EFFECTS OF GENOMICS AND POST-SLAUGHTER TREATMENT ON AGEING BEEF COLOUR

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Abstract – This is the second paper on this project describing the genotypic differences in beef colour of *M. longissimus* from steers consisting of Bos indicus (Brahman), Sanga type (Nguni), British Bos taurus (Angus), European Bos taurus (Charolais) and the composite (Bonsmara), 10 animals per genotype, n=50. Two post-slaughter treatments were applied: ES (short high voltage electrical stimulation, 20 sec, 400 V peak, 5ms pulses at 15 pulses/s followed by chilling within 1 hr at 4°C) and NS (no electrical stimulation with step-wise chilling, 6 hrs at 10°C followed by chilling at 4°C). Steaks were aged for 3 and 9 days on polystyrene plates covered with polypropylene cling wrap (PP) at 6°C in a display cabinet and for 14 and 20 days in vacuum bags at 1-4°C in a cold room. Significant differences were observed between breeds, treatments and aging in terms of colour as judged by a 10 member trained visual panel, CIE (*a, *b**, *L**), and myoglobin oxidative status.**

Key Words – Meat colour, myoglobin, trained visual panel.

I. INTRODUCTION

Visual attributes such as meat colour and visible fat influence the purchase-decision of consumers [1], but are not necessarily an indication of non-visual attributes such as tenderness and juiciness. It is noticed that different beef genotypes produce meat that differs visually in terms of colour appearances, surface morphology and pathology e.g it has been observed that Nguni produce darker meat than other beef breeds and Brahman meat may be lighter and differ structurally from other breeds.

Meat colour is dependent on factors such as ultimate pH (pHu), *post-mortem* pH/temperature decline, oxidative state of myoglobin (Mb) pigment content, age of animal, sex and breed. Mb is the primary protein that determines meat colour and is commonly found in three forms: oxymyoglobin (OxyMb), deoxymyoglobin (DeoMb), and metmyoglobin (Metmb). The relative proportions of these derivatives determine the colour of fresh meat. The oxidation of myoglobin can be assessed by pigment extraction followed by measurements using visible spectrophotometry. King *et al* [2] evaluated the genetic contributions of certain beef breeds on colour stability and observed that meat colour was not affected by breed at day 0 and that the differences in colour amongst breeds were observed during ageing. Behrends [3] reported that myoglobin content decreases with increasing days of display.

The purpose of this study was to evaluate colour differences (using Minolta), myoglobin oxidative status and the visual differences in fresh meat from five different beef breeds as a result of two different post-slaughter procedures, aging and normal packaging and vacuum packaging.

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 steers per genotype were purchased for the first phase of the project (10 animals per genotype, n=50). The animals were fed on a feedlot diet for a period of between 90-110 d depending on their readiness for slaughter at the ARC-API feedlot. All animals were slaughtered, processed and sampled at the abattoir of the Animal Production Institute (Agricultural Research Council, Irene, Gauteng, South Africa). After exsanguination the carcasses were halved. The right sides were electrically stimulated for 20 s (400 V peak, 5ms pulses at 15 pulses/s) and entered the cold rooms (± 4°C) within 60 min after slaughter (ES treatment). The left sides were placed in a room with a controlled temperature of 10°C for 6 hrs, after which they

were placed in the cold rooms at ± 4°C (NS treatment). The carcasses were sampled at the *M. longissimus lumborum* and two retail procedures were simulated for ageing of the sample steaks. The steaks were aged for 3 and 9 days on polystyrene plates covered with polypropylene cling wrap (PP) at 6°C in a display cabinet and for 14 and 20 days in vacuum bags at 1-4°C in a cold room.

Visual analysis was evaluated by a 10 member sensory panel at the ARC-Irene meat science laboratory for each ageing period according to the ASTM standards [4]. The steaks were allowed to bloom for 1 hr prior to visual observations. The steaks were evaluated for meat colour, fat colour, marbling, texture, fiber separation, structure integrity, odour, meat feel/pathology, and overall acceptability.

Meat colour was measured on each steak for each ageing period with a Minolta meter [5] at 3 different places on the steak after blooming the meat for about 1 hr. Three recordings were performed on each steak. The steak colours were obtained as three components; luminance or lightness, L* (dark to light), and two chromatic components; a* (green to red) and b* (blue to yellow) values (CIE colour model). Chroma (intensity of the red colour/saturation index) (S) = $(a^2+b^2)^{1/2}$) were calculated.

Relative concentrations of myoglobin derivatives. were determined in fresh meat sample extracts according to the method described by [6] with some modifications for each ageing period. About 2 g of the upper 1/3 of a meat sample was homogenized in 10 ml of 2mM pH 7 phosphate buffer for 30 s using an ultra-turrax T25. The homogenate was centrifuged at 10000 g (4°C) for 30 min and filtered through Wattman No. 134 filter paper. The spectra of the filtrates were recorded from 400-700 nm using Agilent 8453 diode-array spectrophotometer. The concentrations of MetMb, DeoMb, OxyMb were calculated using absorbances at 503, 544 and 581 nm respectively, 525 nm was taken as the isobestic absorbance according to previously published methods [6,7,8]. The following equations were used to calculate the relative concentrations of myoglobin derivatives as modified by [8] from the original equations of [7].

$[DeoMb] = C_{DeoMb}/ C_{Mb} = -0.543R_1 + 1.594R_2 + 0.553R_3 – 1.329$

$[OxyMb] = C_{OxyMb}/ C_{Mb} = 0.722R_1 - 1.432R_2 - 1.659R_3 + 2.599$

$[MetMb] = C_{MetMb}/ C_{Mb} = -0.159R_1 – 0.085R_2 + 1.262R_3 – 0.520$

Where $R_1 = A_{581}/A_{525}$, $R_2 = A_{544}/A_{525}$, $R_3 = A_{503}/A_{525}$

Total Myo: DeoMb + OxyMb + MetMb.

The data were subjected to analysis of variance for a split plot design [9] with the five beef breeds (Angus, Bonsmara, Brahman, Charolais and Nguni) as whole plots and the four ageing periods (1, 9, 14 and 20 d post-mortem) as sub-plots. Means for the interactions between sub-plot and whole-plot were separated using Fisher's protected t-test least significant difference (LSD) at the 5% level of probability [10].

III. RESULTS AND DISCUSSION

In this paper we are only reporting on beef colour, one of the visual attributes that we are studying in this project. The most frequent colour descriptions chosen by the sensory panel for 3 d and 14 d *post-mortem* steaks are represented in Figure 1. Three day *post mortem* NS steaks of Angus, Bonsmara, Brahman and Charolais were described to be either pink-brown or pale-pink compared to the equivalent ES steaks described to be pink or light cherry red. It is known that ES protects the favourable colour of meat [11]. The vacuum packed 14 d steaks seemed to preserve their colour (pink or light cherry red) irrespective of post-slaughter treatment. The Brahman and Charolais steaks tended to be lighter than the Angus and Bonsmara (judged to be pink versus light cherry red). The Nguni steaks were the exception, being constantly perceived as dark red irrespective of the treatment or day *post-mortem*. It must be stressed that these is preliminary results.

The interaction of post-slaughter treatment and breed on meat colour for the four ageing-packaging steaks was evaluated. There were significant differences ($P < 0.001$) between post-slaughter treatments for *L**, a* and b* coordinates, as well as Chroma. Breed had only significant effects ($P < 0.001$) on *L**, and b* and

therefore Chroma. These differences are represented in Figures 2, 3 and 4.

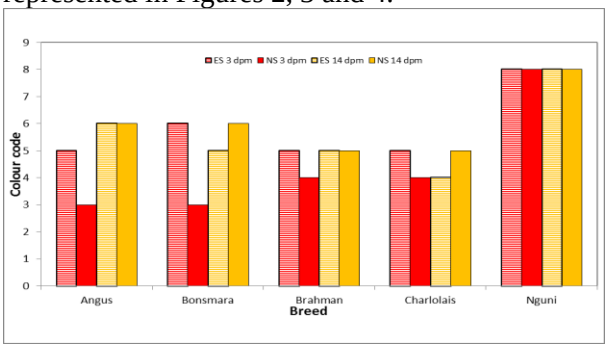

Figure 1**.** The most frequent description of colour of steaks of ES and NS treated beef breeds at 3 d and 14 d *post-mortem*. 1 = Brown-orange; 2 = Greyish-brown; 3 = Pink-brown; 4 = Pale pink; 5 = Pink; 6 = Light cherry red; 7 = Cherry red; 8 = Dark red; 9 = Very dark red to purple.

From Figure 2 it can be observed that the 9 d *post–mortem* steaks were darker (L* = 38.00) ($P < 0.001$) than the steaks from 3 d (L^* = 40.24), 14 d (L^* = 40.09), and 20 d (L^* = 40.36). The 3 d steaks were more red (a* = 11.79) than the 9 d steaks (a* = 8.27) but less red than the 14 d and 20 d steaks (a* = 13.50). Chroma (intensity of redness) of the 14 d and 20 d steaks were also the highest, with the ES steaks even higher than that of the NS steaks. The Chroma of the 9 d steaks were mostly affected because of protein denaturation and decay.

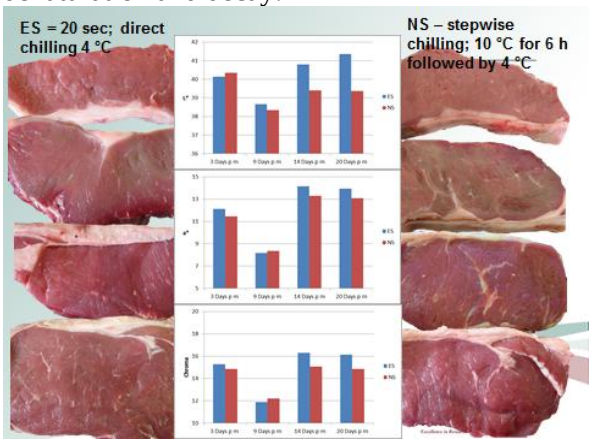

Figure 2**.** The effect of post-slaughter treatment (ES and NS) on meat colour coordinates *(L*, a* and Chroma) of the four ageing-packaging steaks.

From observing Figure 3 it is apparent that the Nguni had the darkest meat, followed by the Brahman, then the Angus and Bonsmara and finally the Charolais, which overall had the lightest meat in all treatments and ageing-packaging steaks.

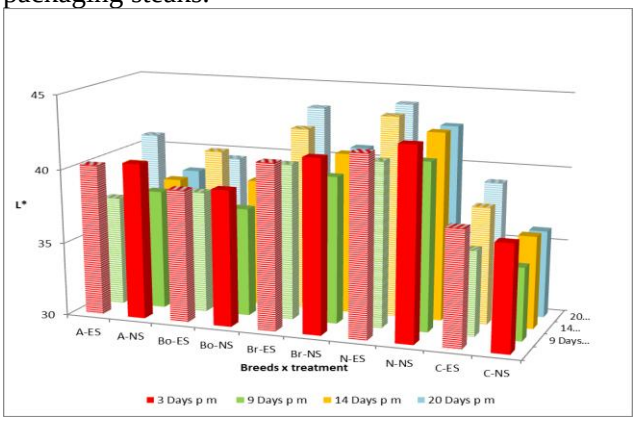

Figure 3. The effect of post-slaughter treatment (ES and NS) and breed (Angus, Bonsmara, Brahman, Charolais and Nguni) on meat colour coordinate *L** of the four ageing-packaging steaks illustrating the lightness of darkness of the steaks.

The higher *L** value following electrical stimulation could be due to a greater amount of light being reflected from the muscle as a result of a looser structure occurring, also allowing deeper oxygen penetration [12]. From Figure 4 it is apparent that the ES Bonsmara, Brahman and Nguni 14 d and 20 d steaks had the highest redness intensity.

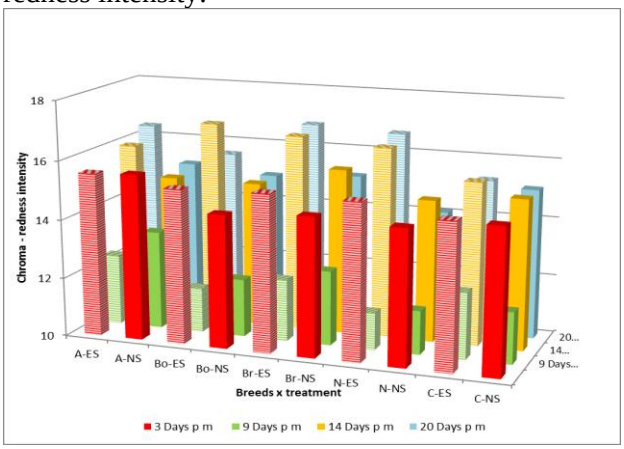

Figure 4. The effect of post-slaughter treatment (ES and NS) and breed (Angus, Bonsmara, Brahman, Charolais and Nguni) on of Chroma of the four ageing-packaging steaks illustrating the meat red colour intensity of the steaks.

Eikelenboom *et al*. [11] found that electrically stimulated beef at 24 hrs was typically more red, an effect attributed to damage to the enzyme systems responsible for oxygen consumption, reduced oxygen consumption rate and, hence,

higher concentrations of oxymyoglobin in the surface meat layer [13]. This corresponds with our results as demonstrated in Figure 5.

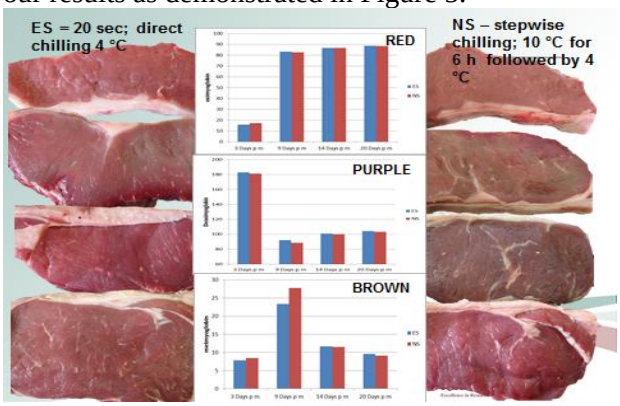

Figure 5. The effect of post-slaughter treatment (ESandNS) on deoximyoglobin, oximyoglobin and metmyoglobin consentrations in the four ageing-packaging steaks.

The effect of post-slaughter treatment on the concentrations of DeoMb, OxyMb and MetMb in the four ageing-packaging steaks are represented in Figure 5. There were no breed differences. There were high levels OxyMb detected in 9 d, 14 d and 20 d steaks which were significantly different ($P < 0.001$) from the 3 d steaks, OxyMb is responsible for the red colour of meat. The 3 d steaks had the highest level of DeoMb in comparison with the 9 d, 14 d and 20 d steaks.

The 9 d steaks had the highest MetMb levels that correspond with the colour of the steaks and the denaturation state of the protein.

IV. CONCLUSION

Colour differences occur in meat as a result of post-slaughter treatments and breed differences, but mostly as a result of ageing and different storage procedures. Measurements of meat colour by means of equipment corresponded with the visual observations of the trained sensory panel and it should therefore be possible for a person to evaluate meat if experienced.

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