INFLUENCE OF CONDENSED TANNIN ON BEEF STABILITY IN NELLORE BULLS FED HIGH CONCENTRATE DIET

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Abstract – The aim was to evaluate color change and lipid degradation of beef from cattle fed different levels of condensed tannins in different periods of shelf storage; and the influence of condensed tannin on beef quality traits. Thirty-five crossbred Nellore were used. Cattle were randomly distributed into 5 treatments (substitution of traditional soybean meal to soybean meal treated with condensed tannin; 0, 33, 66, 100% and one extra treatment). And submitted to a period of 112-day experimental. At the end of the trial, all the animals were slaughtered. 10 samples of Longissimus muscle were collected, and exposed (shelf life) for 0, 3, 6, 9 and 12 days, using two samples per exposure day. There was no interaction (P>0.05) between the treatments and days of storage of beef steaks. No difference was observed between treatments for beef color variables (P>0.05). There was an interaction between storage time and treatments for TBARS (P<0.05). Differences were observed between the shelf life only for treatments 0, 66% and extra treatment. Differences in meat TBAR may be linked to antioxidant effects of tannins and / or effects on ruminal biohydrogenation, and point toward the need for in depth investigation of fatty acid composition to provide further explanation.

Key Words –L* a b*, TBARS, lipid oxidation.

I. INTRODUCTION

Condensed tannin (CT) is known for its inhibitory effect on the rumen microorganisms [1]. In vitro studies have indicated that incubation of rumen fluid with CT reduce the biohydrogenation (BH) of linoleic [2] and linolenic acids [3]. These results were attributed to a decreased activity of ruminal microorganisms due to CT. Lambs supplemented with tannins had a decrease of ruminal BH [4]. In particular, the last step of BH was inhibited to a greater extent than the previous steps, resulting in accumulation of the trans isomer C18:1, thereby having important implications in fatty acid profile of meat, since the isomer C18:1 is the precursor of endogenous biosynthesis of CLA cis-9, trans-11. Moreover, meat from lambs supplemented with CT showed higher percentages of polyunsaturated fatty acids and lower proportion of saturated fatty acids compared with meat from animals not supplemented [4].

These results demonstrate that inclusion of CT may be a useful strategy to improve the healthy properties of meat with regard to its fatty acid composition. However, possible changes in the fatty acid profile of meat might lead to changes in meat quality traits such as color. Lipid oxidation causes changes in taste and color of food products, being primarily responsible for deterioration during processing and storage of foods with high lipid contents [5]. The autoxidation is the main mechanism of oxidation of polyunsaturated fatty acids and is more intense under conditions favored by light and heat [6]. Accordingly, the polyunsaturated fatty acids increase (likely due to inclusion of TC) combined with long periods of storage in ambient light, such as supermarket shelf may take to oxidative modification with subsequent release of compounds volatiles responsible for rancidity and changes on the organoleptic characteristics [7]. In this context, this study was developed aiming to evaluate changes in color and lipids degradation of beef from cattle fed different levels of condensed tannins in different periods of shelf storage; and to evaluate the influence of condensed tannin on beef quality traits.

II. MATERIALS AND METHODS

Thirty-five crossbred Nellore bulls were used in the study, with an average initial body weight of

242.6 ± 5.12 kg. Cattle were randomly distributed into 5 treatments with 7 replicates and submitted to a period of 40 days of adaptation and a 112-day experimental period.

Cattle were fed with *in natura* sugar-cane bagasse (16%), cracked corn, whole cottonseed, soybean meal treated with condensed tannin (SBMCT) and traditional soybean meal (SBM). The treatments consisted of 4 levels of replacement of soybean meal with soybean treated with CT (0, 33, 66, and 100%) and one treatment (extra treatment) with 2.5% of SBMCT (relative to 33% of SBMCT) but without SBM, which was replaced by urea and corn (with the same level of CP of soybean meal). The composition of the experimental diets is presented in Table 1. SBMCT was previously treated with 2.5% of condensed tannin plus 2.5 times the mix volume in water at pH 7.0. After 6 hours the mix was dried.

Table 1 Ingredients and crude protein composition of the experimental diets.

Ingredients (%)	Treatments				
	Control (0%)	33%	66%	100%	Extra treatment
In natura sugar-cane bagasse	16.00	16.00	16.00	16.00	16.00
Whole cottonseed	10.00	10.00	10.00	10.00	10.00
Cracked corn	63.20	63.16	63.19	63.17	67.43
SBM[1]	7.50	5.00	2.50	-	-
SBMCT[1]	-	2.50	5.00	7.50	2.50
Urea	0.30	0.31	0.33	0.34	1.07
Commercial premix[2]	3.00	3.00	3.00	3.00	3.00
CP (%DM)	13.51	13.52	13.50	13.52	13.51

[1]/ SBM = traditional soybean meal; SBMCT = soybean meal treated with condensed tannin. [2]/ Contained: Ca. 160 g/kg; Co. 21.6 mg/kg; Cu. 360 mg/kg; S. 23 g/kg; Fe. 415 mg/kg; P. 17 g/kg; I. 21 mg/kg; Mg. 14 g/kg; Mn. 715 mg/kg; Monensin 714.3 mg/kg; NPN 337 g/kg; K. 45 g/kg; Se. 6 mg/kg; Na. 57 g/kg; Vitamin A. 71500 ui/kg; Vitamin D3. 8940 ui/kg; Vitamin E. 298 ui/kg; Zn. 1715 mg/kg).

Cattle were humanely harvested following the normative instruction n 0.3 of 01/13/2000 (Technical Regulation of Methods for Humane Slaughtering of Livestock). After 24 h postmortem chill (4°C), 10 samples of Longissimus muscle (2.54 cm thick) were collected for instrumental color evaluation. Trimmed samples were packed in polystyrene trays and wrapped in polyvinyl plastic permeable to oxygen. Trays were placed in open shelf (3 ° C) and exposed for 0, 3, 6, 9 and 12 days, using two samples per exposure day. CIE L*, a, b* were evaluated by using colorimeter (COLORQUEST XE) and ratio between 630 and 580 nm reflectance (R630/580) was measured [8] Lipid oxidation analysis was performed on the beef steaks at 0 and 12 days of storage by the TBARS as described by Rosmini *et al*. [9]. The Warner-Bratzler shear force (WBSF) steaks were thawed at 5 ºC for a period of 24 h and oven broiled in an electric oven pre-heated to 150 ºC. Internal steak temperature was monitored with 20-gauge copper-constantan thermocouples placed in the approximate geometric center of each steak and attached to a digital monitor. Steaks were flipped every 15 min and allowed to reach an internal temperature of 71ºC before removal from the oven. Cooked WBSF steaks were cooled for 24 h at 4 ºC. Five round cores (1.27 cm diameter) were removed from each steak parallel to the long axis of the muscle fibers. Each core was sheared once through the center, perpendicularly to fiber direction by a Warner-Bratzler® (G-R Electrical Manufacturing Company, Manhattan – KS, USA).

The experiment was conducted in a completely randomized design. WBSF, thawing loss and cooking loss were analyzed according to orthogonal contrasts: linear, quadratic and cubic for replacement levels SBMCT the SBM, and extra treatment effect (0% *versus* extra treatment). To evaluations of variables TBARS, L*, a*, b* and R630/580 were used repeated measures on time [10]. All statistical analyses were performed using SAS (SAS Institute Inc., Cary, NC).

III. RESULTS AND DISCUSSION

No differences were found (P>0.05) for WBSF, thawing and cooking loss for animals fed different levels of SBMCT and extra treatment (Table 2). Condensed tannins in ruminant diets causes changes on rumen degradable protein

Table 2 Means and SEM for Warner-Bratzler shear force (WBSF); thawing, cooking and total loss (%), according to the experimental treatments.

Item	SBMCT substitution on SBM (%DM)				Extra T.[1]	P-value[2]			SEM
	0	33	66	100		L	Q	0% x extra	
WBSF, Kg	4.55	3.98	4.44	3.98	4.25	0.502	0.901	0.582	0.16
Thawing loss, %	5.78	4.90	6.49	6.85	6.20	0.212	0.469	0.730	0.37
Cooking loss, %	25.08	23.58	23.57	22.89	23.27	0.405	0.812	0.468	0.78
Total loss, %	30.87	28.48	30.04	29.75	29.48	0.868	0.670	0.683	1.07

[1] Extra T. = Extra treatment. [2] Linear (L) and quadratic (Q) treatment effects; and 0% versus extra treatment contrast (0% x extra).

Table 3 Means for the instrumental evaluation of meat color and R630/580, according to the experimental treatments and effect of shelf life.

Item	SBMCT substitution on SBM (%DM)				Extra T.[1]	P-value (treatment)[2]			P-value[3]	
	0	33	66	100		L	Q	0% x extra	Day	T. x day
L*	37.29	38.40	38.74	38.49	38.29	0.203	0.334	0.301	0.001	0.646
a	4.39	3.96	3.57	4.12	4.12	0.325	0.083	0.481	0.001	0.773
b*	5.52	5.48	5.28	5.85	5.70	0.481	0.246	0.598	0.001	0.851
R630/580	1.63	1.61	1.52	1.59	1.55	0.245	0.336	0.216	0.001	0.627

[1] Extra T. = Extra treatment. [2] Linear (L); quadratic (Q) and Cubic (C) treatment effects; and 0% versus extra treatment contrast (0% x extra). [3] Day and treatment *versus* day (T. x day) interaction.

(RDP) and rumen undegradable protein (RUP), which might improve the protein utilization by the animal [1] and also might change the fatty acids profile of beef [3]. These changes were not sufficient to alter the evaluated beef qualitative characteristics (Table 2).

Regarding beef color, there was no interaction (P>0.05) between the treatments and days of storage of beef steaks. Therefore, each variable was analyzed separately (Table 3). No difference was observed between treatments for beef color variables (Table 3; P>0.05). The difference expected in the beef color would be due a change in the beef fatty acid profile (caused by CT), which would decrease its stability. Therefore the lack of effect on these parameters indicates that probably there was no difference in beef fatty acid profile, or the difference in this parameter was not enough to change the beef color. Additionally, no effect was observed for days of storage for all color parameters (Table 3, Figure 1).

The brightness (L*) had a quadratic response with highest value near the ninth day of storage (Figure 1). The redness (a*; cubic response) showed a slight increase until the 3rd day of storage and followed by a decrease (P <0.05, Figure 1). Yellowness (b*) had a cubic effect with increase 0 to 3 days, followed by a slight variation in the following days (Figure 1).

Variations on beef color due to time of storage were expected, since it is known that there is a destabilization of the meat color over time, particularly caused by variations in myoglobin as well as by lipids oxidation.

There was an interaction between storage time and treatments (T. x day) for lipid oxidation (P<0.05; Table 4). Differences were observed between the shelf life only for treatments 0, 66% and extra treatment. However, lipid oxidation did not change (P>0.05) in beef of animals fed diets with 33 and 100% substitution of SBM by SBMCT at different times of storage. This effect might shows that in the treatments that had a greater difference between 0 and 12 d of storage, the fatty acid profile was more unstable. Polyunsaturated fat acids are most unstable that saturated fat acids. The treatment with 66% of CT increased 82% on TBARS at the twelfth day. This difference may be caused by a greater concentration of polyunsaturated fat acids in this treatment which may have caused greater oxidation.

Table 4 Means for the TBARS according to the experimental treatments and effect of shelf life.

Item	SBMCT substitution on SBM (%DM)				Extra T.[1]
	0	33	66	100	
TBARS day 0	0.48	0.68	0.36	1.07	0.62
TBARS day 12	1.75	0.71	2.05	1.29	1.79

P-value[2]	T.	Day	T. x day
	0.558	0.001	0.046

Interaction (contrasts)	*Day x 0%*	*Day x 33%*	*Day x 66%*	*Day x 100%*	*Day x extra T.*
P-value	*0,006*	*0,947*	*< 0,001*	*0,588*	*0,007*

[1] Extra T. = Extra treatment.
[2] Treatment effect (T.), day and interaction T. x day.
[3] Interaction effects between the two treatments.

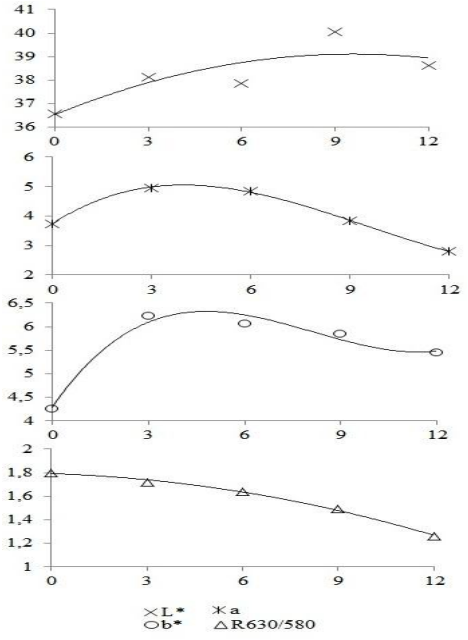

Figure 1. Behavior to CIE L*, a*, b* and R630/580 according to shelf life effects: "L*" $y = 36.56 + 0.5294x - 0.278*x^2$ (r^2=0.09); "a" $y = 3.74 + 0.7287x – 0.1168x^2 + 0.00413x^3$ (r^2=0.43); "b*" $y = 4.305 + 0.9799x– 0.145x^2 + 0.00597x^3$ (r^2=0.39); "R630/580" $y = 1.7955 – 0.00909x – 0.0029x^2$ (r^2=0.52).

IV. CONCLUSION

Differences in TBAR may be linked to antioxidant effects of tannins and/or effects on ruminal biohydrogenation, and point toward the need for in depth investigation of fatty acid composition to provide further explanation.

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