COLOR STABILITY OF *LONGISSIMUS LUMBORUM* AND *PSOAS MAJOR* FROM NELLORE (*BOS INDICUS*) BULLS FINISHED WITH GRAIN DIET

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Abstract – The aim of this study was to investigate the color stability of *Longissimus lumborum* and *Psoas major* from Nellore bulls (*Bos indicus*) finished with grain diet. *Longissimus lumborum* (LL) and *Psoas major* (PM) were obtained from ten (n=10) beef carcasses of Nellore bulls with similar age and finished with grain diet. LL and PM were selected by similar pH, weight and marbling scores (36 h post-mortem) and were fabricated into 1.5 cm thick steaks. The steaks were over-wrapped with oxygen-permeable polyvinylchloride film, and stored under refrigeration (4ºC) for 9 days. Were performed analysis of myoglobin concentration (day 0), surface redness (*a value), ratio of reflectance at 630 nm to 580 nm (R630/580) and metmyoglobin reducing activity (MRA) at days 0, 5 and 9 of storage. LL demonstrated greater values of redness (*a** values), R630/580 and MRA than PM during storage. These results indicated that the variation in beef color stability is associated with differences in muscle profile.**

Key Words – Color stability, Nellore, Grain diet

I. INTRODUCTION

Color is an important attribute of quality determinant for consumer acceptance mainly in red meats [1]. A bright cherry-red color is commonly associated with beef wholesomeness, and any deterioration on this color can lead a rejection [1]. Myoglobin (Mb) is the major protein responsible for beef color and its redox state is directly influenced by extrinsic and intrinsic factors [2] such as genetics and breed [3]. It is well established a muscle-specificity effect on beef color stability [4], in which *Longissimus lumborum* (LL) is classified as a color-stable muscle, whereas *Psoas major* (PM) as a color-labile one [5]. The differences on color stability among different muscles have been extensively studied in *Bos taurus* [6; 7]. However, the influence of muscle on beef color stability from *Bos indicus* finished with grains is not completely understood. Therefore, the aim of this study was to investigate the color stability of muscles *Longissimus lumborum* (LL) and *Psoas major* (PM), obtained from Nellore bulls (*Bos indicus*) finished with grains, during 9 days under refrigerated (4ºC) storage.

II. MATERIALS AND METHODS

Ten (n=10) beef carcasses from purebred Nellore bulls with similar age (18—24 months) and finished (during 90 days) with grain diet were utilized in the present study. LL and PM muscles were removed from carcasses demonstrating similar pH, weight and marbling scores (36 h post-mortem) and fabricated into 1.5 cm thick steaks. The steaks were over-wrapped with oxygen-permeable polyvinylchloride film, and stored under

refrigeration (4ºC) for 9 days. The concentration of myoglobin was performed at day 0 of storage, whereas surface redness (*a** value), ratio of reflectance at 630 nm to 580 nm (R630/580) and metmyoglobin reducing activity (MRA) were analyzed on days 0, 5 and 9 of storage [8].

Myoglobin concentration was determined according to Faustman *et al.* [9]. Duplicate of 5 g frozen samples were homogenized in 45 mL ice cold sodium phosphate (40 mM) buffer at pH 6.8. The homogenate was filtered using Whatman no. 1 filter paper, followed by an additional filtering with 22 µm Millipore membrane. The absorbance of the filtrate at 525 nm (A525) was recorded using UV-1800 spectrophotometer (Shimadzu Corporation, Kyoto, Japan) with sodium phosphate buffer as blank. Myoglobin concentration was calculated using the following equation.

Myoglobin (mg/g)= [A525/(7:6 mM^{-1} cm−1 x 1 cm)] x [17, 000/1000] x 10

Where 7.6 mM^{-1} cm^{-1}= millimolar extinction coefficient of myoglobin at 525 nm; 1 cm = path length of cuvette; 17,000 Da = average of myoglobin molecular mass; 10= dilution factor.

The surface redness (*a** value) and R630/580) were measured at two random surface locations on each steak using Minolta CM-600d spectrophotometer (Konica Minolta Sensing Inc., Osaka, Japan) with 8 mm diameter measuring aperture, illuminant A, and 10° standard observer [8].

MRA measurement, were performed in two cubes measuring 2 cm × 2 cm × 1 cm for each LL and PM muscle and were submerged in 0.3% sodium nitrite solution for 20 minutes, at room temperature, to induce metmyoglobin formation. Samples were blotted dry, vacuum packaged, and scanned from 700 to 400 nm with CM-600d spectrophotometer to obtain the reflectance data. The samples remained under incubation for 2 h to induce reduction of metmyoglobin and then were rescanned. Surface metmyoglobin were calculated using K/S ratios and established formulas according to AMSA [8]. MRA=100 × ([preincubation % surface metmyoglobin]-[postincubation % surface metmyoglobin])/([preincubation % surface metmyoglobin]).

The effects of muscle source (LL *vs*. PM) and days of storage were analyzed (days 0, 5 and 9) on instrumental color and MRA data through repeat measures analysis using XLSTAT statistical software (Version 2014.5.03, Addinsoft, Inc., Brooklyn, NY, USA). Moreover, data of myoglobin concentration was analyzed only for the effect of treatment. The differences between means were detected using Tukey at 5% significance ($P < 0.05$) level.

III. RESULTS AND DISCUSSION

The PM demonstrated higher myoglobin (Mb) content (4.66 ± 0.31 mg/g) than LL (3.97 ± 0.12 mg/g) on day 0 of storage. The difference on Mb content can be attribute to the composition of muscle fibers [10; 11]. PM is composed majority of red fibers (type I), which have high Mb content comparing to LL [11]. Similar results were demonstrated by Jeong *et al*. [10] and Hwang *et al*. [11], which observed high Mb content in PM than LL steaks from Korean native cattle (Hanwoo) on day 0 of storage.

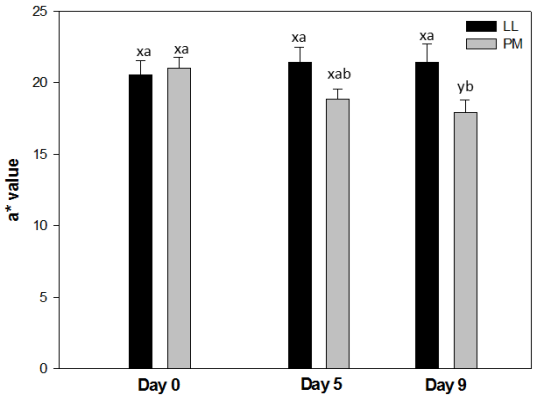

Figure 1. Surface redness (*a** value) of *Longissimus lumborum* (LL) and *Psoas major* (PM) steaks during 9 days of refrigerated storage (4ºC) under aerobic packaging. Standard error bars are indicated. Means without common letters are different ($P < 0.05$).

The LL demonstrated greater (P < 0.05) surface redness than PM on day 9 of storage (Figure 1). The LL muscle is composed predominantly of type IIb fibers, which indicates a glycolytic metabolism [12]. The glycolytic metabolism promotes low oxygen consumption, which reduces the myoglobin oxidation and keeps redness [5]. In addition, a^* values were not affected on LL during storage (P > 0.05) and a decrease on PM redness (P < 0.05) was observed on day 9. The decrease on PM $a*$ values could be related to greater amount of type I fibers and oxidative metabolism of muscle [10]. In general, oxidative muscles demonstrate high oxygen consumption and low color stability during storage due to the susceptibility of myoglobin to autoxidation [5]. The decrease pattern of a^* values in PM was previously reported in PM steaks from *Bos taurus* [7] during 9 days of storage, respectively.

The ratio 630/580 was greater (P < 0.05) in LL than PM on days 5 and 9 of storage (Figure 2). During storage, R630/580 values remain similar (P > 0.05) on LL, while a decrease pattern on (P < 0.05) was observed in PM.

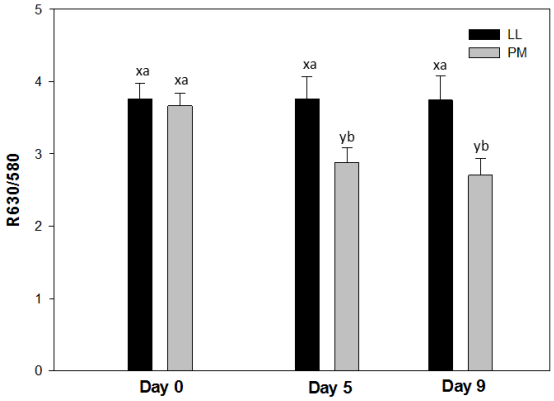

Fig. 2 Surface color stability (R630/580) of *Longissimus lumborum* (LL) and *Psoas major* (PM) steaks during 9 days of refrigerated storage (4ºC) under aerobic packaging. Standard error bars are indicated. Means without common letters are different (P < 0.05).

The high ratio 630/580 observed in LL muscle indicates lower metmyoglobin accumulation and greater color stability than PM [7]. The myoglobin accumulation could be related to oxygen consumption [5], which is lower in LL muscles [5] comparing to PM. The high oxygen consumption of PM could promote greater amounts of deoxymyoglobin (DMb), favoring the oxidation to metmyoglobin [13]. The decrease on surface color stability (R630/580) was also observed in PM from *Bos taurus* [14; 7] on 5 and 9 days of storage, respectively.

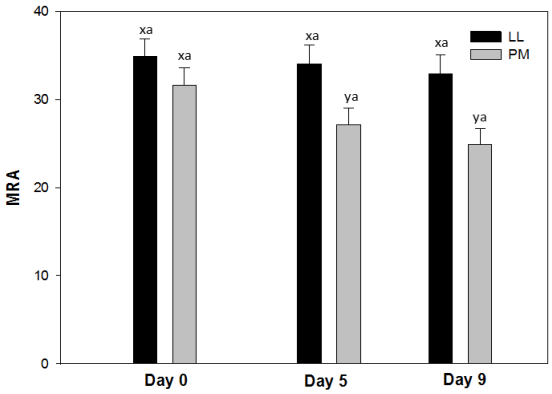

Fig. 3 Metmyoglobin reducing activity (MRA) of *Longissimus lumborum* (LL) and *Psoas major* (PM) steaks during 9 days of refrigerated storage (4ºC) under aerobic packaging. Standard error bars are indicated. Means without common letters are different (P < 0.05).

LL exhibited greater (P < 0.05) MRA values than PM on days 5 and 9 of storage (Figure 3). In addition, while LL demonstrated similar (P > 0.05) MRA throughout the storage, PM steaks exhibited a decrease on MRA (P < 0.05) from day 5. The beef muscles with glycolytic metabolism (LL) are color-stable [5] probably due to presence of NADH [15]. NADH acts converting the myoglobin's iron from ferric to ferrous form [10] and consequently lowering MMb formation [15]. In agreement with present results Joseph *et al*. [7] observed decrease on MRA values of PM obtained from *Bos taurus* during 9 days of storage.

IV. CONCLUSION

PM demonstrated decrease in redness, R630/580 and MRA values comparing to LL, demonstrating that PM can be considered a color-labile muscle whereas LL a color-stable one. Moreover, differences on color stability between LL and PM could be attributed to differences in muscle composition and oxidative metabolism in *Bos indicus*.

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REFERENCES

1. Mancini, R. A. & Hunt, M. C. (2005). Current research in meat color. Meat Science 71: 100−121.

2. Suman, S. P. & Joseph, P. (2013). Myoglobin chemistry and meat color. Annual Review of Food Science and Technology 4: 79−99.

3. Faustman, C. & Cassens, R. G. (1990). The biochemical basis for discoloration in fresh meat: a review. Journal of Muscle Foods 1: 217−243.

4. Von Seggern, D. D., Calkins, C. R., Johnson, D. D., Brickler, J. E. & Gwartney, B. L. (2005). Muscle profiling: characterizing the muscles of the beef chuck and round. Meat Science 71: 39–51.

5. O'Keeffe, M. & Hood, D. E. (1982). Biochemical factors influencing metmyoglobin formation on beef from muscles of differing colour stability. Meat Science 7: 209−228.

6. Suman, S. P., Faustman, C., Stamer, S. L. & Liebler, D. C. (2007). Proteomics of lipid oxidation-induced oxidation of porcine and bovine oxymyoglobins, Proteomics 7: 628–640.

7. Joseph, P., Suman, S. P., Rentfrow, G., Li, S. & Beach, C. M. (2012). Proteomics of muscle-specific beef color stability. Journal of Agricultural and Food Chemistry 60: 3196–3230.

8. AMSA (2012). Meat color measurement guidelines. American Meat Science Association. Champaign, IL, USA.

9. Faustman, C. & Phillips, A. L. (2001). Measurement of discoloration in fresh meat. Ch. F3 Unit F3.3. Current Protocol in Food Analytical Chemistry. New York: Wiley and Sons.

10. Jeong, J. Y., Hur, S. J., Yang, H. S., Moon, S. H., Hwang, Y. H., Park, G. B. & Joo, S. T. (2009). Discoloration Characteristics of 3 Major Muscles From Cattle During Cold Storage. Journal of Food Science 74: 1—5.

11. Hwang, Y. H., Kim, G. D., Jeong, J. Y., Hur, S. J. & Joo, S. T. (2010). The relationship between muscle fiber characteristics and meat quality traits of highly marbled Hanwoo (Korean native cattle) steers. Meat Science 86: 456—461.

12. Choi, Y. M. & Kim, B. C. (2009). Muscle fiber characteristics, myofibrillar protein isoforms, and meat quality. Livestock Science 122: 105–118.

13. King, D. A., Shackelford, S. D. & Wheeler, T. L. (2011). Relative contributions of animal and muscle effects to variation in beef lean color stability. Journal of Animal Science 89:1434—1451.

14. McKenna, D. R., Mies, P. D., Baird, B. E., Pfeiffer, K. D., Ellebracht, J. W. & Savell, J. W. (2005). Biochemical and physical factors affecting discoloration characteristics of 19 bovine muscles. Meat Science 70: 665−682.

15. Kim, Y. H., Keeton, J. T., Smith, S. B., Berghman, L. R. & Savell, J. W. (2009). Role of lactate dehydrogenase in metmyoglobin reduction and color stability of different bovine muscles. Meat Science 83: 376–382.