BEEF QUALITY AND CREATINE KINASE ACTIVITIES AS AFFECTED BY ANIMAL-RELATED FACTORS AND SEASON

Amanda Y. Chulayo[1*], T. Mpakama[1] and V. Muchenje[1]

[1]Department of Livestock and Pasture Science, University of Fort Hare, Alice, 5700, South Africa

*Author: Achulayo@ufh.ac.za

Abstract – The objective of the study was to determine the effects of age, breed, sex and season on the activity of creatine kinase (CK) concentration in blood and beef quality. Three hundred and twenty one cattle from three genotypes (108 Bonsmara, 130 Beefmaster and 83 Brahman) were used in the study and grouped according to age in months as follows: 16 months, 18 months and 24 months old. At exsanguinations, blood samples were collected using disposable vacutainer tubes for CK determination. *Muscularis longissimus thoracis et lumborum* (LTL) samples were collected 24 h after slaughter to determine the color (L*, a* and b*) and ultimate pH (pH_u) of beef. Age, breed, sex and season had significant effects ($p<0.05$) on CK levels and on beef quality. Bonsmara had the highest CK concentration (705.3±80.57 U/L) and pH_u (6.3±0.05), L* (24.8±0.78) a* (17.5±0.53) and b* (12.8±0.53) values as compared to Beefmaster and Brahman. Higher CK levels were also observed in winter (704.1.3±43.85) than other seasons. Therefore, it was concluded that animal-related factors (age, breed and sex) had an effect on muscle damage which have a detrimental effect on the levels of CK and meat quality.

Keywords: Age, breed, beef quality, creatine kinase, season.

I. INTRODUCTION

Several pre-slaughter processes that are at play before the animal is slaughtered results to poor animal welfare and beef quality. The pre-slaughter period involves rounding up, kraaling, loading, transportation and off-loading at the abattoir (1; 2). Animal transportation is associated with numerous risks resulting from management, intrinsic and extrinsic factors; of these, intrinsic factors such as breed, age and sex have been found to significantly affect beef quality (3). At the slaughterhouse, beef cattle are grouped by their age, size and breed which is done by the farm and abattoir workers. Male and young animals due to their comparatively more aggressive behavior are more at risk of poor meat quality than female and old animals. Moreover, the results are also due to rough driving and mishandling before and after transportation (4; 5; 6). It is enlightened that sex of animals, gender and breed has an effect on animal stress (7). Stress results in an increase in the activity of creatine kinase in the blood and this is due to tissue damage and poor muscular tissue reperfusion (8; 9). In goats and sheep, higher levels of CK in the plasma were found to be caused by breed temperament, excitability and fighting against each other (10; 11). The aforementioned factors, including transportation, are documented to likely have a greater adverse effect on the welfare of calves than on mature (>17 to 19 months) age animals (12). Moreover, older animals (>36 months) experience similar welfare challenges which later reduce carcass quality and meat quality resulting in low economic value (13). Breeds such as Beefmaster, Bonsmara, Brahman and Nguni are recorded to withstand adverse environmental conditions (hot temperatures), long dry periods, diseases and parasites (14; 15; 16). Several studies indicate that stress increase post mortem ultimate pH (pH_u) values due to depletion of glycogen in ruminants and produces tougher meat (4; 2; 17). Research on breed stress responsiveness (17), mutton quality (18; 2) and creatine kinase in sheep (11) has been done. However, there is little or no information on the relationship between creatine kinase (CK) and meat quality attributes (pH_u and color) in beef cattle. Therefore the objective of the study was to determine the effects of animal-related factors and season on the activity of creatine kinase (CK) and the quality of beef.

II. MATERIALS AND METHODS

Study site

The study was conducted at a high-throughput commercial abattoir in the Eastern Cape Province

of South Africa. The climate of the area is mild with an average rainfall of 850 mm. Permission to conduct the study was obtained from the Ethics Committee of the University of Fort Hare, South Africa. Ethical principles were considered in the study to conform to the national and international standards governing research with usage of animals. The day temperature during the period of study ranged from 10°C to a high of 36°C, averaging 22.3°C.

Animal management

Table 1 Least square means (±SE) for the effect of age, breed and sex of animal on the activity of CK

Variables	Number of animals per breed	Creatine Kinase (Units per liter)
Breed		
Bonsmara	108	705.3±80.57[c]
Beef-master	130	657.4±73.85[ab]
Brahman	83	461.8±80.63[a]
Sex		
Females	222	579.3±13.65[a]
Males	91	724.6±21.31[b]
Age		
16 months	116	636.6±76.83[b]
18 months	85	729.6±89.75[c]
24 months	112	524.1±78.19[a]

[a,b,c]Means in the same column with different superscripts are significantly different at p<0.05.

Three-hundred and twenty one cattle (*n* = 321) composed of 3 different breeds (108 Bonsmara, 130 Beefmaster and 83 Brahman) that were brought to the abattoir for slaughter were used in the study. The animals used were balanced according to sex (males and females) and grouped according to age categories as follows: Group 1 (16 months), Group 2 (18 months) and Group 3 (24 months). Data was collected over four seasons (winter, spring, summer and autumn) between June 2011 and May 2012. Animals were allowed to rest at lairage while having *ad-libitum* access to water for 24 hours (overnight) prior to slaughter in all the animal groups.

Sample preparation and analysis of creatine kinase

During exsanguinations, disposable vacutainer tubes with Ethylenediaminetetraacetic acid (EDTA) anticoagulant were used to collect blood. The blood samples were centrifuged (Model 5403 Centrifuge, Gatenbay Eppendorf GmbH, Engelsdorp, Germany) at 21 °C for 10 min at 3550 rpm and were then stored at -20°C. Analysis of CK was done at the National Health Laboratory Services (NHLS), Port Elizabeth in South Africa using a Model DXC 600 machine (Beckman Coulter, Ireland). The ingredients were added for quantitative determination of CK activity of units per liter (U/L) in plasma (11).

Determination of color and ultimate pH

A sample was extracted from *Longisimus thoracic et Lumborum* (LTL) muscles, removed from the 4th and 6th ribs of the loin region at 24 hours after animals were slaughtered. This sample was used to measure color (L* = lightness, a* = redness and b* = yellowness) and pH_u. The color coordinates were measured using a color-guide 45/0 BYK-Gardener GmbH machine with a 20 mm diameter measurement area and illuminant D65-day light, 100 standard observer. Ultimate pH was also measured from the same muscles using a portable pH meter (CRISON pH 25, CRISON Instruments, SA Spain).

Statistical analysis

Age group, breed, gender and seasonal effect on the activity of CK and beef quality was analyzed using PROC GLM of SAS (19). Significant differences in means between CK levels and beef quality parameters were compared using Duncan Multiple Range Test.

III. RESULTS AND DISCUSSION

Results in Table 1 show that Bonsmara had significantly higher (705.3±80.57 U/L) CK levels than Brahman (461.8±80.63 U/L), and Beefmaster breed (657.4±80.63 U/L). Bonsmara was more susceptible to stress due to rough driving and mishandling before and after transportation (20; 7). Long hours of transportation have been recorded to lead to fatigue and bruising that affects the permeability of the membranes and liberation of enzymes in the blood (14; 21). The reaction of this breed to transportation is perplexing because it has been noted that Bonsmara` s are able to withstand harsh and unfamiliar conditions (15). The lower CK levels in Brahman and Beefmaster is

ascribed to the fact that they are breeds which adapt well to handling and adverse environmental conditions (14). Table 1 shows that males had higher CK activity (p<001) as compared to female. Males are more active, aggressive and stress sensitive than females. Similar results were reported that normally have higher CK levels than females (22). Moreover, the observed increase (p<0.05) in CK levels for the 18 months old animals was due to muscle fatigue as a result of strenuous exercise. Creatine kinase found in muscles was reported to be expressed in higher levels in males and younger animals (22). Similarly, young animals being at risk of more muscle damage was also reported (4).

Season had an effect on the activity of CK in slaughter cattle as represented in Table 2. Creatine kinase (CK) was higher during the winter season (704.1±43.85 U/L) and lower in the summer season (181.3±124.09 U/L), while spring (698.3±59.19 U/L) and autumn (658.0±116.25 U/L) had intermediate CK levels. It was observed that CK levels were higher during winter season as a result of poor pre-slaughter conditions (8). However, increased CK activity in lambs was reported to be caused by physical stress during summer (23; 21).

Table 2 Least square means (±SE) for effects of season on bruising score and CK levels of cattle

Season	Creatine kinase (Units per liter)
Spring	698.3±59.19[a]
Summer	181.3±124.09[b]
Winter	704.1.3±43.85[a]
Autumn	658.0±116.25[a]

[a,b,c]Means in the same column with different superscripts are significantly different at p<0.05.

Age and breed had a significant effect on pH_u, and color (Table 3). Beef from Beefmaster and Brahman breeds had significantly higher (p<0.05) pH_u values of 6.3±0.05 and 6.1±0.06, respectively compared to that of the Bonsmara breed which had an average value of 5.6±0.05. Age had an effect (p<0.05) on L* values. The L* values ranged from 25.2±0.71, 26.6±0.83 and 20.9±0.73 for 16, 18, and 24 months old cattle respectively. The lower L* values were observed in 24 months old animals indicating meat becomes darker with increasing animal age. Higher values of pH had been reported to results in lower L* (lightness), a* (redness) and b* (yellowness) values than normal pH meat, indicating that high pH meat is darker and less brown than in normal pH meat (12).

IV. CONCLUSION

Age, breed and sex (animal-related factors) had an effect on the activity of CK and also on meat/beef quality. Creatine kinase levels were higher during winter months than in spring and autumn. Therefore, it was concluded that animal-related factors and season can have an effect in the development of muscle damage due to physical activity prior slaughter which increased CK activity and consequently provoking poor meat quality. Considering age, breed and sex, in slaughter animals, they should be managed so that they outcome should contribute to improve animal welfare and beef quality.

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Table 3 Least square means (±SE) of creatine kinase, ultimate pH and color of meat as affected by age and breed

Parameters	Age			Breed		
	16 months	18 months	24 months	Bonsmara	Beefmaster	Brahman
N	120	87	114	108	130	83
CK (U/L)	636.9±76.83[b]	729.6±89.75[c]	524.1±0.63[a]	705.3±80.57[c]	657.3±73.85[b]	461.8±80.63[a]
pH_u	6.1±0.05[a]	6.1±0.06[a]	6.1±0.05[a]	5.6±0.05[a]	6.3±0.05[b]	6.1±0.06[b]
L*	25.2±0.71[b]	26.6±0.83[b]	20.9±0.73[a]	24.8±0.78[b]	24.6±0.71[b]	21.7±0.89[a]
a*	17.9±0.53[b]	17.7±0.62[b]	12.9±0.54[a]	17.5±0.53[b]	16.8±0.53[b]	13.2±0.66[a]
b*	12.9±0.49[c]	11.5±0.58[b]	9.3±0.51[a]	12.8±0.53[b]	11.0±0.49[b]	9.6±0.61[a]

[a,b,c]Means in the same row with different superscripts are significantly different at p<0.05. pH_u = ultimate pH, L* = Lightness, a* = Redness, b* = Yellowness, CK = Creatine kinase, U/L = Units per liter.

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