THE INFLUENCE OF POST MORTEM MUSCLE ENERGY STATUS ON MEAT COLOUR AND TENDERNESS OF FIVE SOUTH AFRICAN BEEF BREEDS

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Abstract – This paper describes how early *post mortem* muscle energy affects meat colour and tenderness in *m. longissimus lumborum* of five different South African beef breeds (Angus, Bonsmara, Brahman, Charolais and Nguni). Ten animals per genotype were used. Muscle energy status were analysed at 1, 3, 6 and 20 h *post mortem*. Colour was measured on steaks aged for 3, 9, 14 and 20 days *post mortem*. Breed had an effect on muscle energy metabolism. Charolais and Nguni had lower glycogen and lactate levels, which corresponds to the darker meat colour observed in these breeds. Higher ultimate pH was found to be associated with tenderer meat, more so for the Nguni than the Charolais.

Key Words –Glycolytic metabolites, muscle energy pre-slaughter, ultimate pH and tenderness

I. INTRODUCTION

The development of meat quality characteristics, including colour, tenderness and water holding capacity (WHC) are controlled largely by the rate and extent of *post mortem* (pm) pH decline. pH decline is thought to follow the anaerobic degradation of glycogen to lactic acid [1]. Analysis of the glycolytic metabolites gives an opportunity to evaluate whether the experimental groups had the same muscle energy prior to slaughter [2]. Therefore, the aim of this study was to evaluate the differences in muscle energy pm and to evaluate how these differences affected meat colour and tenderness in five South African beef breeds.

II. MATERIALS AND METHODS

The following genotypes were studied – *Bos indicus* (Brahman), Sanga type (Nguni), British *Bos taurus* (Angus), European *Bos taurus* (Charolais) and the composite (Bonsmara). Ten animals per genotype (n=50). The animals were fed on a feedlot diet; all animals were slaughtered, processed and sampled at the ARC-Animal Production Institute abattoir. After exsanguination, the carcasses were halved; right sides were electrically stimulated and put in to cold rooms (±2 °C) within 60 min pm (ES treatment). Left sides were placed in a room with a controlled temperature of 10 °C for 6 hours, then placed in the cold rooms (±2 °C) (NS treatment). The concentrations of lactate, glycogen, creatine phosphate, ATP and glucose-6-phosphate, were determined in samples taken from the *m longissimus lumborum* (LL) from both sides at 1, 3, 6 and 20 h according to the method of Dalrymple and Hamm [3]. Meat colour was measured using Minolta meter (CIE L*a*b*) and tenderness was determined using Warner Bratzler shear force. Extreme climate conditions during slaughter were noted (day temperature > 35 °C).

III. RESULTS AND DISCUSSION

Muscle energy immediately pm affects meat colour and tenderness [1, 2, 4]. The Charolais and Nguni breeds had the lowest glycogen, glucose, glucose-6-phosphate and lactate concentrations. Congruently these breeds showed slower pm pH decline and higher pH_u (Table 1). Several studies have also reported that higher pH_u is associated with lower muscle glycogen levels and low lactate production [1, 2]. Some studies associate higher pH_u with more tender meat [5]. Consistently Nguni breed, which had the highest pH_u i.e. 5.78, gave rise to the most tender meat (Table 2) and darkest meat colour. This was because the reduction in glycolytic metabolites causes more rapid ATP depletion, earlier rigor and allowed prolonged activity of proteases [1]. However, the Charolais and Angus breeds did not follow the same trends. Although the Angus breed had a pH_u of 5.46 it had similar tender meat than that of Nguni, whereas the Charolais breed that had similar pH_u, than Nguni (pH 5.7), muscle glycogen and lactate levels than Nguni, the tenderness and colour averages did not correspond to that of the Nguni (Table 2). As an indigenous breed, Nguni is adapted to sub-tropical climate and harsh conditions. This could explain its lower energy needs, lower glycogen and other energy components, and explaining the natural tendency to produce darker meat [2]. On the other hand, the higher pH_u, lower energy components and darker meat of Charolais is not normal because of heat stress pre-slaughter. As mentioned under

Methods, extreme warm weather were experienced during time of slaughter. A preliminary study when environmental conditions were cooler (< 30 °C), the Charolais produced lighter pinkish meat (results not shown). To summarise; steaks from Nguni were the darkest followed by Angus, Bonsmara and Charolais which were similar and steaks from Brahman were lightest (higher L* values). The low glycogen and low lactate levels of the Charolais and Nguni corresponds with the dark colour observed in meat from these breeds.

Table 1: Effect of breed on lactate, glucose, glycogen, glucose-6-phosphate (G-6-P), adenosine triphosphate (ATP) and creatine phosphate (CP) of LL.

	Beef cattle breeds						
	Angus	**Bonsmara**	**Brahman**	**Charolais**	**Nguni**	**SEM[1]**	***P*-Value**
Lactate (µmol/g)	42.30^{ab}	43.27^{ab}	46.05^{a}	39.43^{bc}	36.44^{c}	3.668	< 0.0001
Glucose (µmol/g)	2.53^{a}	2.19^{a}	2.42^{a}	1.60^{b}	1.30^{b}	1.496	<0.0001
Glycogen (µmol/g)	31.38^{a}	22.78^{b}	35.61^{a}	16.89^{bc}	12.73^{c}	22.217	<0.0001
G-6-P (µmol/g)	4.38^{b}	3.91^{b}	5.39^{a}	2.30^{c}	2.21^{c}	2.741	<0.0001
ATP (µmol/g)	5.10^{a}	5.02^{a}	4.54^{b}	5.17^{a}	4.48^{b}	1.254	0.0006
CP (µmol/g)	7.07^{b}	7.04^{b}	6.28^{c}	7.68^{a}	6.81^{bc}	1.888	0.0004
pH_u	5.46^{b}	5.46^{b}	5.38^{b}	5.70^{a}	5.78^{a}	0.0149	<0.001

[1] Standard error of means
[a,b,c,d] Means within a row with different superscripts differ significantly

Table 2: The effect of breed on meat colour characteristics (CIE L*a*b*) and Warner Bratzler shear force (WBSF) of LL

	Beef breeds						
	Angus	**Bonsmara**	**Brahman**	**Charolais**	**Nguni**	**SEM[1]**	***P*-Value**
L*	40.42^{b}	41.35^{b}	43.95^{a}	41.06^{b}	37.09^{c}	5.944	<0.0001
a*	14.19^{a}	12.63^{b}	13.22^{ab}	10.98^{c}	10.92^{c}	3.494	<0.0001
b*	8.69^{b}	8.175^{b}	9.89^{a}	6.70^{c}	6.05^{c}	3.537	<0.0001
WBSF (N)	39.83^{b}	46.40^{a}	40.91^{ab}	43.46^{ab}	37.87^{b}	2.117	<0.0001

[1] Standard error of means
[a,b,c,d] Means within a row with different superscripts differ significantly

IV. CONCLUSION

It is not obvious that higher pH_u gives rise to tenderer meat; it depends on the characteristics of an individual breed. Dark meat colour has been seen to be associated with high pH_u and low lactate and low glycogen levels for both the Nguni and Charolais and vice versa. Where it is a characteristic of Nguni to produce darker meat, the Charolais do not normally produce dark meat, but it is more sensitive to environmental conditions than the other breeds, Angus, Bonsmara and Brahman.

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