COLOR COMPARISON IN AGED BEEF ORIGINATED IN NELORE STEERS WITH OR WITHOUT VITAMIN E SUPPLEMENTATION

Lage, Moacir Evandro[1], Godoy, Helena Teixeira[2], Felício, Pedro Eduardo de[3]

[1]Centro de Pesquisa em Alimentos – Escola de Veterinária – Universidade Federal de Goiás
[2]Departamento de Ciência de Alimentos – FEA – UNICAMP
[3]Departamento de Tecnologia de Alimentos – FEA – UNICAMP

Background

It is well known that the α-tocopherol has activity against myoglobin oxidation in beef and other animal species, although the mechanism has not been completely elucidated. Several studies have been done to evaluate this influence. Most of them express the meat color by the L*a*b* system defined by CIE (Comission Internationale of L'Eclairange). The indexes usually used are the values of L*, which represents brightness, a* is the red-green axis, b* is the yellow-blue axis, and there are also the geometric transformations of the a* and b* values to obtain the saturation index (C*) and the hue angle (h). The results in literature vary for several reasons, some without well-defined mechanisms. Nutritional background before supplementation, dietary α-tocopherol concentration, supplementation period, muscular type, animal species, breed, storage and the display conditions of the meat seem to interfere in the results.

Objectives

This work has the objective of evaluating the meat color in Nelore steers supplemented with α-tocopherol in the quantity of 1,000 mg/head/day for 98 days, considering 3 muscles of different characteristics, aged by 14 days and illuminated continuously with the cool white fluorescent light for 5 days at 7°C.

Methods

Twenty-four 30 months old Nelore steers (*Bos indicus*), with average weight of 279 Kg at the beginning of the experimental period and 421Kg at the end, were used. Half the animals were supplemented with 1,000 mg of α-tocopherol acetate for 98 days. They were slaughtered and then the muscles *supraspinatus* (SS), *longissimus lumborum* (LL) and *semitendinosus* (ST) were excised, aged 14 days, and frozen at 20°C until required for analysis. Then they were thawed, cut in steaks and displayed in polystirene trays with oxygen permeable plastic film and under cool white illumination for 5 days at 7°C. The color measurements were taken in triplicate for steaks in duplicate of each sample. The samples with pH 6.0 or more were discarded.

The color measurement was accomplished in the color space L*a*b*, by reflection measurements using a HunterLab Color-Quest II spectrophotometer calibrated with illuminant D65 and observer angle of 10°. The statistical analysis of the data was run from the values obtained in triplicate, using the software SAS (1985). The procedure GLM was used to evaluate the effects of the muscle (1,2,3), treatment (1,2) and display length (1,2,3,4,5), in the determined color parameters. A T test was used to accomplish multiple comparisons between pairs of individual average measures (least squares means).

Results and Discussion

The results are shown in Table I. The L* value was greater in the three not supplemented muscles than in the three supplemented muscles, being different ($P<0.05$) for LL between 2nd and the 4th day of display and for SS in the 4th and 5th day. The oxidation occurs in heterogeneous form in the meat, starting to fade in different areas of the steak. It was noticed during the analyses that steaks with larger areas of visible fading showed more elevated L* values. This observation together with higher L* values in controls indicates a positive relationship between the L* value and oxidation. In counterpoint, there is a fall in the L* values during the display of the meat between 1st and 5th day, which probably is justified by the dehydration of the surface of the steak, overcoming the effects of the oxidation. But, there was an increase in the L* values on the first two days of display for LL and ST, and on the first three days for SS. These differences are significant in its majority ($P<0.05$, not shown in table). LIU et al., (1996) noted that there was not influence of dose (0, 250, 500 and 2,000 mg/head/day) or duration (42 or 126 days) of supplementation of vitamin E in the L* values of fresh beef during display for either of the muscles (LL, SM-*semimembranosus* and GM-*gluteus medius*) or ageing periods (14, 28 and 56 days for LL and 14 days for SM and GM). The only exception was duration of supplementation for SM, in which L* was higher ($P<0.01$) for 42 d (39.0) than that for 126 d (37.6). Length of display affected L*, so that, between 0 and 10 days of display, L* declined from 39.7 to 37.6 for LL and SM, and from 41.2 to 38.9 for GM. Most studies focusing the relationship between the color of the meat and supplementation of vitamin E did not consider the L* value (O'GRADY et al., 1998; GATELLIER et al., 2001; EIKELENBOOM et al., 2000; STUBBS et al., 2002) or they did not find difference ($P>0,05$) between meat from supplemented and not supplemented animals (CHAN et al., 1996; CHAN et al., 1998; MITSUMOTO et al., 1998; HOUBEN et al., 1998; HOUBEN et al., 2000). In a meat shelf life comparison of different Spanish breeds, kept under modified atmosphere, was noted that L* increased with storage time (INSAUSTI et al., 2001).

The b* value was higher in animals supplemented in the three muscles, being different ($P<0.05$) for LL on the 2nd and 3rd day of display, for ST on the 1st and 3rd day and for SS on the 4th day. INSAUSTI et al.(2001) related b* values with deterioration of the smell in the raw meat, maybe influenced by the biochemical alterations that occur in the meat during the first 5 stock days under modified atmosphere. Most studies focusing the relationship between the color of the meat and supplementation of vitamin E did not consider the b* value (GRADY et al., 1998; GATELLIER et al., 2001; EIKELENBOOM et al., 2000; STUBBS et al., 2002) or they did not find difference ($P>0.05$) between meat from supplemented and not supplemented animals (CHAN et al., 1996; CHAN et al., 1998; MITSUMOTO et al., 1998; HOUBEN et al., 1998; HOUBEN et al., 2000). LIU et al., (1996) noted that the vitamin E in the diet caused decline of the yellow component ($P<0,05$) in LL, SM and GM during simulated display in the retail case.

The a* value was higher in the three muscles of supplemented animals, being different ($P<0.05$) for LL on the 2nd to the 5th day of display, for ST on the 2nd and 3rd day and for SS on the 4th and 5th day. These results confirm previous studies, which supplemented the animals with 250 to 2,000 mg/head/day (CHAN et al., 1996; LIU et al., 1996; CHAN et al., 1998; GRADY et al., 1998; MITSUMOTO et al., 1998; HOUBEN et al., 2000; STUBBS et al., 2002). GATELLIER et al. (2001) did not find difference ($P>0,05$) between supplemented muscles and controls (LL and TB-*triceps brachii*), and they found that the average a* value on the first 3 days of display was identical, indicating an incomplete oxygenation of the pigment during this time. Numerous authors in literature, particularly in red meat, previously observed these

data. EIKELENBOOM et al. (2000) did not find significant difference between supplemented muscles and controls (LT-*longissimus thoracis* and PM-*psoas major*). They also found that the average a* value, on the first 2 days of display for aged meat and on the 1st day for fresh meat, was lower for the supplemented muscles (PM) due to a lower oxygenation. The reason for that is not clear yet. FAUSTMAN et al. (1989) reported higher stability of the values Hunter 'a' and Hunter 'C' for top-loin in Holstein steers supplemented with vitamin E (370mg/day) than for controls, although average 'L' and 'b' values were larger for supplemented steers.

The C* value was higher in animals supplemented in the three muscles, being different (P<0.05) for LL from the 2nd to the 4th day of display, for ST from the 1st to the 3rd and 5th day and for SS just on the 4th day. The h value was lower in the three muscles of supplemented animals, being different (P<0.05) for LL from the 2nd to the 5th day of display and for SS on the 4th and 5th day. LIU et al., (1996) noted that the color saturation loss (C*) was lower in muscles (LL, SM and GM) supplemented with vitamin E, while the increase of the 'h' values was retarded. CHAN et al. (1996) noted that the decrease in the a* values and the increase in the h values were higher in the muscles PM, GM and LL that did not receive vitamin E supplementation in the diet. This indicated a better stability of the color in supplemented muscles. CHAN et al. (1996) and LANARI et al. (1995) verified that the hue angle (h) was highly correlated with the sensory analysis of the meat fading and it can be a more appropriated objective measure than a* value. CHAN et al. (1998) noted that the 'h' values were lower in supplemented muscles (PM and LL) than in controls.

There was difference (P<0.05) among muscles for the L* value (ST>LL>SS), for the b* value, (LL slightly >SS>ST) and for the a* value (SS>LL>ST). MITSUMOTO et al. (1998) noted that the muscle PM showed a* values lower than the muscle LT (12 and 17,2, respectively). CHAN et al. (1998) noted that PM showed lower a* values and higher h values than LL, indicating that PM faded more quickly than LL.

It was observed on the first three days of display that there was a relationship among muscles for the C* and 'h' values (SS=LL>ST and SS<LL=ST, respectively) which modified on the two subsequent days (SS>ST>LL and LL<SS=ST, respectively). This was due, mainly, to higher relative fall of the b* value in LL on the last two days of display. LL seems to be more resistant to oxidation of myoglobin that remaining muscles. According to these findings, LIU et al. (1996) noted that the meat color shelf life for muscles followed this order LL>SM>GM, while the α-tocopherol concentration showed the inverse order. RENERRE (1990) classified LL as of most and SS of least stability by color.

Conclusions

The α-tocopherol supplementation retarded the myoglobin oxidation with lower decrease of a* and C* values and retardation of 'h' value increase. The effect of α-tocopherol supplementation on myoglobin oxidation manifested after the first day of display. The L* value seems to have a positive relationship with oxidation, mostly in the muscles LL and SS. There were differences among muscles SS, ST and LL regarding color stability: the muscle LL has shown better stability. All the analyzed parameters were important in beef color evaluation.

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Table I. Color parameters in aged beef (LL, ST and SS) from vitamin E supplemented and not supplemented animals (control), displayed in simulated retail conditions for 5 days.

Treatment	Display days	L*			a*			b*			C*			h		
		LL	ST	SS	LL	ST	SS	LL	ST	SS	LL	ST	SS	LL	ST	SS
Control	1 day	41.9^{ac}	54.0^{ad}	35.2^{ae}	17.3^{ac}	14.0^{ad}	19.0^{ae}	23.4^{ac}	19.3^{ad}	23.1^{ac}	29.2^{ac}	23.9^{ad}	30.0^{ac}	53.9^{ac}	54.1^{ac}	51.1^{ae}
	2 days	43.3^{ac}	55.8^{ad}	36.0^{ae}	12.3^{ac}	10.9^{ad}	15.3^{ae}	20.0^{ac}	17.8^{ad}	20.8^{ae}	23.5^{ac}	20.9^{ad}	25.8^{ae}	58.2^{ac}	58.2^{ac}	53.8^{ae}
	3 days	39.0^{ac}	55.3^{ad}	40.0^{ac}	11.9^{ac}	10.3^{ad}	12.8^{ae}	16.8^{ac}	17.6^{ad}	17.5^{acd}	20.7^{ac}	20.4^{ac}	21.7^{ae}	54.6^{ac}	59.4^{ad}	53.7^{ac}
	4 days	36.5^{ac}	51.9^{ad}	36.2^{ac}	10.9^{ac}	11.6^{ad2}	12.3^{ad}	13.4^{ac}	17.7^{ad}	19.4^{ae}	17.4^{ac}	21.2^{ad}	22.9^{ae}	50.7^{ac}	56.7^{ad}	57.6^{ad}
	5 days	31.9^{ac}	53.4^{ad}	36.4^{ae}	11.0^{ac}	10.0^{ad}	10.6^{acd}	11.3^{ac}	16.3^{ad}	17.5^{ae}	15.8^{ac}	19.2^{ad}	20.4^{ae}	45.7^{ac}	58.3^{ad}	58.7^{ad}
Supplemented	1 day	41.3^{ac}	53.7^{ad}	33.6^{ae}	17.4^{ac}	14.9^{ad}	19.5^{ae}	23.5^{ac}	20.2^{b2d}	22.7^{ac}	29.2^{ac}	25.1^{b2d}	29.9^{ac}	53.5^{ac}	53.7^{ac}	49.7^{ae}
	2 days	40.3^{bc}	55.2^{ad}	35.1^{ae}	14.2^{bc}	12.0^{b2d}	15.1^{ac}	21.2^{bc}	18.4^{ad}	20.2^{ae}	25.5^{bc}	22.0^{b3d}	25.2^{ac}	56.3^{b2c}	57.0^{ac}	53.3^{ae}
	3 days	35.8^{bc}	54.1^{ad}	38.4^{ae}	14.1^{bc}	11.8^{bd}	13.6^{ac}	18.3^{bce}	18.6^{b3c}	17.5^{ae}	23.1^{bc}	22.1^{bd}	22.2^{acd}	52.4^{bc}	57.7^{ad}	52.3^{ac}
	4 days	34.3^{bc}	50.4^{ad}	33.9^{bc}	12.8^{bc}	12.6^{ac}	14.4^{be}	14.1^{ac}	18.2^{ad}	20.8^{be}	18.9^{bc}	22.1^{ad}	25.3^{be}	47.6^{bc}	55.5^{ad}	55.4^{bd}
	5 days	30.0^{ac}	52.9^{ad}	34.4^{b2e}	12.3^{bc}	11.0^{ad}	12.2^{bc}	11.5^{ac}	17.1^{ad}	17.6^{ad}	16.7^{ac}	20.4^{bd}	21.4^{ad}	42.9^{bc}	57.7^{ad}	55.5^{be}

ab – values with different letters inside the same muscle and display period and among different treatments is different (P<0.05) or ^{b2} (P<0.08 to L* and C*, P<0.07 to a*, b* and h) or ^{b3} (P<0.06 to b*, P<0.09 to C*)
cde – values with different letters inside the same treatment and display period and among different muscles is different (P<0.05) or ^{d2} (P<0.08 to a*)