Effects of medium voltage electrical stimulation on color during ageing and frozen storage of Nellore beef

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I. INTRODUCTION

A large part of the Brazilian herd comes from the Nellore breed and its crosses. Electrical stimulation has been extensively used in the beef and lamb industry [1]. Electrical stimulation brings rapid benefits to the development of qualitative carcass characteristics such as bright red muscle color faster than in non-stimulated carcasses [2]. This study aimed to evaluate the influence of medium voltage electrical stimulation at three different intensities, 200V (Treatment 200V, T200), 300V (Treatment 300V, T300) and 400V (Treatment 400V, T400) on the color of *post-mortem* beef muscle of *M. longissimus thoracis* - Nellore, both during ageing and during frozen storage

II. MATERIALS AND METHODS

Forty-three Nellore male animals (not castrated) with an average age close to 18 months were selected. After the carcass division, the left sides were submitted to different medium voltage electrical stimulation (ES) of (Treatment 200V, T200), (Treatment 300V, T300), and (Treatment 400V, T400). The right side did not undergo any treatment (control - CON). After 48 h, the carcasses were deboned and 30 cm cuts of *M. longissimus thoracis* were collected, between the 5th and 12th vertebra. One batch (86 samples) was intended for the study of ageing process (14 days/0±2ºC) and the other batch (86 samples) was for the study of frozen storage (180 days/-18±2ºC). A ColorFlex 45/0 spectrophotometer (Hunterlab, Reston, USA) was used. The configurations were: the illuminant was D65, the observer angle was 10° and the aperture for reading the sample was 0.75 cm. The reading was taken using Universal Software version 4.10. and the CIELAB color specification system with the parameters: L* (lightness), a* (red color intensity) and b* (yellow color intensity). The color saturation or intensity index (*C**), the hue or chromaticity angle (*h**) and the total color difference (ΔE^*) were calculated according to Hunter and Harold (1987) [3]. For the statistical analysis of the results of the effect of ES as a main factor, and storage time as a secondary factor, on color parameters were subjected to analysis of variance using the general linear model (Statistica, version 7.0). Voltage and storage time were considered fixed factors and the interaction between them was also evaluated. The data were submitted to analysis of variance (ANOVA).

III. RESULTS AND DISCUSSION

For the color parameters *L**, *a**, *b**, *C** and *h**, T200 suggested the highest results compared to the control and all other treatments during ageing time. Regarding ageing time, an increase in *L** values was observed after 7 days and remained constant at 10 and 14 days. For parameters *a**, *b**, *C** and *h** the values increased until 10 days, where they reached their highest values and remained constant at a time of 14 days (Table 1).

For the color parameters *a**, *b*and C**, T200 suggested the highest results compared to the control during frozen storage. Regarding frozen storage, a decrease in *L**, *a** and *C** values was observed, showed loss of color. For parameters *b** increased value until 60 days, where they reached their highest values and decreased at 120 and 180 days. *h** values increased until 120 days and remained constant at 180 days (Table 2). All treatments showed satisfactory values for *L** and *a** and higher for *b** [5].

Table 1. Effect of aging process on beef color parameters.

		Voltage (V)				Time (Days)				SEM	*P value*		
											Voltage	Time	Voltage*Time
		CON	T200	T300	T400	3	7	10	14				
Color	***L****	42.89^{AB}	43.71^{A}	42.23^{B}	42.57^{AB}	41.65^{b}	43.11^{a}	43.51^{a}	43.21^{a}	0.134	0.006	<0.001	0.991
	a*	22.72^{B}	23.60^{A}	22.34^{B}	22.90^{AB}	20.91^{c}	23.21^{b}	23.95^{a}	23.25^{ab}	0.119	0.002	<0.001	0.838
	b*	15.77^{B}	16.51^{A}	15.16^{C}	15.73^{AB}	13.64^{c}	15.98^{b}	17.09^{a}	16.44^{ab}	0.118	0.001	<0.001	0.674
Chroma (C*)		27.67^{B}	28.81^{A}	27.01^{B}	27.79^{AB}	24.97^{c}	28.19^{b}	29.43^{a}	28.49^{ab}	0.162	0.001	<0.001	0.765
Hue (h*)		34.65^{A}	34.90^{A}	34.04^{B}	34.31^{AB}	33.06^{c}	34.46^{b}	35.41^{a}	35.21^{a}	0.093	0.004	<0.001	0.821
ΔE*		-	2.42	2.26	2.49	2.43	2.46	2.36	2.30	0.105	0.663	0.953	0.832

***** Capital letters superscripted within the same row refer to the significance of the Voltage variation (*P*<0.05).
* Lowercase letters superscripted within the same row refer to the significance of the Time variation (*P*<0.05).
* CON: means untreated or control carcasses (n = 43). T200: means electric stimulation at 200 V (n = 15). T300: means electric stimulation at 300 V (n = 15). T400: means electric stimulation at 400 V (n = 13).
* *Hue**: degrees. *ΔE*:* total color difference.

Table 2. Effect of frozen storage on beef color parameters.

		Voltage (V)				Time (Days)				SEM	*P value*		
											Voltage	Time	Voltage*Time
		CON	T200	T300	T400	3	60	120	180				
Color	***L****	36,90	37,58	36,79	36,99	41,65^{a}	33,27^{c}	36,53^{b}	36,60^{b}	0,204	0,210	<0.001	0,998
	a*	16,30^{B}	16,84^{A}	16,45^{AB}	16,61^{AB}	20,91^{a}	16,85^{b}	14,32^{c}	13,77^{d}	0,168	0,042	<0.001	0,950
	b*	13,33^{B}	13,86^{A}	13,24^{B}	13,57^{AB}	13,64^{b}	14,27^{a}	13,25^{b}	12,71^{c}	0,074	0,028	<0.001	0,948
Chroma (C*)		21,16^{B}	21,89^{A}	21,17^{AB}	21,52^{AB}	24,97^{a}	22,10^{b}	19,54^{c}	18,76^{d}	0,158	0,016	<0.001	0,937
Hue (h*)		39,76	39,93	39,21	39,70	33,06^{c}	40,29^{b}	42,69^{a}	42,70^{a}	0,245	0,323	<0.001	0,952
ΔE*		-	2,76^{A}	2,14^{B}	2,65^{AB}	2,43	2,63	2,42	2,55	0,109	0,041	0,867	0,841

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* Lowercase letters superscripted within the same row refer to the significance of the Time variation (*P*<0.05).
* CON: means untreated or control carcasses (n = 43). T200: means electric stimulation at 200 V (n = 15). T300: means electric stimulation at 300 V (n = 15). T400: means electric stimulation at 400 V (n = 13).
* *Hue**: degrees. *ΔE*:* total color difference.

IV. CONCLUSION

In frozen storage, color parameters remained within acceptable standards. Notably, electrical stimulation at 200 V proved effective in increase color meat in Nellore beef (M. *longissimus thoracis*). The total difference in color between meat treated with ES and untreated meat, both those subjected to ageing process and those frozen storage, were classified as “noticeable” [4], demonstrating that electrical stimulation improves the color of the Nellore beef.

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REFERENCES

1. Zhang, Y., Ji, X., Mao, Y., Luo, X., Zhu, L., & Hopkins, D. L. (2019). Effect of new generation medium voltage electrical stimulation on the meat quality of beef slaughtered in a Chinese abattoir. *Meat Science, 149*, 47–54.
2. Byrne, C. E., Troy, D. J., & Buckley, D. J. (2000). Postmortem changes in muscle electrical properties of bovine M. *Longissimus dorsi* and their relationship to meat quality attributes and pH fall. *Meat Science, 54*(1), 23–34.
3. Hunter, R. S.; Harold, R. W. (1987). The measurement of appearance. 2ed. Reston, Virginia. Hunter Associates Laboratory, Inc, p. 391.
4. Stark, G.; Fawcett, J.P.; Tucker, I.G.; Weatheral, I.L. (1996). Instrumental evaluation of color of solid dosage forms during stability testing. International Journal of Pharmaceutics, Volume 143, Issue 1, 1996, Pages 93-100, ISSN 0378-5173.
5. Muchenje, V., Dzama, K., Chimonyo, M., Strydom, P. E., Hugo, A., & Raats, J. G. (2009). Some biochemical aspects pertaining to beef eating quality and consumer health: A review. *Food Chemistry, 112*(2), 279–289.