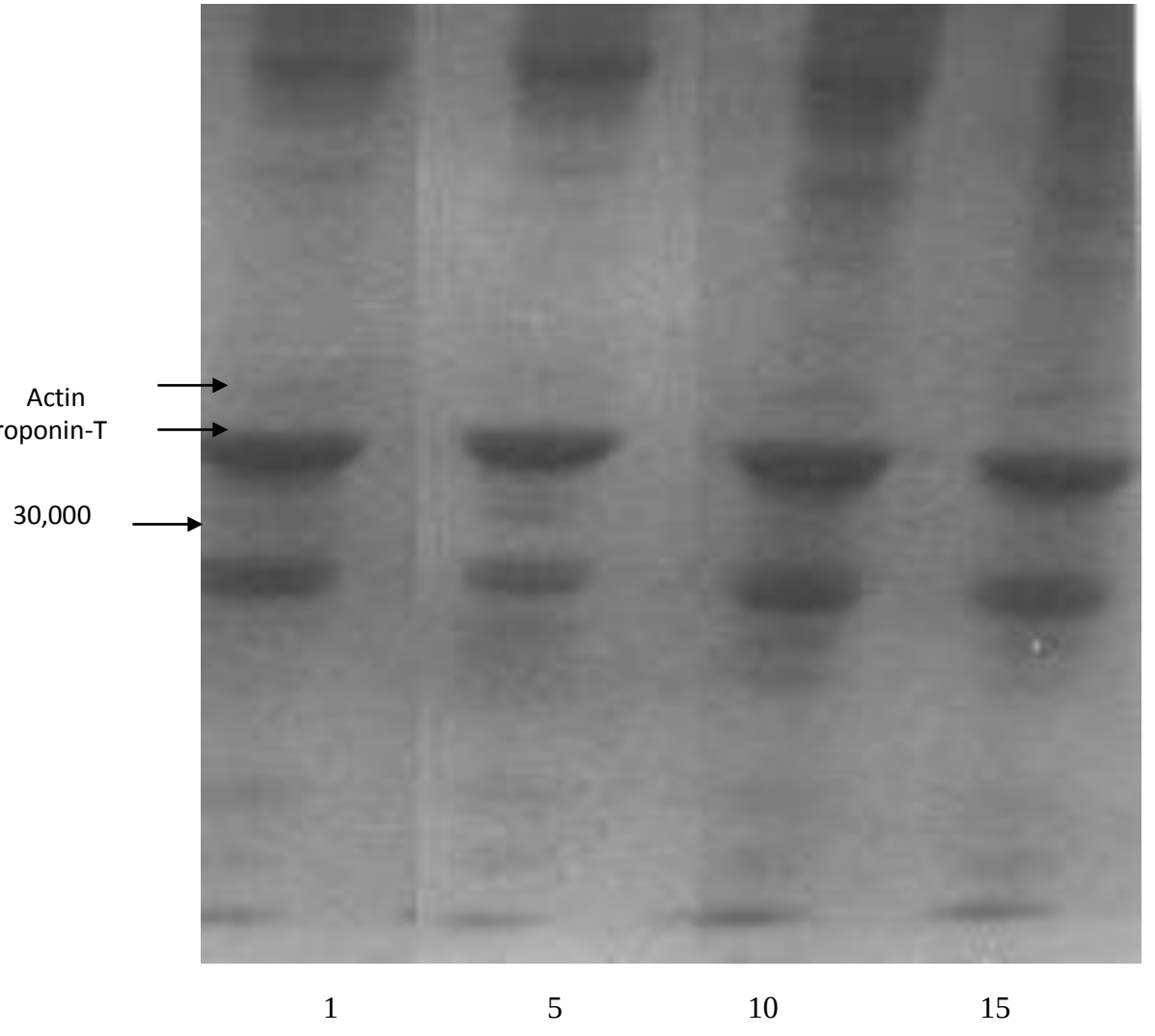

Figure 2: SDS 15% Polyacrylamide gels of myofibrils prepared from Semimembranosus muscle aged for different postmortemtimes (1, 5, 10 and 15 days PM) at 2ºC

Water holding Parameters

Table 2 gives water holding capacity (ratio) and cooking loss (%) for LD, SM and ST muscles aged at 2ºC for 1, 5, 10 and 15 days postmortem. Increasing aging time from 1 to 15 days postmortem was associated with highly significant (P<0.001) improvement in water holding capacity and a significant (P<0.001) decrease in percentage of drip. Cooking loss decreased significantly (P<0.001) with increasing aging time from 1 to 15 days in all of the muscles. The weep increased significantly with increase of aging period among treatments, SM muscle had the highest cooking loss while LD muscle had the least cooking loss and ST was intermediate between the two muscles.

Table 2: Effect of aging time on water holding capacity, drip, weep and cooking loss of some muscles of beef hindquarter

Parameter	Days of aging				SE	LS
	1	5	10	15		
WHC (ratio)						
SM	3.15[a]	2.49[b]	2.14[c]	1.56[d]	0.034	***
ST	3.10[a]	2.49[b]	2.11c	1.52[d]	0.035	***
LD	2.96[a]	2.46[b]	2.03c	1.47[d]	0.037	***
Drip (%)						
SM	6.70[a]	5.64[b]	4.29c	1.98[d]	0.083	***
ST	6.64[a]	5.52[b]	4.13c	1.92[d]	0.061	***
LD	6.46[a]	5.58[b]	4.24c	1.90	0.073	***
Weep (%)						
SM	00.00	2.26[a]	3.52[b]	5.32[c]	0.22	***
ST	00.00	2.27[a]	4.16[b]	5.63[c]	0.23	***
LD	00.00	2.21[a]	3.80[b]	5.32[c]	0.22	***
Cooking loss (%)						
SM	44.49[a]	43.24[b]	40.88[c]	37.00[d]	0.157	***
ST	43.34[a]	42.13[b]	39.19[c]	35.88[d]	0.196	***
LD	44.14[a]	42.97[b]	40.48[c]	36.50[d]	0.22	***

Muscle eating quality

Objective assessment

Figure 3 shows values shear force of LD, SM and ST aged at 2ºC up to 15 days postmortem. There was a significantly ($P<0.001$) decrease in shear force with progress of aging time in all the muscle studied. Day one of aging recorded the highest shear force values and day 15 showed the least value in all the muscles studied. LD muscle had the lowest shear force values, while SM muscle being intermediate and ST muscle had the highest shear force value among the treatments.

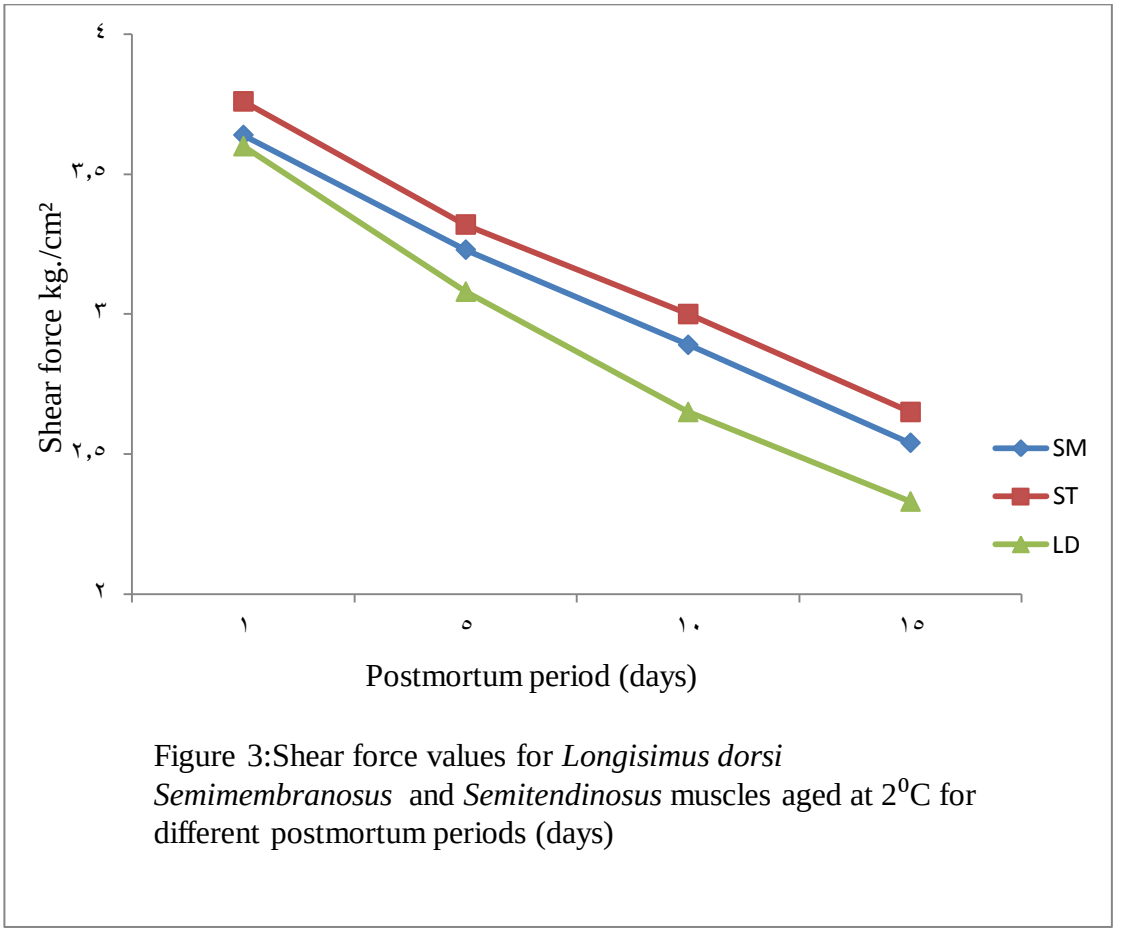

Figure 3:Shear force values for *Longisimus dorsi* *Semimembranosus* and *Semitendinosus* muscles aged at 2^0C for different postmortum periods (days)

Subjective assessment

Table 3 shows means and standard errors for bovine L. dorsi, Semimembranosus and Semitendinosus muscle eating quality attributes. The results show that postmortem aging at 2ºC for either 1,5,10 and 15 days had no significant (P>0.05) effect on cooked LD, SM and ST quality attributes although the sensory panel rating of tenderness, juiciness and acceptability increased not significantly (P>0.05) with increasing aging time for the three muscles. Colour and flavour were more desirable at day 1 and 5 of aging than at 10 and 15 days postmortem although the differences were not significant (P>0.05).

Bacterial colony count

Figure 4 shows the means and standard error of the logarithms of total bacterial count (TBC) at 4ºC and 37ºC for both the control and experimental muscles aged at 2ºC for various postmortem periods (1, 5, 10 and 15 days).

Table 3: Effect of aging on the quality attributes of bovine hind quarter muscle attribute

Parameter	*Days of aging*				SE	LS
	1	5	10	15		
Colour:						
SM	3.14	3.21	3.07	3.29	0.06	NS
ST	3.14	3.32	3.11	3.00	0.05	NS
LD	3.36	3.21	3.21	3.07	0.06	NS
Flavor:						
SM	3.18	3.17	3.16	3.14	0.06	NS
ST	3.21	3.11	3.28	3.32	0.05	NS
LD	3.36	3.25	3.32	3.29	0.06	NS
Tenderness:						
SM	3.25	3.54	3.57	3.61	0.05	NS
ST	3.39	3.57	3.61	3.61	0.05	NS
LD	3.07	3.39	3.53	3.51	0.05	NS
Juiciness:						
SM	3.07	3.11	3.14	3.21	0.06	NS
ST	2.89	3.03	3.06	3.18	0.05	NS
LD	3.14	3.14	3.28	3.39	0.06	NS
Acceptability:						
SM	3.25	3.25	3.29	3.43	0.06	NS
ST	3.11	3.36	3.32	3.36	0.06	NS
LD	3.32	3.46	3.46	3.53	0.06	NS

TBC at 37ºC was observed to increase with increasing aging period. Bacterial counts between day 1 and 5 and between day 10 and 15 were not significant. The increase in total bacterial count was found to be significant ($P<0.001$) between day 10 and day 1 and 5 and between day 15 and day 1 and 5. Total bacterial counts at 4ºC increased slightly with increasing the aging period but the differences between 1 (control), 5 and 10 days treatments were not significant ($P>0.05$). The differences were only significant between day 15 of aging and the other aging times for all the muscles studied. In general the total bacterial counts values were higher at 37ºC than at 4ºC.

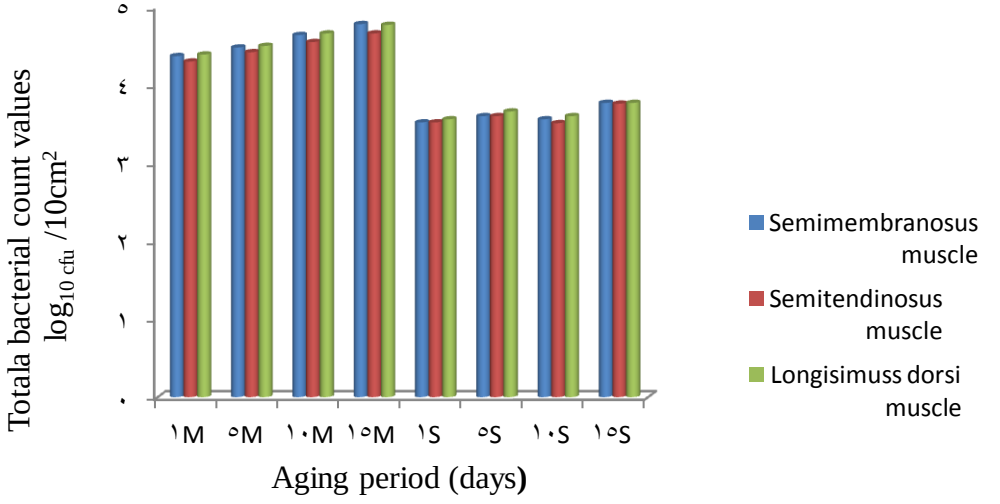

Figure4:Total bacterial counts (mesophiles 37C (M), Sychrophiles4C(S)) of some beef muscles as affected by the aging period(1,5,10,15 days)

Discussion

In the present study the extractability of myofibrillar proteins increased significantly with increasing aging time to 15 days for all the studied muscles. Myofibrillar proteins extractability was lowest at day one (24 h post slaughter) and highest at 15 days of aging for all the three muscles studied. LD exhibited the greater increase and SM be least of the three muscles. On the other hand, the extractability of sarcoplasmic proteins decreased ($P<0.001$) with increasing storage time to 15 days as a result of proteolysis. Sarcoplasmic proteins were most extractable at day one and least extractable at day 15 for all the muscles studied. The soluble non-protein nitrogen increased significantly with increasing aging time to 10 and 15 days. However, there was a non-significant increase in the amount of NPN extracted at 5 days of aging from that at 24h postmortem for all experimental muscles. This could be due to autolytic effect of muscle cathepsins. The protein extractability may be influenced by the breakdown of the myofibrillar structure protein due to postmortem proteolytic activity. These findings agreed with Aberle and Merkel (1966) who reported that the myofibrillar proteins were least extractable at 24 h postmortem but their solubility was significantly higher at 7 and 14 days than at 24 h postmortem in SM and LD muscles. While the sarcoplasmic proteins were most extractable immediately after death and that their solubility subsequently decreased with increasing aging time. Soluble non-protein nitrogen increased significantly during postmortem aging in both L. dorsi and Semitendinosus muscles with Semitendinosus exhibiting the greater increase. Non-protein nitrogenous compounds present in muscle tissue also had received a great deal of attention as to their role in explaining differences in tenderness. Peng *et al.* (2014), study the effect of ultimate pH on postmortem myofibrillar

protein degradation of Londissimus dorsi muscle of Chinese yellow crossbreed cattle and found that myofibril fragmentation index (MFI) was higher in high pHu (6.2) beef than intermediate (5.8- 6.2) and low pHu (5.8) beef throughout aging ($P < 0.05$). MFI significantly increased among the three pHu groups from 1 to 9days postmortem. Polidori et al., (2000) reported that activation of calpain and m-calpain was responsible for postmortem proteolysis and tenderization. In addition, 1-caplain plays an important role in meat tenderization by weekening the structural integrity of the myofibrillar protein (Geesink *et al.*, 2006 and Koohmaraie and Geesink, 2006).

SDS polyacrylamide gel electrophoresis (PAGE) revealed a gradual decrease and disappearance of the troponin-T and a build up of a 30 kd component. Complete disappearance of troponin-T and appearance of a 30 kd component at day 10 of aging and continue to be observed at day 15. These changes seemed to be the major changes during postmortem aging. These changes could be due to proteolysis and enzymatic action of acidic cathepsins. Koohmaraie et al. (1984) found that the major changes in myofibrillar proteins, of bovine L. dorsi and Semimembranosus muscles which were examined on the 14th day of postmortem storage at 2°C by SDS- PAGE were the appearance of 95 kd component and the gradual disappearance of troponin-T and gradual appearance of 30 kd component. Semimembranosus muscle showed major changes beyond 2 days postmortem with the disappearance of titin and troponin-T and the appearance of 30 kd component (Xiong *et al*., 1996). One of the most common indications of protein degradation during aging of L.dorsi muscle for 14 days at 2-4 C is the significant decrease of the Troponin appearance of Tn-T degradation products having molecular weight about 30-kDa (Veselka et al.,2010). Many studies indicate that μ-calpain is responsible for the degradation of proteins postmortem (Geesink et al., 2006; Mohrhauser et al., 2011). Huff Lonergan et al., (2010) also showed that the appearance of the 30-kDa and 28-kDa bands in the myofibril was strongly related to the shear force. Bowker et al., (2008) found that myofibrillar fragmentation and myofibrillar protein solubility increased ($P < 0.01$) with hydrodynamic pressure processing and aging. Sodium dodecyl sulfate-polyacrylamide gel electrophoresis and Western blotting analysis of myofibrillar proteins showed that hydrodynamic pressure processing and aging decreased the intensity of the troponin T (TnT) band and enhanced the accumulation of the 30 kD TnT degradation product. They suggest that hydrodynamic pressure processing is more effective than aging tenderization where tenderization is caused by both protein degradation and physical disruption of the myofibril apparatus

Water holding capacity decreased with increasing aging period up to 15 days in all the three muscles studied. This might be due to aging effect which induced protein denaturation and proteolysis as well as changes in the ionic changes of muscle proteins. Conditioning of meat increases its water holding capacity at various environmental pH values (Lawrie, 1991) which was reflected in the decreased drip and cooking loss percentages. These results were comparable to the results reported by Huff- Lonergan and Lonergan (2005) that the water holding capacity of the meat decreases over time due to the denaturation of the myofibrillar proteins.Our findings agree with Peng *et al*. (2014) who measure the purge loss after vaccum packaging during aging period and reported that it increased as aging time was extended.

Colour rating of aged L. dorsi, Semimembranosus and Semitendinosus muscles revealed a decrease ($P>0.05$) in colour with increasing aging period. Colour pigments oxidation during aging could be the cause, prolongation of storage increased the formation of metmyoglobin on meat surface which became worse the higher the storage temperature and longer the time of storage. Aging of the meat affects the color composition of beef, as aged beef has brighter and slightly red color due to the enzymatic changes that result from the breakdown of certain proteins (Gasperlin,2001; Jayasooriya;2007)

Increasing aging period from 5 to 15 days resulted in low flavour rating possibly due to the changes in the free fatty acids and protein decomposition. The results agree with previous studies, as meat ages, off-flavour attributes increase, while desirable flavours (beefy or brothy) decrease (Gorraiz et al..2002). Beef flavor results from the combination of basic

tastes and odour derived from volatile compounds (Stetzer et al.. 2008) also differences in fat or iron content among muscles have been reported to determine flavour differences (Yancey et al. 2006) . These changes are partly due to an increased availability of free amino acids and dipeptides (Dugan *et al.* 2004) and lipid oxidation products (Melton 1990), which react during cooking contributing to cooked beef flavours. Juiciness increased non-significantly with increasing aging period this could be due to decrease in cooking loss and increased tenderness of muscles aged to 15 days. Juiciness is known to vary inversely with cooking loss. These finding were consistent with Warris (2000) in that tenderness and juiciness were closely related the more tender meat the more juicier.

The meat tenderness was measurable both subjectively and objectively. The data presented in this study showed that panel rating of tenderness increased but not significantly ($P>0.05$) with increasing aging period to 15 days for the three muscles studied. This coincided with objective measurement of tenderness where shear force values decreased significantly ($P<0.01$) with extending aging time. An improvement in juiciness during dry aging and steaks were significantly juicier after 21 d aging than after 14 d, which in turn gave steaks which were juicier than those for non-aged or aged 7 days (Campbell *et al*, 2001 and DeGreer *et al*, 2009).).The results agree Sañudo *et al.*, 2004 who stated that aging has an important effect on the quality of the meat product. Panea *et al.* (2008) compare the shear force (Warner-Bratzler test) for both bone in and deboned and found that it was decreased for both with increasing the aging period from7 to 14 days postmortem. The aging method and aging period had more influence on the meat textural properties and meat tenderness mainly improved during the first week of storage. Thus the increasing tenderness with aging was an indication of protein breakdown. Shear force values of different beef steaks aged 14 d were greater ($P < 0.05$) than those for steaks aged 28 and 42 d, but WBSF values did not ($P>0.05$) differ between steaks aged 28 and 42 d (Adcock, et. al. 2015). Our results also agreed with Gruber et. al. (2006) who demonstrated little to no improvement in WBSF values in Infraspinatus muscle steaks after 14 d of postmortem aging or in Gluteus medius and Longissimus lumborum steaks after 21 d of postmortem aging.Obuz *et al.*, 2003 and Panea et al.(2008) reported that the changes observed in meat tenderness during cooking result, from modifications occurring in the connective tissue, and myofibril proteins. Generally shear force is accepted to decline over time postmortem, with the rate of decrease being more rapid initially and decreasing over time; however, most of the researchers limit the time of aging to 30 days and the pattern of tenderization for individual muscles can be quite variable over 30 days post-mortem (Aalhus *et al*. 2004).

Prolonging the aging period caused an increase in total bacterial count at 4° and 37°C incubation temperatures in all the experimental muscles. The increase in total bacterial count from day one to day 5 was not significant, but it was highly significant on progress of aging time to 10 and 15 days. Inoculation at 4°C resulted in a non-significant increase of total bacterial count with increasing aging time to 10 days but significantly increased at day 15 of aging. The total colony count was higher at 37°C when compared with that at 4°C. The temperature during storage time greatly affects the shelf –life of meat. Borch (1989) reported that total aerobic count on vacuum packed beef loin steak was 7.0 log10 cfu / cm2 after 4 weeks at 4°C. In steaks displayed in oxygen permeable film, the total bacterial count increased rapidly and reached 7 log10 cfu /cm2 after 4-6 days at 4°C and took 2.5-4 days at 8°C to reach the same count. The increase in total bacterial count during meat storage could be due to the fact that most of the contaminating bacteria were mesophiles which are cold tolerant but grow better at higher temperature (Warris, 2000; Newton *et al.*., 1978). X Li *et al.* (2013) study the meat quality and consumer preference after ageing beef Gluteus medius in a water vapour-permeable dry-ageing bag or in vacuum for 14 days. Samples aged in dry ageing bags had higher total bacteria and yeast counts but lower lactic acid bacteria counts than those aged in vacuum, both before and after trimming. No differences were found in pH, smell, shear force, colour, enterobacteriaceae, and mould counts. Thus, by using a dry ageing

bag, it is possible to produce dry-aged meat in a more controlled condition without negative effects on sensory or other quality attributes.

Conclusion

Aging of Western Baggara bulls (4 years age) meat for varying periods up to 15 days at 2°C improve the tenderness where shear force values decreased significantly with increasing aging period. Aging the carcasses for 15 days resulted in a decreased in colour and flavour scores and an increase in total bacterial count at 4°C and 37°C incubation temperatures although the tenderness, juiciness and over all acceptability increased. Since colour and flavour of meat were more desirable 10 days aging period at 2°C can be recommended.

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