Applied Tropical Agriculture
Volume 22, No. 2, 36-41, 2017.

Characteristics and Meat Attribute of Domesticated and Wild Grasscutters

Adewunmi, A.A.*and Oluyode, M.O.

Department of Fisheries and Wildlife Management, Osun State University, College of Agriculture, Ejigbo Campus, Ejigbo, Osun State, Nigeria
*Corresponding author: abibay2001@yahoo.com

ABSTRACT

The characteristics and meat attribute of domesticated and wild grasscutter were conducted at College of Agriculture, Osun State University, Nigeria. Fifteen Grasscutters (Thryonomys swinderianus) were raised for the study. Five grasscutters were taken from the domesticated and wild grasscutters respectively and were slaughtered to determine the characteristics and attributes of their meat. Both the initial weight, carcass weight and bled weight differed (p<0.05) between treatment groups. Carcass length was shorter in wild grasscutter (p<0.05). Dressing percentage of wild grasscutter was observed to be higher (80.0±3.42) while shoulder weight was higher in wild grasscutter (0.28±0.03). Backbone weight was observed to be higher in wild grasscutter (0.34±0.20) while intestinal weight was observed higher in domesticated grasscutter (3.31±2.24). Mineral composition appears to have no significant difference in raw samples but Iron was observed to decrease in value when cooked. There is thus little or no significant difference in nutrient composition of both wild and domesticated grasscutters but differences were observed in their carcass evaluation.

Key words: Carcass attributes, domesticated grasscutter, meat, wild

INTRODUCTION

Grasscutters (*Thryonomys swinderianus*) also known in some areas as cane rats are wild hystricomorph rodents found in Africa (Adoun, 1993). The grasscutter is a monogastric herbivore that can be found in the Guinea-Gulf savannah areas with tall grasses, particularly, those areas with elephant and guinea grasses that serve as their food (Ankrah, 2005). Grasscutter meat is considered a delicacy that is highly relished (Boateng, 2005). Among the wild animals, the family of rodents contribute the highest percentage of meat and indeed, rodents contribute an average of 80 percent of meat to the diet of the people (Fayenuwo *et al.,* 2003).Grasscutter meat constitutes an important food for many Africans and is greatly appreciated in western and central Africa (Fayenuwo *et al.,* 2003) and social acceptance studies among different ethnic groups in Nigeria have shown in all instances that the meat of the grasscutter is acceptable to all social classes of people both in the urban and rural areas (Ayodele, 1988: Tewe *et al.,* 1998).

Major hindrances to the development of the captive grasscutter include lack of improved breeding stock (Annor and Djang-Fordjour, 2006), lack of technical know-how, poor management practices, poor housing and lack of start-up capital (Adu *et al.,* 1999). The productivity of captive grasscutters is also low due to poor reproductive performance and high mortality rates. There is a direct relationship between nutrition, reproduction and survival of mammals (Barrick and Herman, 1991) as optimal nutrition results in faster growth rate, low mortality rate, high reproductive and survival rates (Betridge, 1986). Data on meat characteristics and attributes of wild and domesticated grasscutters could be important for marketing purposes.

MATERIALS AND METHODS

The experiment was carried out at the research farm of the Department of Fisheries and Wildlife, Osun State University, Osogbo, Ejigbo Campus, Osun State which geographically lies between latitude $7^0 53$ N and longitude 4^0 19 E. The mean annual rainfall of the area is about 52.35mm with temperature of between 21.1^0 C and 31^0C. It has an area of 373km^2 and a population of 132,641, the rainy season lasts from April to October. The vegetation of the area is a tropical dry forest and savannah.

Experimental Animals and Design

Fifteen Grasscutter (*Thryonomys swinderianus*) were raised for the study. Five wild and domesticated grasscutters respectively were slaughtered. The wild grasscutters were captured alive within Ejigbo environs.

The experimental design was Randomised Complete Block Design (RCBD).

Housing: The animals were housed singly in cages of 50cm x50cmx 40cm dimensions. Concrete feeders and drinkers were used during the experiment. The cages were cleaned while the feeding and drinking containers were washed daily.

Carcass parameters: Five domesticated and five captured wild animals were slaughtered respectively in order to obtain their carcass. Prior to slaughtering, the grasscutters were fasted overnight and had access to only water. Various carcass parameters were then evaluated.

Meat quality: The meat quality were determined through physical characteristics such as cooking loss, thermal shortening, cold shortening, water holding capacity and shear force, proximate analysis and mineral analysis.

Cooking loss and thermal shortening: These were determined according to procedure described by Mahendraker *et al*. (1988). The muscle types were placed individually in heat resistant polythene bags and labelled with a paper tape. Each sample had three replicates, the polythene bags were immersed in water contained in a cooking pot and then cooked to an internal temperature of 72^0 C for 15 minutes with electric cooker. The weight and length of muscles was recorded before and after cooking, the bags were taken out and muscles were allowed to cool before taking their measurements. The change in muscle length and weight due to cooking were the thermal shortening and cooking loss respectively.

Cold shortening: The muscles of meat were cut into specific lengths of 5cm by10cm for all the samples. The muscles were cut into 3 parts and arranged in separate tray. The trays were labelled for identification and put inside a deep freezer at a temperature of -4^0C for 24hours after which the trays were removed and average change in length was recorded.

Water Holding Capacity: This was determined by using raw meat of samples following the modified method of Suzuki *et al.* (1991). In this procedure, intact samples (1g by 1g) were weighted separately for each muscle and then pressed between two filter papers for a minute using a vice. The samples were then oven dried at 60^oCfor 48 hours in order to determine the moisture content. The pressed meat was removed from the filter paper and wrapped with a foil before putting it inside the oven for drying.

The amount of water released was determined indirectly by measuring the area of the filter paper wetted relative to the area of the pressed samples. The filter paper was placed on a tracing paper and the two areas were traced out (areas wetted paper and area of the pressed samples). The tracing paper was then placed on a graph sheet to determine the areas in figures. The water holding capacity of the muscle samples were then calculated following Suzuki *et al.* (1991):

$$WHC= 100-\{(Ar-Aw \times 9.47)\}/Wm \times W_0$$

Where; Ar= Area of water released from meat cm^2
Am =Area of meat sample cm^2
Wm= Weight of meat samples in g
W_0= Moisture content of meat
9.47= constant factor

Shear force: Most samples used for shear force determination were those used for the measurement of thermal shortening and cooking loss described above. After the thermal shortening and cooking loss was determined for the cooked meat, three cores were taken parallel to the direction of the muscle fibres. Each core was then sheared perpendicular to the fibre using Warner Bartzler Shear Force machine and the average shear force for each muscle was recorded.

Moisture determination of Fresh and Cooked Meat: These were determined according to the procedure described by A.O.A.C. (2005). A known weight of each sample was weighed into oven dried silicate dishes of known weight and placed in an oven at 100^0 C for 24 hours. The silicate dishes and the samples were then cooled in desiccator and reweighed. The percentage moisture was calculated.

Table 1: Composition of experimental diets

Ingredients	(%)
Pennisetum purpureum	50
Palm kernel meal	18.25
Cassava meal	10
Soybean meal	8.25
Maize	7
Wheat bran	5.25
Dicalcium phosphate	1
Common salt	0.5
1 Vitamin/Mineral premix	0.25

Table 2: Proximate analysis of Sweet cassava (A), *Pennisetum purpureum (B)* and Compounded feed (C) fed to the Domesticated grasscutter

Proximate	A (%)	B (%)	C (%)
Crude protein	2.38	5.5	19.2
Ether extract	0.65	0.86	2.8
Ash	2.89	7.5	5.8

Ash determination of Fresh and Cooked Meat: This was determined according to the procedure described by A.O.A.C. (2005). The samples used for moisture determination were used for ashing. The samples were firstly put in a known weight crucible, the crucible plus the sample were again weighed, and then the samples were chaired on a burner. Each charred sampled was cooled in a dessicator while each charred sample with the crucible was weighed and put inside a Gallen Kamp hotspot furnace. The samples were shred at 600^0 C for 40 minutes until the ash became white. The percentage ash was calculated thus:

Weight of Ash = Weight of ash and crucible – weight of crucible.

Fat determination of Fresh and Cooked Meat: This was determined according to the method outlined in A.O.A.C. (2005).

- **i.** 250ml extraction flask was washed, dried in an oven dried and allowed to cool in the dessicator and then weighed.
- **ii.** The soxhlet extraction was fitted up and the water flow was started through the condenser.
- **iii.** 1gm dry sample was weighed out in a filter paper and transferred into a flat free extraction thimble and then plugged tightly with cotton wool.
- **iv.** The thimble was placed in the extraction barrel and petroleum ether was being added until it siphoned over once in the flask directly below it.
- **v.** After making sure that all points were thigh, the flask was heated and samples were refluxed for about 5 hours.
- **vi.** The solvent in the sample was distilled off by replacing the barrel. This was done until the flask was almost dry.
- **vii.** The flask containing the fat was detached and dried in the oven at a low temperature.
- **viii.** The flask plus fat was weighed and the fat content was calculated.

Residual Meat of Fresh and Cooked Meat: The residual meat represents the protein content of the meat. The value of residual meat was calculated from the sum of the values of moisture, fat and ash subtracted from 100, i.e. 100- (values of moisture + fat + ash).

Mineral Analysis of Fresh and Cooked Meat: The different samples were analysed using the standard procedures of A.O.A.C. (2005). Minerals analysed include Calcium, Magnesium, Potassium and Iron.

Proximate analysis of the diet: The proximate content of the diet was determined according to the procedure of the A.O.A.C. (2005).

Data analysis: Data obtained were subjected to independent t-test using Systat computer package version 5.02.

RESULTS AND DISCUSSION

Carcass characteristics of wild and domesticated grasscutters are in Table 3. Both the initial weight, carcass weight and bled weight differed significantly ($p<0.05$) between treatment groups. The highest blood loss was observed in wild grasscutters (37.0±1.70) while the least was observed in domesticated grasscutter. Carcass length was Shorter in wild Grasscutter ($p<0.05$) compared to domesticated Grasscutters. There was no significant difference ($p>0.05$) between the dressing percentage, shoulder weight, backbone weight and intestinal weight. However, dressing percentage of wild grasscutters was observed to be higher (80.0±3.42) than that of the domesticated grasscutters (79.4±3.42). Also, shoulder weight was higher in wild grasscutters (0.28±0.03) than domesticated grasscutters (0.22±0.03). Backbone weight was also higher in wild grasscutters (0.34±0.20) while the intestinal weight was higher in domesticated grasscutters (3.31±2.24).

Table 3: Carcass characteristics of wild and domesticated grasscutters

Parameters	Wild Grasscutters (±SE)	Domesticated Grasscutters (±SE)
Initial weight	$4.04±0.41^a$	$2.10±0.41^b$
Bled weight	$0.05±0.48^b$	$0.34±0.48^a$
Dress weight	$3.26±0.38^a$	$1.71±0.38^b$
Blood loss (%)	$37.0±1.70^a$	$27.0±1.70^b$
Carcass length	$34.6±1.53^b$	$47.4±1.53^a$
Thigh weight	$0.78±0.09^a$	$0.36±0.09^b$
Tail length	$18.4±1.69^b$	$24.3±1.69^b$
Lung weight	$34.8±1.86^a$	$26.89±1.86^b$
Heart weight	$18.1±0.76^a$	$12.02±0.76^b$
Liver weight	$62.6±5.13^a$	$46.1±5.13^b$
Spleen weight	$18.8±0.57^a$	$11.76±0.57^b$
Kidney weight	$14.2±0.52^a$	$14.85±0.52^b$
Dress percentage	80.10±3.42	79.4±3.42
Intestine weight	0.34±0.02	0.28±0.02

Means in the same row with different superscript are significantly different ($p<0.05$)

Physio-chemical properties

The physio-chemical properties of wild and domesticated grasscutters are in Table 4. The result obtained shows that there is significant difference in the cold shortening ($p<0.05$) between wild and domesticated grasscutters. A highest cold shortening was observed in wild grasscutters (8.47±0.23) while domesticated grasscutters muscle has the higher degree of cold shortening. Results on thermal shortening also shows significant difference ($p<0.05$)

between domesticated grasscutters and the wild grasscutters. However, the mean thermal shortening of wild grasscutters was higher (35.3±1.85) when compared with the domesticated grasscutters

Cooking loss was higher in wild grasscutters than in the domesticated ones. Aaslyng *et al.* (2003) reported 33.2 % - 38.0% for cooking loss of camel meat while Okubanjo *et al.* (2003) reported 24.0%, 8.7% and 17.0% cooking loss for Bunaji, Gudali and Keteku meat respectively. Result further shows that there was no significant difference in water holding capacity between the domesticated and wild grasscutters. Omojola and Adesheyinwa (2006) reported the values from 42.2 to 67.0 % for scalded, singed and skinned dress rabbit. The values for water holding capacity in this study is higher than 1.3-2.0 % reported by Babiker and Lawrie (1985) hot deboned beef. Tornberg (2005) observed that cooking induces structural changes and in turn decreases the water holding capacity of the meat.

Table 4: Physico-chemical properties of the raw muscle of wild and domesticated grasscutter

Parameters	Wild Grasscutter (±SE)	Domesticated Grasscutter (±SE)
Cold Shortening (%)	8.92±0.23^{a}	4.92±0.23^{b}
Thermal Shortening (%)	35.2±1.85^{a}	26.3±1.85^{b}
Cooking Loss (%)	38.7±1.93^{a}	30.9±1.93^{b}
Water Holding Capacity (%)	64.7±3.01^{a}	71.7±3.01^{a}
Shear Force (kg/Cm^{3})	7.53±0.19^{b}	0.79±0.19^{a}

Means in the same row with different superscript are significantly different ($p<0.05$)

Findings on shear force of wild and domesticated grasscutters show that there was a significant difference in the values of shear force ($p<0.05$) between domesticated (5.79±0.19) and wild grasscutter meat. (7.53±0.19). The shear force value in this study were higher than 2.92 kg km^{3} -3.15 kg km^{3} reported by Soniran and Okubanjo (2002) for pork and loin roast cooked to internal temperatures, but are within the range of 3.16 kg km^{3}-6.27 kg km^{3} reported by Kembi and Okubanjo (2002). The values for wild grasscutters' muscle was higher and this could have contributed to the higher cooking loss obtained for wild grasscutters. Wild grasscutters muscle was observed to be very tough than the domesticated ones.

Proximate composition

Proximate composition of both wild and domesticated grasscutters is presented in Table 5. The study shows that there is significant difference in the moisture content ($p<0.05$) between the raw and cooked muscles of wild and domesticated grasscutters. In addition, the value obtained for cooked wild grasscutters muscle is slightly higher (45.5±0.99) than for cooked domesticated muscle (38.5±0.99). The moisture content for raw muscles of wild grasscutter (68.9±0.99) is higher than 52.30% obtained by Abulude (2007) for wild grasscutter but the mean moisture content resulting to cooked domesticated grasscutter meat is within the range of values observed by Fakolade (2012) for processed camel meat.

Table 5: Proximate composition of fresh and cooked meat of wild and domesticated grasscutters

Parameters	**Wild Grasscutter**		**Domesticated Grasscutter**	
	Cooked (±SE)	Raw (±SE)	Cooked (±SE)	Raw (±SE)
Moisture	45.5±0.99^{a}	68.9±0.99^{b}	38.5±0.99^{a}	55.1±0.99^{b}
Protein	46.3±0.94^{a}	20.2±0.94^{b}	58.3±0.94^{a}	21.9±0.94^{b}
Ash	8.26±0.12^{a}	4.44±0.12^{b}	11.64±0.12^{a}	7.12±0.12^{b}
Ether Extract	5.49±0.11^{a}	2.68±0.11^{b}	8.74±0.11^{a}	6.46±0.11^{b}

Means in the same row with different superscripts are significantly different ($p<0.05$)

Table 6: Minerals composition of fresh and cooked Meat of wild and domesticated grasscutters

Parameters	**Wild Grasscutter**		**Domesticated Grasscutter**	
	Cooked (±SE)	Raw (±SE)	Cooked (±SE)	Raw (±SE)
Calcium	0.02±0.04^{a}	0.01±0.04^{a}	0.02±0.04^{a}	0.01±0.04^{a}
Magnesium	0.25±0.04^{a}	0.21±0.04^{a}	0.22±0.04^{a}	0.21±0.04^{a}
Potassium	2.05±0.30^{a}	0.98±0.30^{b}	4.48±0.30^{a}	1.76±0.30^{b}
Iron	113.1±5.06^{a}	129.1±5.06^{b}	123.2±5.06^{a}	129.4±5.06^{b}

Means in the same row with similar superscripts are not significantly different ($p<0.05$)

There were significant differences ($p<0.05$) in protein content between the cooked and raw muscles of wild and domesticated grasscutters. Mean crude protein content of raw wild and domesticated grasscutters were 20.2±0.94 and 21.9±0.94 respectively. The protein content for wild and domesticated grasscutters meat are within the range of 20.50-22.70% reported by Kadim *et al*. (2006). The result obtained for cooked wild and domesticated grasscutters were higher ranging from 46.3% - 58.3%. The increase in protein content could be due to the removal of moisture which contained two to three times the protein content of the equivalent raw meat. The crude protein content of cooked wild and domesticated grasscutters meat was lower than 64.80 -72.10% reported by Soniran and Okubanjo (2002) for pork loin roans but higher than 34.60 - 44.60% reported by Paleari *et al.* (2003) for cured meat products. There is significant difference in ash ($p<0.05$) between the cooked and raw muscles of wild and domesticated grasscutters. The higher ash content observed in the cooked and raw muscles of domesticated grasscutters indicates that domesticated grasscutters had higher mineral profile compared with wild grasscutters. The result also reveals that ether extract of both the cooked and raw muscles of wild and domesticated grasscutters were significantly different ($p<0.05$). The meat of domesticated grasscutters was observed to be higher in fat content while that of wild grasscutter meat had lower fat content. The high fat content in cooked domesticated grasscutters meat could be due to low moisture content which according to Solomon *et al.* (1994) relates inversely to fat content in meat.

Mineral composition of wild and domesticated grasscutters is presented in Table 6. The result indicates that there was no significant difference ($p>0.05$) in the values of calcium obtained between the cooked and raw muscles of wild and domesticated grasscutters. There was also no significant difference in magnesium value ($p>0.05$) between the cooked and raw muscle of wild and domesticated grasscutters. The values obtained for potassium is significantly different ($p<0.05$) between the cooked and raw muscle of wild and domesticated grasscutters while there is significant difference in the values of iron ($p<0.05$) between the cooked and raw muscle of wild and domesticated grasscutters.

CONCLUSION

The results from this study revealed that domesticated grasscutters had the least cold and thermal shortening when compared with the wild grasscutters. Domesticated grasscutter meat can hold more water than wild grasscutter. Percentage of cooking loss was low in domesticated grasscutter which shows that heat does not have effect on the meat. The moisture content of cooked domesticated grasscutter meat was low which also contributed to the high protein and ash contents observed in the meat. There was increase in minerals of cooked domesticated grasscuter except for iron. Decrease in nutrient profile of wild grasscutter's meat may be due to what they feed on (mostly grasses) compared to conventional feed stuff fed to domesticated grasscutters. It is therefore concluded that there was little or no significant difference in nutrient composition of wild and domesticated grasscutters but differences appear in the carcass evaluation.

REFERENCES

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

Abulude, F.O. (2007). Determination of the chemical composition of bush meats found in Nigeria. *American Journal of Food Technology,* 2(3): 153-160.

Adoun, C. (1993): Place De L' aulacole (*Thryonomysswinderianus*) Dans Le Regne Animal Et Sa Repartiton Geographique. Pp. 35-40 in "I' er Conference International L' Aulacodiculture: Acquuis Et Perspective

Adu, E.K., Alhassan, W.S and Nelson, F.S. (1999): Smaller holder farming of the cane rat, *Thryonomys swinderianus, Temminnck,* in southern Ghana: A baseline survey of management practices. *Tropical Animal Health and Production*, 31(4): 2230-232.

Ankrah, J.K., (2005). Policies and Advocacy-Role of Government in Grasscutter Production. In: Proceedings of the International Forum on Promoting Grasscutter for Business in West Africa. 12th-16th December, 2005. Institute of Local Government Studies, Medina, Accra, Ghana.

Annor, S.Y. and Djang- Fordjour, K.T. (2006). From the rearing of large and small ruminant to a relatively tiny grasscutter (*Thryonomys swinderianus*); problems and prospects of grasscutter rearing in Ghana. Proceedings of Sunyani Polythechnic Lecture Series Ghana, September 24-27. Quali Type Limited, Accra, Ghana, Pp.49-58.

AOAC, (2005). Official Methods of Analysis of the Association of Analytical Chemists International.18th edn., Gathersburg, MD U.S .A. Official Methods, August.

Ayodele, I.A. (1988). Essentials of grasscutter Domestication and production. Africa Link. 65 Pp.

Babiker, S.A. and Lawrie, R.A. (1983). Post Mortem electrical stimulation and high temperature ageing of Hot-deboned beef (1983). *Meat Science,* 8: 1-20.

Barrick, R.K. and Herman, H. L., (1991). Animal Production and Management. Gleucoe Division, Macmillan/McGraw-Hill, New York, pp: 45-50.

Betridge, K.T. (1986). Increasing Productivity in Farm Animals. In: C.R. Austin and R.V. Short, (Editors). Reproduction in mammals: Manipulating Reproduction 2nd Edition, Cambridge, University Press, pp: 1-47.

Boateng, P., (2005). Reaching the Poor with Marketable Products. In: Proceedings of the International Forum on Grasscutter held at the Institute of Local Government Studies, Accra, Ghana from 12-16 December, pp:40

Fakolade P.O. (2012) Quality characteristics and microbiology status in Kundi an intermediate moisture meat (IMM) product. *International Journal of Agricultural Science,* 2(10): 563-569

Fayenuwo, J.O., Akande, M., Taiwo, A.A., Adeebayo, A.O., Saka, J.O. and Oyekan, P.O. (2003).Guidelines for Grasscutter Rearing. Institute of Agriculture Research and Training Publications. 38pp.

Kadim, I.T., Mahgoub, O., Al-Marzooqi, W., Al-Zadjali, S., Annamali, K. and Mansoor M.H. (2006) Effect of Age on Composition and Quality of Muscle longissimus Throracxis of the Omani Arabian Camel (*Camulus dromedaries*). *Meat Science,* 73: 619-625.

Kembi, S.O. and Okubanjo, A.O. (2002) Physico-chemical and sensory properties of dehydrated beef patties containing soybean products. *Tropical Animal Production Investigation* 5: 137-148.

Mahendraker ,N.S., Khabe, V.S. and Dan, N.P. (1988) Studies on the effect of fattening on carcass characteristics and quality of meat from Bannu-Lamb. *Journal of Food Science and Technology,* 25: 228- 230.

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. *Tropical Animal Production Investigation* 6:185.

Omojola, A.B. and Adesehinwa, A.O.K. (2006). Meat Characteristics of Scalded, Singed and Conventionally dressed rabbit carcasses. *World Journal of Zoology,* 1(1): 24–29.

Paleari, M. A., Moretti, V. M., Beretta, G., Mentasti, T., Bersani, C. (2003): Cured products from different animal species. *Meat Science*, 63: 485-489

Solomon, I.P., Ekanem, E.O., and Okubanjo, A.O. (1994). Effect of salt (NaCl) level and smoke application of chemical and sensory characteristics of UmanInung- a cured Nigeria Pork Product Dev. Tripenlndwirt. Zeitschrift for die landwinschaft in den Tropen.Und.Subtropen as, johrgang 5:365-367.

Soniran, O.G. and Okubanjo, A.O. (2002). Physio-chemical and sensory characteristic of pork loin roast cooked to three internal temperatures. *Nigerian Journal of Animal Products,* 29: (1) 138-141.

Suzuki, A., kojima, N., Ikeuchi, Y., Ikarashi, S., Moriyama, N., Ishizuka, T. and Tokushige, H. (1991): Carcass composition and Meat Quality of Chinese Pure bred and European and Chinese Cross Breeds Pigs. *Meat Science,* 29: 31- 41.

Tewe, O.O., Ayodele, I.A., Agbelusi, E.A., Meduna, A.T and Ajayi, S.S (1998). Biology, Domestication and Production of the grasscutter (*Thryonomys swinderianus*) in Nigeria: National Agricultural Research Project (NARP) 52 Pp

Tornberg, E. (2005) Effects of heat on meat proteins - Implications on structure and quality of meat products. *Meat Science,* 70: 493-508.

*****