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Histological evaluation of fresh, boiled and dried beef and camel meat

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Abstract

The Semimembranosus muscle used for the study was excited from the wholesale beef and camel meat of 2-3 years old male animals. The meat were trimmed of all surface fat, bone and connective tissue and chilled for 24 hours. Sizeable pieces of 7- 9 cm within a weight range of 60-80 gram were cut. Two treatments were applied cum; boiling of meat for 30 minutes at 100 ^{0}C till uniform doneness was achieved. Secondly treatment involved smoking of boiled meat for 6 hours at 200 ^{0}C – 320 ^{0}C. The cooking loss, cold shortening, thermal shortening, shear force, water holding capacity and histological observation were measured. The camel meat gave the highest significant value ($P<0.05$) in cold shortening, shear force and cooking loss compared to beef. The water holding capacity of beef evaluated gave the highest ($P<0.05$) 68.12 % than 59.09 % obtained for camel meat. Increase in temperature and duration of cooking, increases shrinkage, coagulation, duration of collagen and protein hardening.

Keywords: Camel meat, beef, semimembranosus, smoked and boiled

Introduction

Of all the attributes of eating, tenderness is rated the most important factor affecting beef palatability and much research has been focused on improving tenderness. Effect of cooking on meat tenderness has received considerable attention because, consumer acceptance and this quality factor usually dictates the method of cooking, in addition to efficiency and cost (Vasanthi, 2007).

Meat quality evaluation is important in improving meat production but analytical methods do not consider some aspect perceived by consumers as cooking effects on meat. Nevertheless, complete understanding of how water in meat change during cooking has not yet been achieved (Barbera and Tassone, 2006). It has been shown that thermal conditions during meat cooking have little significant effects on all the meat texture.

During heating, at varying temperatures, meat proteins denature and cause structural changes such as transversal and longitudinal shrinkage of muscle fibers and connective tissue shrinkage. Most of the water in the living muscle is held within the myofibrils and any large changes in the distribution of water within the meat structure originate from changes in this spacing. Cooking induced structural changes and decreased the water holding capacity

The mechanical properties of meat are affected by the connective tissue protein, collagen. Meat texture is influenced not only by the quantity of collagen but also its solubility on heating. Heat induced changes in

muscle components and the net effect on toughening or tenderization depends on the cooking conditions (Vasanthi, 2007).

Drying of meat could increase the demand for beef and camel products by improving the consistency of products and allowing processing technologies to be targeted toward maximum effectiveness, both of which could increase carcass value. Furthermore, marketing meat in this manner allows the removal of seam fat, producing more attractive cuts with greater nutritional quality.

Materials and Methods

Source of meat

The beef was purchased from the slaughter house of the department of Animal Science, University of Ibadan, Ibadan Nigeria. Meat from 2 to 3 years old male *Camelus dromedarous* and beef of While Fulani, cattle were used. The camel meat was purchased from an open market at Agege abattoir in Lagos State Nigeria, soon after slaughter. The semimembranosus muscles from hindquarter of the cow and camel were purchased and used for this study. Each of the meat was taken to the meat science laboratory where experiments were carried out.

Cooking loss

Samples of known weight were taken from both meat types (Camel, White Fulani) meat and boiled in a moist - heat to an internal temperature of 72 ^{0}C and water boils at 100 ^{0}C. The water released after cooking and cooling was manually separated and the weight of the cooked meat was taken to obtain the cooking loss.

$$\text{Cooking loss} = \frac{\text{weight of sample before cooking} - \text{weight of sample after cooking} \times 100}{\text{Weight before cooking}}$$

Share force determination

The objective evaluation of tenderness was performed using the modified Warner Braztler share force procedure (Bouton and Harris, 1978). Meat samples from the animal muscles were boiled to an internal temperature of 72 ^{0}C. The boiled samples were allowed to equilibrate to room temperature. Three cores of 1.0cm diameter were removed from each boiled meat sample. Each core was sheared at three locations parallel to the orientation of the muscle fibre.

Water Holding Capacity

This was determined in triplicate by the press method (Tsai and Ockerman, 1981). Approximately 1.0 g of sample was weighed into a 9 cm Whatman No. 1 filter paper and pressed between two 10.2 x 10.2 cm plexi glasses at approximately 35.2 kg/cm for 1 minute. The area of free water was measured using a compensatory planimeter (Planix 5000, Tamaya Technics, Inc., Tokyo, Japan) and percent free water was calculated based on sample weight and moisture content (Tsai and

Ockerman, 1981), while percent bound water or water holding capacity (WHC) was calculated as 100% minus free water percentage.

Cold shortening:

Cored samples of meat (1cm by 1cm) were stored in refrigerator for 24 hours at 4^0C. The percent difference in length gave the cold shortening.

$$\text{Cold shortening} = \frac{\text{Length of sample before frozen} - \text{Length of sample after frozen} \times 100}{\text{Length before frozen}}$$

Thermal shortening

Cored samples of meat of know length were taken and broiled in oven at 175^0C for 20 minutes, the percent difference in length gave thermal shortening.

$$\text{Thermal shortening} = \frac{\text{Length of sample before broiling} - \text{Length of sample after broiling} \times 100}{\text{Length before broiling}}$$

Boiling Method

The cut meat samples from both beef and camel muscles were separately boiled in water (5 times weight of meat sample). The meat samples were boiled in a pressure cooker for 30 minutes at 100^oC and stirred at intervals for uniform doneness. The liquid broth was drained and the meat samples were allowed to equilibrate to room temperature.

Smoking Method

The boiled meat samples were smoked using charcoal as the heat source at 200-320^oC (using the oven thermometer) for 6 hours. The drying samples were covered with a tray to impact the smoky compound from the heat source to the surface of the meat samples.

Histological evaluation

Pieces of meat from semimembranosus muscle of camel and beef were used to assess structural changes in fresh, boiled and smoked meats. The samples were fixed in buffered formalin for 24 hours and processed by routine histological techniques which involve dehydration, clearing, embedding, blocking, sectioning and staining. Muscle with thick sections were cut and stained using Masson's Trichrome method (Luna, 1968) to observe the qualitative changes that occur in collagen fibers on heating for fresh, boiled and smoked meat.

Statistical Analysis

All data obtained were subjected to analysis of variance and were statistical significance were observed. The means were compared using Duncan Mutiple Range (DMR) test. The SAS computer software package was used for all statistical analysis (SAS 1999).

RESULTS

Plates 1 and 2 show the photomicrographs of transverse sections of raw, semimembranosus muscle, Plates 3 and 4 show the photomicrographs of transverse sections of boiled semimembranosus muscle, while Plates 5 and 6 show the photomicrographs of transverse sections of dried, semimembranosus muscle.

Table 1: Physical Characteristics of Beef and Camel Meat

Physical Property	Meat Samples		
	Camel meat	Beef	SEM
Cold shortening, %	2.40[a]	2.20[a]	0.19
Thermal shortening, %	23.00[a]	14.83[b]	3.10
Cooking loss, %	37.76[a]	23.35[b]	1.90
Shear force, kg km^3	7.19[a]	4.98[b]	1.12
Water holding capacity, %	59.09[b]	68.12[a]	0.94

[a,b]: Means in the same row with different superscripts are significantly different ($P<0.05$).

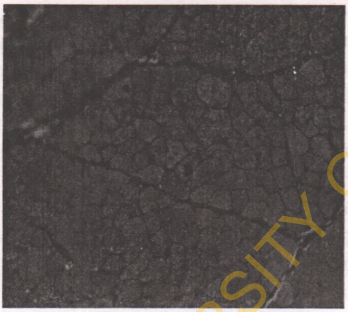

Plate 1: Fresh Beef (Mag. X 125)

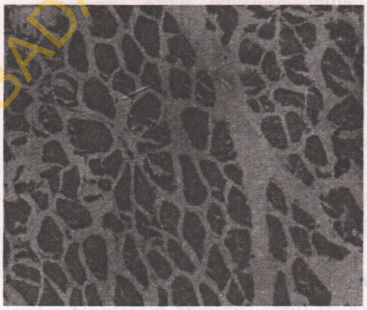

Plate 2: Fresh Camel Meat (Mag. X 125)

Plate 3 Boiled Beef (Mag. X 250)

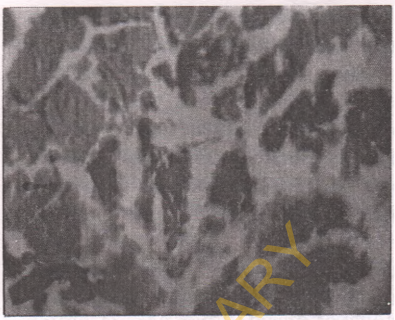

Plate 4 Boiled camel meat (Mag. X 250)

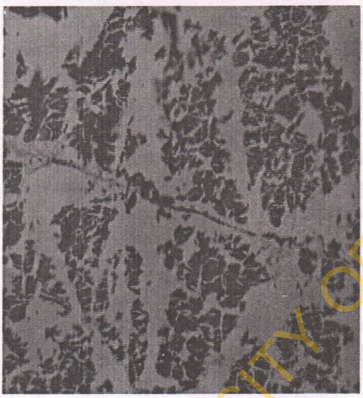

Plate 5 Dried beef (Mag. X 250)

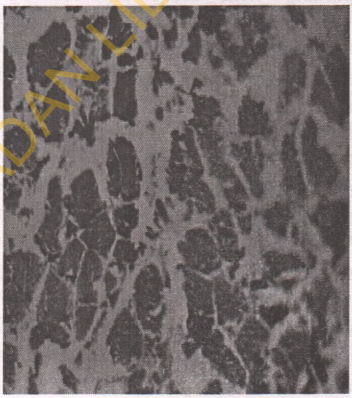

Plate 6 Dried Camel (Mag. X 250)

Fig 1: The histological structure of raw, boiled and smoked dried semimembranosus muscle of beef and camel meat are shown in Plates 1-6

Discussion

The mean values of cold shortening, thermal shortening, cooking loss, shear force, and water holding capacity are presented in Table 1.

The histological changes that occurred during heating are presented in Fig 1.

Cooking loss

The cooking loss is a combination of liquid and soluble matter which is lost from the meat during cooking. At increasing temperatures the water content of the meat decrease, while the fat and protein content increases indicating that the main part of cooking loss in meat is water (Heymann *et al.*, 1990). Lost of water from meat is due to

the effect of heat, which induced protein denaturation during cooking and causes less water to be entrapped within the protein structures which are held by capillary forces. Okubanjo *et al.* (2003) concluded that water loss is of economic concern because it affects weight loss along the distribution chain during cooking.

The mean cooking loss obtained varied from 23.35 to 37.76%. Values reported differ significantly ($P<0.05$). Cooking loss obtained in this study were comparable with those reported by Aaslyng *et al.* (2003) for cooking loss of oven dried beef and 33.2-8.0% for cooking loss of camel meat reported by Yousif and Babiker (1989). While Okubanjo *et al.* (2003) reported 24.0%, 8.7% and 17.0% cooking loss for Bunaji, Gudali and Keteku meat which were lower than the values obtained in this study. Also, Omojola and Adesheyinwa, (2006) reported 29.4%, 29.7%, 27.7% for cooking loss of scalded, singed and skinned dressed rabbit carcasses. The values obtained is however lower than 39.5% and 43.0% for cooking loss of roast and braised camel meat reported by (Abdelbary, 1995). The highest cooking loss in camel meat could be due to a greater degree of shrinkage of the muscle fibres and protein coagulation (Asghar and Pearson, 1980).

Cooking loss depends on the raw meat quality. Asalyng *et al.* (2003) reported that raw meat quality influenced the cooking loss at a certain temperature. Meat with higher cooking loss will have lower water holding capacity. Cooking loss is of interest to the meat processor because it is expected to explain part of the variation in juiciness; it also influences the appearance of the meat after processing. Hence high cooking losses will affect the optimal eating quality and is of a great economic importance to the catering industry. There was a gradual increase in coking loss with increase in temperature and time of cooking observed by Seuss *et al.* (1986). An increase in cooking loss with temperature was also observed by Combres *et al.* (2003) in rabbit meat.

Water holding capacity

Water holding capacity (WHC) is the ability of meat to retain its water during application of external forces such as cutting, heating, grinding and pressing. Water holding capacity could be loss by evaporation from meat surface, as exudates or when muscle is cut (Hedrick *et al.*, 1994). Beef had the highest significantly ($P<0.05$) 68.12% water holding capacity than 57.88% for camel meat. The mean values 57.88-68.12% obtained for water holding capacity in this study could be compared with the values, 42.2-67.0% reported for water holding capacity of scalded, singed and skinned dressed rabbit reported by Omojola and Adesehinwa (2006) and were far greater than values of 1.3-2.0% reported by Babiker and Lawrie (1983) for water holding capacity of hot deboned beef and 2.1-2.3% reported by Yousif and Babiker (1989) for water holding capacity of camel meat.

The values obtained for water holding capacity obtained in this study was as a

result of heat application, i.e., thermal treatment. It is well known that protein is denaturated and coagulated by heating, also heating reduces the space within the myofibrillar protein network with a consequence decrease of water and lowering the water holding capacity (Hamm, 1969). Tornberg (2005) reported that cooking induces structural changes and in turn decrease the water holding capacity of the meat.

Cold shortening and Thermal shortening

The thermal shortening obtained was lower for beef than camel meat. However, that of camel meat was significantly ($P<0.05$) higher. The values ranged from 2.20% for beef to 2.40% for camel meat. The reaction of meat obtained from both muscles to heat (cold shortening) was statistically similar ($P>0.05$). The mean cold shortening is in the range of values observed by Fakolade *et al.* (2006). Cold shortening have been recognized in recent year as resulting from a low temperature in the muscle before the onset of rigor mortis, which causes contraction in muscle resulting to reduction in the length of muscle from the initial length (Hedrick *et al.*, 1994). Reduction in length during cold shortening could be due to the release of calcium ion and resulting muscle rigidity (Hedrick *et al.*, 1994). The least cold shortening percentage recorded for beef could be due to the lowest shear force value obtained showing that such beef appears more tender than the other. Hedrick *et al.* (1994), reported that tenderness of muscle decreases as the degree of cold shortenings increases.

Shear force

Shear force values reported showed a significant ($P<0.05$) difference between the values obtained for beef 4.68% and 7.19 % for camel meat. The shear force value in this study were higher than 2.92-3.15 kg km^3 reported by Soniran and Okubanjo (2002) for shear force of physical and sensory characteristic of pork and loin roast cooked to three internal temperatures and were higher than 4.60 kg km^3, 4.93 kg km^3 and 4.04 kg km^3 reported by Okubanjo *et al.* (2003) for shear force of Bunaji, Gudali and Keteku breed of cattle.

However, the values obtained fell within the range of 3.16-6.27 kg km^3 reported by Kembi and Okubanjo (2002) for physical properties of raw all-beef and soybean extended beef patties after dehydration. Also the values obtained were lower than 7.73-8.10 kg km^3 for shear value of Najdi camel meat (Abdelbary, 1995). Abdelbary (1995) also reported that shear force values are lower for younger camels than for older camels and that higher shear force will command longer cooking time. Differences in shear force may represent changes in the elastic characteristics of the connective tissue of different muscles which had different mechanical properties as mentioned by Robertson *et al.* (1984).

Vasanthi *et al.* (2007) reported that meat cooked under pressure will have lower shear force value. The shear force value of pressure cooked meat clearly indicates that greater thermal shrinkage

accompanied an increase in tenderness. This finding is in agreement with the finding of Mahendraker *et al.* (1990) in ovine muscles.

Camel muscle was reported to have higher connective tissue than beef (Babiker and Yousif, 1990) and this contributed to the higher cooking loss obtained for camel muscle. Thus, Babiker and Yousif, 1990 concluded that camel meat appeared to be very tough, but in establishing consumer threshold values for muscle tenderness (Miller *et al.*, 2001) classified beef with Warner Bratzler shear values of 5.7 as being very tough, between 4.9-5.7 as intermediate and below 3.0 as tender. Based on these classifications, camel muscle was observed to be very tough while beef appears to be intermediate, which makes beef more acceptable to consumers. Okubanjo *et al.* (2003) deduced that breed has a significant effect on the meat quality, so in this study, beef produced the best meat quality, compared camel meat.

Histological evaluation

Generally, it appeared that more connective tissues were observed in plate 1 (raw camel meat) compared to plate 2, while rupture of connective tissue (endomysium and perimysium) were observed more in boiled and dried camel muscle to that of beef.

In Plates 1 and 2 muscle bundles were intact, with little or no muscle fibre disintegration. The nuclei were slightly seen arranged peripherally as dark specks on the muscle fibre. The muscle tissue showed a homogenous appearance of the myofibres with indistinct cellular boundaries. The crimped thick collagen fibers were observed only in raw meat section in plates 1 and 2 as reported by (Jones *et al.*, 1977; Reid and Harrison, 1971).

Plates 3 and 4 photomicrograph of cooked semimembranosus muscle of beef and camel meat, cooked at 100°C for 20 minutes. The boiled samples tissues suffered some degree of denaturation and coagulation as a result, they become less soluble with reduced water holding capacity and water activity. The loss of crimp structure of the perimysium in cooked meat observed was due to shrinkage and denaturation of collagen fibres as reported by Lewis and Purslow (1989). Granular deposits were observed in the gaps between the endomysium and myofibillar mass in plates 3 and 4. These are the remains of plasmalemma, which are non colloidal particles. The presence of granules indicates passive shortening of muscle fibres, which however remains, bound together by the open random network of collagen fibres.

Plates 5 and 6 photomicrograph of smoked dried semimembranous of beef and camel products dried at 220-320°C for 6 hours. The photomicrograph of the smoked dried semimembranosus muscle plates 5 and 6 revealed that the muscle fibre bundles have shriveled in size. They showed poor sectioning, non-structured legion and the fibre appeared shapeless, deformed and more connective tissue can be seen. Extensive deposits observed in plates 5 and 6 were due to the rupture of endomysium and

perimysium, which occurred in meat cooked at higher temperatures.

Loss of structural integrity of myofibrils observed in meat cooked at higher temperature was due to progressive distortion of endomysium and perimysium in cooking. The trend of increase in fracturing is due to softening of endomysial collagen around fibres and progressive weakening of adhesion between fibres as reported by Jones *et al.* (1977). Similar finding's observed by Palka (2003) in bovine semitendinous muscle cooked in the range of 80-90% by roasting.

Palka (2003) observed that roasting bovine semitendinous muscle to an internal temperature of 50°C, slightly affected the structure of the meat. Similar results were obtained during the retorting of the bovine semitendinous muscle to the same temperature of 60-90°C significant changes occurred both in myofibrils and in the intramuscular connective tissue. Palka (2003) also observed that the relationship between the texture of raw and roasted meat is rather limited.

These qualitative changes indicate progressive denaturation changes in collagen fibres hereby leading to tenderness when boiled (Vasanthi *et al.*, 2007). The dried meat products muscle progressively lost it fluid, reduced in size, and became firmer, rigid because of hardening of the protein.

Conclusion

The results obtained in this study revealed that increase in temperature, duration of cooking, shear force and cooking loss, which lead to decreased in the water holding capacity and water activity will increase shrinkage, coagulation, denaturation of collagen fibres and protein hardening.

References

Aaslyng, D.N., Berjerholm C., Ertbjerg, P., Bertram, C.H. and Andersen, H.J. (2003). Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure. *Food Quality Preference,* 14: 277-288.

Abdelbary, A.D. (1995). Physical and sensory characteristics of Najdi Camel meat. *Meat Science*, 39:59-69.

Ashgar, A. and Pearson, A.M. (1980). Influence of ante- and post mortem treatment upon muscle composition and meat quality. *Advances in Food Research*, 26: 55-77.

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.

Babiker, S.A. and Yousif, O.Kh. (1990). Chemical composition and quality of camel meat. *Meat Science*, 27: 283 - 287.

Barbera, S. and Tassone, S. (2006). Meat cooking shrinkage. Measurement of a new meat quality parameter. *Meat Science.* www. Science direct.com www. Elesevier. Com. locates. Meat. Sci.

Bouton, P.E. and Harris, P.V. (1978). Factors affecting tensile and Warner-Bratzier Shear values of raw and cooked meat. *J. Texture Studies*, 9: 395-413.

Combres, S., Lepetit, J., Darche, B. and Lebas, F. (2003). Effect of cooking temperature and time on Warner-Bratzler tenderness measurement and collagen content in rabbit meat, *Meat Science*, 66: 91-96.

Fakolade, P.O., Omojola, A.B. and Afolabi, K.D. (2006). Physical characteristics of camel muscle compared with three breed of cattle. ASAN proceedings of 11th annual conference. 18th – 21st Sept, 2006. Pp. 304-306.

Hamm, R. (1969). Properties of meat proteins. *In*: Lawrie, R.A. (Ed). *Proteins as Human Food*. West Port, Conn. Aui Publishing Co. Pp. 167-185.

Hedrick, H.B., Aberle, E.D., Forrest, J.C., Judge, M.D. and Merkel, R.A. (1994). *Principles of Meat Science* 3rd ed. Kendall Hunt Publishing Co. Dubuque. Iowa.

Heymann, H.J., Hedrick, H.B., Karrasch, M.A., Eggeman, M.K. and Ellersieck, M.R. (1990). Sensory and chemical characteristics of fresh pork roasts cooked to different centre temperatures. *Journal of Food Science*, 55: 613-617.

Jones, S.B., Carroll, R.J. and Hoes, T.L. (1977). Structural changes in heated bovine muscle: a scanning electron microscope study. *Journal of Food Science.*

Kembi, S.O. and Okubanjo, O.A. (2002). Physicochemical and sensory properties of dehydrated beef patties containing soybean products. *Trop. Anim. Prod. Invest.*, 5: 137-148.

Lewis, G.J. and Purslow, P.P. (1989). The strength and stiffness of perimysial connective isolated from cooked beef muscle. *Meat Science,* 26, 255-269.

Luna, L.G. (1968). *Manual of histological staining methods of the Armed forces Institute of Pathology* (pp. 94-95)(3rd ed.). New York McGraw-Hill Book Co.

Mahendraker, N.S., Dani, N.P., Rasmesh, B.S. and Amla, B.L. (1990). Effects of post-mortem conditioning of ewe carcasses on instrumental texture profile of cooked thigh muscles. *Meat Science*, 28: 195-202.

Miller, M.F., Carr, M.A., Ramsey, C.B., Crockett, K.L. and Hoover, L.C. (2001). Consumer thresholds for establishing the value of beef tenderness. *J. Anim. Sci.*, 79: (12): 3062-3068.

Okubanjo, O.A., Omojola, A.B., Ogunsola, O.O., Adewumi, M.K., Ajiboro, G., Alabi, G.F. and Babayemi, O.J. (2003). Meat characteristics of Bunaji, Gudali and Keteku breeds of cattle. *Trop. Anim Prod. Invest.*, 6: 185.

Omojola, A.B. and Adesehinwa, A.O.K. (2006). Meat characteristics of

scalded, singed and conventionally dressed rabbit carcasses. @ International Digital Organization for scientific Information, Online Open access Vol. 1, No. 1: 24-29 Jan – Jun, 2006.

Palka, K. (2003). The influence of post-mortem ageing and roasting on the microstructure, texture and collagen solubility of bovine semitendinosus muscle. *Meat Science,* 64: 191-198.

Reid, H. C. and Harrison, D.L. (1971). Effects of dry and moist hest on selected histological characteristics of beef Semimembranosus muscle. *Journal of Food Science*, 36: 206-208.

Robertson, J., Ratcliff, D.P.E., Bouton, P.V., Harris and Shorthose, W.R. (1984). Effect of cooking temperture and age on the shear properties of beef and buffalo meat. *J. Food Sci.*, 49: 1163 -1166, 1177.

SAS (1999). Statistical Analysis System *Institute's Users Guide.* SAS Institute Inc. Cary N. C.

Seuss, Ingrid E., Pospiech, and Honikel, K.O. (1986). *In:* 32nd European Meeting of Meat Research Workers (pp. 143-146). Ghent: Belgium.

Soniran, O.G. and Okubanjo, A.O. (2002). Physio-chemical and sensory characteristics of pork loin roast cooked to three internal temperatures. *Nig. J. Anim. Prod.*, 29 (1): 138-141.

Tornberg, E. (2005). Effect of heat on meat protein - implications on structure and quality of meat products. *Meat Science,* 70: 493-508.

Tsai, T.C. and Ockerman, H.W. (1981). Water. *J. Food Sci.*, 46: 697-707.

Yousif, O. Kh. and Babiker, S.A. (1989). Chemical composition and quality of camel meat. *Meat Sci.* 26: 245.

Vasanthi, C., Venkataramanujam, V. and Dushyanthan, K. (2007). Effect of cooking temperature and time on the physico-chemiacal, histological band sensory properties of female carabeef (buffalo) meat.

Meat science ×××(2007)×××. www.elsevier.Com/locate/meatsci. available on line www.sciencedirect.com