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Full Length Research Paper

Cooking loss components of beef from Nguni, Bonsmara and Angus steers

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The effects of breed and ageing on beef cooking loss components were investigated. Correlations among the beef cooking loss components were also determined. *Longissimus thoracis et lumborum* (LTL) muscle steaks from Nguni, Bonsmara and Angus steers were prepared by an electric oven-broiling method using direct radiant heat at 260°C. They were placed in an oven pan on a rack to allow meat juices to drain during cooking and placed in the pre-heated oven 90 mm below the heat source. Raw and cooked weights were recorded. Percentage cooking loss, thawing loss, drip loss and evaporation loss were determined. Beef cooking loss components were affected (P<0.05) by ageing with meat aged for two days having higher (P<0.05) losses than meat aged for 21 days. Cooking loss components were not (P>0.05) affected by breed. There were no (P>0.05) significant correlations among the cooking loss components.

Key words: African beef cattle, drip loss, evaporation loss, processing quality, thawing loss

INTRODUCTION

Throughout the developing world, especially in Africa, food requirements have favoured the use of cattle breeds that have the ability to produce beef even under limiting conditions (Trail and Gregory, 1981). The limiting conditions may affect beef eating and processing quality traits such as cooking loss. Furthermore, the harsh conditions favour the use of indigenous breeds such as the Nguni breed of South Africa. Nguni cattle resist parasites and tick-borne diseases, tolerate harsh environments, and thrive under poor nutrition in South Africa (Muchenje et al., 2008a; 2008b; Ndlovu et al., 2007). On the other hand, Bonsmara breeds developed in Limpopo Province of South Africa to rival European beef breeds, in terms of beef production, are a composite breed made up of the indigenous Afrikaner cows and exotic Shorthorn and Hereford bulls (Holloway et al., 2000). Like Nguni, they are able to thrive in harsh conditions of South Africa (Holloway et al., 2000; Muchenje et al., 2008a). Such adaptive traits have resulted in the effort to promote and encourage the use of the Nguni breed in the production of a high quality meat under the harsh environmental conditions. The exotic Angus is a cattle breed that has been developed under temperate conditions. It hardly survives on harsh conditions and low input systems where the Nguni thrives (Muchenje et al., 2008a), which makes them unsuitable in rural areas.

The cooking process of beef from the above cattle breeds is an important tool for the sensory perception of beef by consumers. Cooking is a process of heating beef at sufficiently high temperatures that denatures proteins and makes it less tough and easy to consume (Garcia-Segovia et al., 2006). It can be achieved either by boiling or by roasting (Shilton et al., 2002) and in all cases losses occur. Cooking loss, which is one of the meat quality parameters that is often ignored by meat scientists and technologists, refers to the reduction in weight of beef during the cooking process (Vasanthi et al., 2006). The major components of cooking losses are thawing, dripping and evaporation (Bender, 1992; Barbantia and

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Pasquini, 2004; Obuz et al., 2004). Thawing loss refers to the loss of fluid in beef resulting from the formation of exudates following freezing and thawing. Such losses are lower following a rapid freezing compared with slow freezing. This is because of small crystallization formed by the rapid freezing (Hui, 2004). Dripping is the loss of fluid from beef cuts and water evaporation from the shrinkage of muscle proteins (actin and myosin) (Yu et al., 2005).

Drip loss is of high importance due to its financial implications. Low water holding capacity reduces beef yield during processing. Generally, beef with high drip loss has an unattractive appearance and therefore has low consumer acceptance, which leads to loss of sales (Lawrie, 1974). It also decreases meat tenderness and juiciness which lessen consumers' demand for beef. Evaporation refers to the loss of fluid from the beef surface through its conversion to gaseous form. It changes the shape of beef through shrinkage and causes firmness and poor juiciness in beef (Yu et al., 2005). The different components of cooking loss may vary depending on the ageing period. Furthermore, the cooking components may also be related.

An increase in cooking loss has a large financial impact in beef industry. For example, beef products such as sausages have significant amounts of high protein quality and are good sources of several essential minerals, including iron and zinc as well as B vitamins. The increased loss of such nutrients deteriorates the beef nutritional quality and lowers its purchase (Pearson and Gillett, 1988).

Despite its importance as a beef quality trait, previous studies on beef quality of cattle raised in low input cattle production systems on natural pasture did not consider cooking loss (Muchenje et al., 2008a). Therefore, there is need to determine beef cooking loss of cattle raised on natural pasture in low input cattle production systems. The objective of the current study was to compare cooking losses of beef from Nguni, Bonsmara and Angus steers raised on natural pasture in a low input system over different ageing periods. The study also sought to determine relationships among different cooking loss components. The null hypothesis tested was that there were no breed and ageing differences on different components of cooking loss. It was further hypothesized that there were no relationships among the cooking loss components.

MATERIALS AND METHOD

Site description

The study was conducted at the University of Fort Hare farm. The farm is located 5 km east of the town of Alice, Eastern Cape, South Africa and is 520 m above sea level. It is located 32.48˚ south and 26.53˚ east. It is situated in the False Thornveld of the Eastern Cape, and the vegetation is characterised by several trees, shrubs, and grass species with *Acacia karroo, Themeda triandra, Panicum maximum, Digitaria eriantha, Eragrostis spp., Cynodon dactylon,* and *Pennisetum clandestinum* being the dominant plant species. The average rainfall is approximately 480 mm per year, and mostly comes in summer. Mean temperature of the farm is about 18.7˚ C per year. The topography of the area is generally flat with a few steep slopes.

Animals used and muscle sampling

The meat for sample analyses were collected from fifteen steers of each of the following cattle breeds: Nguni, Bonsmara, and Angus. The steers were raised on a natural pasture through rotational grazing, and were slaughtered at 18 months. Details of the natural pasture are as described by Muchenje et al. (2008a). The steers were slaughtered at the East London abattoir which is about 120 km away from the farm. They were left in the lairage waiting for slaughter the following morning. During that time, there was no feed except water which was always available. The *longissimus thoracis et lumborum* (LTL) muscle of left and right side, in the region of 8 - 12^{th} ribs were sampled a day after slaughter in the direction of the rump for meat quality analyses as described by Muchenje et al. (2008a). Samples were placed in vacuum plastic bags and flown to the Agricultural Research Council (ARC) Irene Institute, which is close to 1000 km away from East London, in an insulated box. Forty eight hours post slaughter the following samples were taken:

a) A 100 mm thick of the anterior side of the left LTL for 2-day aged cooking loss determination.
b) A 100 mm thick of the anterior side of the right LTL for 21-day aged cooking loss determination.

The samples for treatment (b) were frozen at -20˚C till CL determination. They were then transferred to a refrigerator and kept at 0 - 3˚C to age for 19 days (21 days in total). After that they were frozen at -20˚C till cooking loss determination.

Cooking loss components determination

The steaks were prepared by an oven-broiling method using direct radiant heat. An electric oven was set on "broil" 10 min prior to preparation at 260°C. Steaks were placed in an oven pan on a rack to allow meat juices to drain during cooking and placed in the preheated oven 90 mm below the heat source. They were cooked to an internal temperature of 70°C recorded by direct probe. Raw and cooked weights were recorded. Following cooking, the steaks were cooled down at room temperature for 5 h before cooking loss determination. Percentage thawing loss, drip loss, cooking loss and evaporation loss were calculated as follows:

- Immediately after slaughter before freezing, the samples from LTL were weighed. The samples were thawed over a period of 24 h at 0 - 4˚C and weighed again.
- Thawing loss = [(weight before thaw - weight after thaw) ÷ weight before thaw] × 100.
- Drip loss was calculated as the weight of drip after cooking divided by the weight of the thawed meat sample. Drip loss = [drip weight ÷ raw weight before drip] × 100
- Cooking loss = [(weight of raw steak after thawing – weight of cooked steak) ÷ weight of raw steak after thawing] × 100.
- Evaporation loss = 100 – [(weight after cooking) ÷ raw weight] × 100

Statistical analysis

Breed and ageing effect on cooking loss components were analysed using Generalised Linear Models procedures of SAS (2000). The significance differences between least square group means

Table 1. Least square means and standard errors of means (in parenthesis) of cooking loss components for beef from Nguni, Bonsmara, and Angus steers aged for two days (CL2) and 21 days (CL21).

Cooking loss components	Nguni		Bonsmara		Angus	
	CL2	CL21	CL 2	CL 21	CL 2	CL21
Thawing loss (%)	.26(0.289)[bc]	2.59(0.289)[ab]	3.35(0.299)[bc]	2.23(0.299)[a]	3.60(0.355)[c]	2.80(0.355)[abc]
Drip loss (%)	0.97(0.138)[ab]	0.84(0.138)[ab]	1.05(0.143)[ab]	1.14(0.143)[b]	0.71(0.169)[a]	0.84(0.169)[ab]
Evaporation loss (%)	24.1(0.439)[d]	22.3(0.439)[ab]	22.5(0.455)[abc]	22.2(0.455)[a]	24.3(0.538)[d]	23.1(0.538)[abcd]
Cooking loss (%)	25.1(0.446)[d]	23.2(0.446)[a]	23.5(0.462)[abc]	23.4(0.462)[ab]	24.9(0.547)[d]	23.9(0.547)[abcd]

Table 2. Pearson correlation coefficients *r* among beef cooking loss components.

	Thaw loss	Drip loss	Evaporation loss
Thaw loss	-	- 0.11931	0.05185
Drip loss		-	- 0.15000

were compared using the PDIFF test of SAS (2000). Pearson's correlation coefficients among cooking loss components; thawing loss, drip loss and evaporation were determined using SAS (2000).

RESULTS

The effect of breed and ageing on the cooking loss components are shown in Table 1. Except for drip loss in meat from Bonsmara and Angus steers; as ageing increased, the thawing loss, drip loss, evaporation loss and cooking loss decreased ($P<0.05$). There were no ($P>0.05$) significant differences among the breeds in all the cooking loss components. Table 2 shows the Pearsons' correlation coefficients among thawing loss, drip loss and evaporation loss. All the beef cooking loss components were not ($P> 0.05$) significantly correlated.

DISCUSSION

The decrease in cooking loss as ageing increased was as expected since enzymatic reactions by endogenous enzymes, such as collagenase which are produced by bacteria within beef or by ionic solubilisation, progresses at faster rates as ageing increases. The collagenase enzymes disintegrate the myofibrillar proteins and connective tissue thereby improving water holding capacity by proteins (den Hertog-Meischke et al., 1998; Bruce et al., 2003).

There were no differences between the breeds in cooking and thawing loss. The only difference was seen within the Bonsmara steers. The thawing loss levels in the current study were slightly lower than those reported in beef steaks by Jeremiah and Gibson (2003) from beef sampled from different abattoirs in Canada. The cooking loss levels in steaks in the current study were slightly higher than those reported by Jeremiah and Gibson (2003) which averaged 22.5% but lower than those reported by Razminowicz et al. (2006) in pasture-fed steers which averaged 30%. The differences in cooking and thawing losses in the current study and those reported by other authors may be attributed to several factors such as differences in ageing, cooking method applied, cooking temperatures, duration of cooking temperatures, pH and Marbling (Lawrie, 1974, Nour et al., 1994, Yu et al., 2005).

Dripping and evaporation losses of steaks from the steer breeds were not significantly different. The only difference was found within the Nguni steers whereby at two days ageing there was higher evaporation loss than at 21 days ageing. This may be ascribed possible to the high existence of calcium dependent protease inhibitor called calpastatin in *Bos indicus* breeds. Calpastatin inhibits the action of calpains in disintegrating the muscle proteins therefore not improving the water and nutrients retention (Ferguson et al., 2000; Simela, 2005). However, cooking losses of steaks from all the breeds were not different at both periods of ageing.

Although cooking temperature in the current study was similar at 70°C, cooking temperatures have been reported to cause drastic changes in beef, such as shrinkage of beef protein network and protein coagulation (Bertram et al., 2004; Barbera and Tassone, 2006). Beef cooked swiftly to a given internal temperature has a low cooking loss and is juicier than beef cooked at the same temperature slowly. This is because a high heat (≥70˚C) rapidly coagulates the proteins on the beef surface and so rapidly forming a layer that protects much cooking losses by evaporation and drip (Lawrie, 1998). Contrary, shrinkage of protein networks increases at cooking temperatures below 60˚C. This occurs because of the long duration to be taken to achieve the required internal temperature. This duration also retards the rapid forma-tion of the surface layer for protection against moisture losses. Shrinkage network exerts a mechanical force on the water between the fibres, and the proteins are denatured (Vasanthi et al., 2006). Denaturation is the change of protein structure during cooking which brings a decrease in diameter and thickness of the protein and so a less juicy and tougher cut (Barbera and Tassone, 2006). These phenomena result in decrease in bound water with an accompanying increase in beef weight losses. Cooking losses up to a temperature of approximately 60˚C are due mainly to evaporative losses, where as more than 60˚C results in losses in the form of drip (Lawrie, 1998).

Although pH was not measured in the current study, beef ultimate pH has a marked influence in muscle capability to retain natural water (Bruce et al., 2003; Sheard et al., 2005). Rapid pH fall due to possible short-term stress susceptibility mostly shown by exotic breeds results in poor water holding capability by myofibrillar muscle proteins (Bruce et al., 2003). Muscle of lower holding capacity is associated with higher drip and cooking losses hence lower juiciness and less tender muscle (Bruce et al., 2003; Sheard et al., 2005). On the other end, long-term stress depletes the muscle glycogen storage after slaughter. This depletion of glycogen leads to low acid production and high ultimate pH. This ultimate pH improves the space availability and thus more water is withheld within the myofibrillar proteins (Bruce et al., 2003).

The absence of significant correlations among cooking loss components was unexpected since cooking loss and evaporation loss are normally negatively correlated. The negative correlation is caused by the fact that as ageing increases at elevated temperatures, the myofibrillar water holding capacity improved resulting in a decrease in the ability of fluid to flow, while that of gases increases with an increase in temperature (den Hertog-Meischke et al., 1998; Bertram et al., 2004; Yu et al., 2005). Thawing loss and drip loss are normally negatively correlated because of the crystallisation rate formed during freezing (Hui, 2004; Drummond and Sun, 2005). Rapid freezing in combination with rapid thawing provide the most firm texture and the lowest amount of exudates (Jeremiah, 1996).

Positive correlations between thawing loss and evaporation loss were expected because after the beef has been frozen, ice sublimation during thawing from the beef surface occurs, and if it is excessive during thawing, a dry and spongy beef product may occur (James and James, 2002).

Conclusion

The present study demonstrated that cooking losses from beef are affected by ageing but not by breed. Lower cooking losses were observed as ageing increased. There were no relationships among the cooking loss components. It is therefore recommended that each cooking loss component has to be determined when analysing for cooking loss as a meat eating and pro-cessing quality trait.

However, more work needs to be done to assess cooking loss at high input cattle produc-tion systems.

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