MEAT FOAL COLOUR OXIDATION.

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Abstract— **Thirty-one foals 24 months old from Burguete breed were used to study the meat foal colour oxidation taking the percentage of Metamyoglobin (MMb) as oxidation index. The *longissimus dorsi* was aged for 4 days. At this point, the meat was analysed immediately after cutting (day 0) and then, it was placed in a plastic foam packaging tray and overwrapped with an oxygen-permeable film until 1 day and 3 days of display. After display, reflectivity between 400 and 700 nm was measured with a spectrocolorimeter Minolta CM-2002, (D_{65} iluminant and 10º observer) and MMb percentage in the muscle surface was calculated [1].**

After 4 days of ageing only about 7% of the samples showed values higher than 20% of MMb. At day 1 and day 3 of display, 27% and 80% of the samples reached values higher than 20% of MMb, respectively. Thus, foal meat samples aged 4 days with 3 days of display could be rejected due to the foal meat discolouration, and when it is sliced it has a shelf-life of 1 day and no more than 3 days in any case.

Keywords— **Foal meat, colour oxidation, Metamyoglobin**

I. INTRODUCTION

The success of any product is determined by the consumer´s acceptance which in turn is related to the percepcion of quality [2]. Colour, texture and marbling are the main characteristics of the meat evaluated by the consumers at the sales moment. The freshness of the product is correlated with the meat colour [3] and if it does not coincide with the consumer's satisfaction it can cause significant economic losses in the fresh meat market.

The colour of the meat depends on the myoglobin concentration, its chemical state, lipid oxidative status [4], muscle structure [5], microbial growth [6], oxygen consumption rate [7] and drip losses [8]. It is reported that half of the consumers refused beef when metamyoglobin (MMb) percentage in the muscle surface achieved 20%; when MMb percentage achieved a concentration of 50%, beef was considered unacceptable [9].

Foal meat is considered to be highly nutritious, low fat, rich in iron and with a positive fatty acid composition as well as with a high content in unsaturated fatty acids [10], [11], [12] and [13]. However, there is an absence of data describing the meat foal colour oxidation and the shelf-life after display. Hence, it would be useful to identify the relationship between the percentage of the MMb and the changes of the colour coordinates through display.

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II. MATERIALS AND METHODS

Thirty-one foals 24 months old from Burguete breed were used in this experiment. A fuller description of the animals used was published in [11]. Briefly, after weaning at approximately 6 months the foals were reared in an extensive production until 16 months old. Then the animals were taken indoors to be finished on commercial concentrates for 7 or 8 months. The concentrate ration and the chemical composition of the commercial feeds were described in [11] and [12]. The animals were harvested and dressed in an officially approved slaughterhouse (council Directive of the European Union 95/221EC). After 24h *post-mortem* the LD muscle was removed from the left carcass side and it was carried to the Food Science and Nutrition Laboratory (Public University of Navarra) in a cooler. This muscle was stored at 2 ± 1 ºC in darkness and 90–95% relative humidity until the fourth day of ageing. At this point the 13th rib of the LD of the foals was used to study the colour oxidation and the shelf-

life. These ribs were cut into 2–3 cm of thickness and the meat was analysed immediately after cutting (day 0). Then, it was placed in a plastic foam packaging tray and overwrapped with an oxygen-permeable film until 1 day and 3 days of display (day 1 and 3, respectively). The CIE L*, a*, b* and C*, H* were measured with a spectrocolorimeter Minolta CM-2002, (D65 iluminant and 10º observer) at the 4th day of ageing immediately after cutting the LD (day 0) and after the 1st and 3th days of display (days 1 and 3, respectively).

The reflectance data of the meat surface were used to obtain the relative percentage of deoxymyoglobin (Mb), oxymyoglobin (MbO_2) and metmyoglobin (MMb) [14] at the 4th day of ageing. A fuller description of the reflectance data of the meat surface were described in [15]. In this research, the recommendations of [16] and [17] are considered where less than 20% MMb in meat can be accepted by the consumer.

III. RESULTS AND DISCUSSION

Table 1 shows the percentage of the foal samples with MMb concentration lower and higher than 20% on the surface of the meat. From these results it is possible to see that after 4 days of ageing (day 0) only about 7% of the samples showed values higher than the 20% of MMb. However, at day 1 and 3 under display 27% and 80% of the samples reached values higher than 20% of MMb, respectively. Therefore keeping the samples 3 days under display with a gas permeable film caused the deterioration of colour in most of the foal samples. These results show that the foal meat discolouration keeps shorter periods compared with beef [18] and it should not be kept more than 2 days under display in order to obtain a foal meat with a MMb concentration lower than 20%, otherwise consumers could reject them by their apparent rusty colour.

Table 2 shows the differences in colour coordinates measured on the foal meat with MMb percentages higher and lower than 20% on the *longissimus dorsi* muscle aged 4 days (Day 0), and 1 day (Day 1) and 3 days (Day 3) of display. According to these results all the colour coordinates had lower values in samples with MMb >20% at every time registered (Day 0, Day 1 and Day 3). These differences are more pronounced at the Day 1 of display where the L*, b* and C* coordinates had lower values ($p<0.05$) in those foal samples with MMb>20%. However, these differences disappeared in Day 3 of display except for L* where this coordinate continued being lower in foal samples with MMb >20%. These results are in concordance with a previous study [15] where beef samples aged 3 and 7 days had lower L* values in those animals with MMb percentages lower than 20% compared with those samples with MMb percentages higher than 20%. In the cited study the beef meat discolouration could be justified by the different content of the haemin pigment found between samples with MMb percentages higher and lower than 20% but that was not the case with the foal samples used in this study because no differences were found for the concentration of the haem pigments.

Many authors have shown that lipid and pigment oxidation are closely coupled in beef [19] and they have shown that lipid oxidation is a promoter of myoglobin oxidation but this doesn't happen in this study because no differences were observed neither in the total lipids content nor in the pigment content ($p\leq0.05$) between animals with MMb higher and lower than 20%.

IV. CONCLUSIONS

From the obtained results it is possible to say that the foal meat once it is sliced it has a shelf-life of 1 day and no more than 3 days in any case.

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REFERENCES

1. Hunt, M.C., Acton, J.C., Benedict, R.C., Calkins, C.R., Cornforth, D.P., Jeremiah, L.E., et al. (1991). Guidelines for meat color evaluation. In Proceedings of the 44th reciprocating meat conference of the American meat science association (pp. 3–14). Chicago, USA.South A, North B (2007) The future of meat technology. Blackwell, London.
2. Dransfield, E. (2001). Consumer issues and acceptance of meat. Proceedings of the 47th International Congress of Meat Science and Technology, Kraków, Poland (pp.72−77)
3. Rentfrow, G., Linville, M. L., Stahl, C. A., Olson, K. C., Berg, E. P. (2004). The effects of the antioxidant lipoic acid on beef longissimus bloom time. Journal of Animal Science, 82,3034−3037.
4. Kannan, G., Kouakou, B., Gelaye, S. (2011). Color changes reflecting myoglobin and lipid oxidation in chevon cuts during refrigerated display. Small Ruminant Research, 42, (1), 67-74.
5. Brewer, M. S., Zhu, L. G., Bidner, . B., Meisinger, D. J., McKeith, F. K. (2001). Measuring pork color: effects of bloom time, muscle, pH and relationship to instrumental parameters. Meat Science, 57, (2), 169-176.
6. Stivarius, M.R., Pohlman, F.W., McElyea, K.S., Waldroup, A.L (2002). Effects of hot water and lactic acid treatment of beef trimmings prior to grinding on microbial, instrumental color and sensory properties of ground beef during display. Meat Science, 4, 60, (4), 327-334.
7. Wulf, D.M., and Wise, J.W. (1999). Measuring muscle color on beef carcasses using the L*, a*, b* color space. Journal of Animal science, 77, 2418-2427.
8. Choe, J.H., Choi, Y.M., Lee, S.H., Nam, Y.J., Jung, Y.C., Park, H.C., Kim, Y.Y., Kim, B.C. (2009). The relation of blood glucose level to muscle fiber characteristics and pork quality traits. Meat Science, 83, (1), 62-67.
9. Van den Oord, A. H., Wesdorp, J. J. (1971). Analysis of pigments in intact beef samples. Journal of Food Technology, 6, 1–8.
10. Badiani, A., Nanni, N., Gatta, P., Tolomelli, B., and Manfredini, M. (1997). Nutrient profile of horsemeat. Journal of Food Composition and Analysis, 10, 254−269
11. Sarriés, M.V., and Beriain, M. J. (2005). Carcass characteristics and meat quality of male and female foals. Meat Science, 70, 141-152.
12. Sarriés, M.V., and Beriain, M. J. (2006). Colour and texture characteristics in meat of male and female foals. Meat Science, 74, 738-745.
13. Lanza, M., Landi, C., Scerra, M., Galofaro, V., & Pennisi, P. (2009). Meat quality and intramuscular fatty acid composition of Sanfratellano and Haflinger foals. Meat Science, 81, 142−147.
14. Stewart, M. R., Zipser, M. W., & Watts, B. M. (1965). The use of reflectance spectrophotometry for the assay of raw meat pigments. Journal of Food Science, 30, 464–469.
15. Beriain, M.J., Goñi, M.V., Indurain, G., Sarriés, M.V., Insausti, K. (2009). Predicting *Longissimus dorsi* myoglobin oxidation in aged beef based on early *post-mortem* colour measurements on the carcass as a colour stability index. Meat Science, 81, 439-445.
16. MacDougall, D. B. (1982). Changes on the colour and opacity of meat. Food Chemistry, 9, 75–88.
17. Hood, D. E., and Riordan, E. B. (1973). Discolouration in pre-packaged beef: Measurement by reflectance spectrophotometry and shopper discrimination. Journal of Food Technology, 8, 333–334.
18. Estimate of the shelf-life of beef under vacuum packaging by objective and subjective measurements. Chasco, J., alzueta, M.J., beriain, M.J., insausti, K. (2003). Journal of Food Quality, 26, 499-509.
19. Insausti, K., Beriain, M. J., Lizaso, G., Carr, T. R., & Purroy, A. (2008). Multivariate study of different beef quality traits from local Spanish cattle breeds. Animal, 2, 447–458.

Table 1 Percentage of foal samples with a metmyoblobin concentration (MMb) on the surface higher and lower than 20% on the *longissimus dorsi* muscle aged 4 days after cutting the meat (Day 0) and 1 day (Day 1) and 3 days (Day 3) of display.

Display moment	<20%MMb	>20%MMb
Day 0	6,9%	0%
Day 1	16.7%	10%
Day 3	20%	60%

Table 2. Differences in colour coordinates, in the percentage of intramuscular fat (IMFat) and in the pigment (Pigment) concentration with metmyoblobin (MMb) percentages higher and lower than 20% on the *longissimus dorsi* muscle aged 4 days (Day 0), and 1 day (Day 1) and 3 days (Day 3) of display.

Display moment		MMb <20%	MMb >20%	SEM	P
Day 0	**L***	34.13	36.84	2.8626	0.2068
	a*	13.82	12.46	1.5931	0.2553
	b*	7.56	5.58	1.4094	0.0660
	C*	15.81	13.66	1.6452	0.0852
	H*	28.7	24.11	4.8995	0.2113
	IMFat (%)	5.31	3.51	2.6858	0.3685
	Pigment (mg/g)	1.83	1.40	0.7653	0.4459
Day 1	**L***	35.96	33.61	2.2093	0.0157
	a*	18.70	17.56	1.7732	0.1323
	b*	12.38	10.86	1.3562	0.0114
	C*	22.46	20.66	1.8974	0.0295
	H*	33.55	31.71	3.0486	0.1535
	IMFat (%)	5.54	4.19	0.2206	2.6062
	Pigment (mg/g)	1.83	1.66	0.7640	0.5943
Day 3	**L***	39.93	34.65	2.7609	0.0002
	a*	15.39	15.99	1.8404	0.4839
	b*	11.75	11.20	1.2638	0.3463
	C*	19.39	19.54	2.0105	0.8733
	H*	37.39	35.07	2.8528	0.0856
	IMFat (%)	6.67	4.81	2.5650	0.1231
	Pigment (mg/g)	2.20	1.68	0.7367	0.1305