SENSORY ANALYSIS AND FATTY ACID PROFILE OF BEEF FROM NELLORE CATTLE FINISHED WITH COTTONSEED BYPRODUCT

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Abstract – This study aimed to evaluate cottonseed byproduct (CB) effects, as diet fat source, in sensory analysis and fatty acid composition of Nellore beef. Were utilized 40 Nellore males, non-castrated, slaughtered with 452 kg after 102 days of feedlot. CB inclusion was based on diet EE value: 3%, 4% and 5%. Reference treatments were also tested: 3% and 5% of EE on diet, with soy products as fat source. Means were analyzed by contrasts, and regressions were elaborated with CB levels. In diets with low EE level, the CB use reduced meat heptadenoic acid (C17:0) proportion and in diets with higher EE level, the CB use resulted in meat with strange odor presence and increased meat linoleic acid (C18:2) proportion.

Key Words – beef quality, beef smell, cottonseed cake

I. INTRODUCTION

In ruminant nutrition it is increasingly important to replace traditional fat sources for alternative sources, prioritizing waste or agro-industrial byproducts. In response to high demand for cottonseed oil as a feedstock for biofuel production, there is an increase in by-product availability for animal feeds, as studied in dairy cows by Winterholler *et al*. [1]. However, this fat source substitution may cause modification of meat fatty acid composition, and it may cause changes in meat qualitative aspects. Thus, this study aimed to evaluate the effects on beef sensory analysis and fatty acid composition of cottonseed byproduct (CB) as a dietary fat source in finishing diets of young Nellore bulls.

II. MATERIALS AND METHODS

The experiment was a partnership between APTA Research Center for Beef Cattle (Sertãozinho, SP, Brazil) and College of Veterinary Medicine and Animal Science (Botucatu, SP, Brazil).

Forty Nellore male, non-castrated cattle were slaughtered at 452±48.4 kg live weight and 21 months of age, after 102 days in the feedlot. The animals were placed in individual pens, distributed in eight blocks, according to initial live weight, as each animal was an experimental unit. The CB was supplied by Bunge Limited and is commercially known in Brazil as High Energy Cottonseed Meal®. It is a byproduct from the physical oil extraction of cottonseed, as described by Winterholler *et al*. [1].

The CB inclusion was based on diet ether extract (EE) level: 3, 4 and 5% (3CB, 4CB, 5CB, respectively). Two reference treatments were also tested: 3% and 5% of EE on diet, with soybean (S) products as fat source (3S and 5S, respectively). This totaled five experimental diets (Table 1).

Animals were slaughtered at Frigonobre Slaughterhouse, 204 km away from the feedlot location. Samples of loin removed from the 12th rib (*Musculus longissimus thoracis*), were used for the quality analyses.

Sensory evaluations were performed as described by Meilgaard *et al*. [2] with 10 trained panelists. Four steaks by diet treatment, were thawed in a refrigerator for 20 hours until they reached 5±2°C, and fragmented into several smaller pieces free of apparent subcutaneous fat, creating sub-sample groups of each treatment.

Part of this sub-sample group was shown to panelists *in natura* in glass Petri dish, kept at a maximum temperature of 15°C, and, another part was weighed, placed in beakers with high edges, and boiled in twice the sample's weight of distilled water until internal temperature reached 71°C. The presentation to panelists was in the same beaker, capped with a glass Petri dish, on hot plate at 50°C.

The method of unstructured scale of 9 cm was applied for the attributes of bovine meat aroma intensity, and the structured scale of 1 to 9 for the attributes of strange odor intensity, in which 1 indicated a sample as not having a strange odor and 9 having an extremely strong strange odor.

Table 1. Diet and fatty acid composition of experimental diets

	Diets[1]				
	3S	5S	3CB	4CB	5CB
	% of Dry Matter				
Brachiaria sp hay	19.5	19.9	19.5	19.4	19.4
Corn	31.2	31.9	31.2	31.1	31.1
Sorghum	35.2	14.7	33.02	19.31	5.52
Soybean meal	5.84	24.1	-	-	-
Soybean oil residue	1.66	7.43	-	-	-
Cottonseed byproduct (CB)	-	-	9.77	26.1	42.2
Molasses	2.63	0.34	2.63	1.55	0.33
Urea	2.65	0.32	2.67	1.47	0.31
Mineral	1.10	1.10	1.10	1.10	1.10
	% of Fat Acid				
$C_{6:0}$	0.00	0.00	0.11	0.03	0.40
$C_{10:0}$	0.00	0.00	0.00	0.00	0.57
$C_{11:0}$	0.37	0.09	0.40	0.09	0.99
$C_{12:0}$	0.15	0.00	0.00	0.00	0.90
$C_{14:0}$	2.86	3.73	2.65	2.62	2.40
$C_{14:1}$	0.53	0.16	1.51	0.50	0.79
$C_{15:0}$	0.17	0.40	0.00	0.17	0.09
$C_{16:0}$	17.6	17.7	18.4	22.6	18.7
$C_{16:1}$	11.0	10.2	8.8	10.1	12.4
$C_{17:0}$	8.34	6.11	1.93	0.81	5.00
$C_{17:1}$	0.00	0.29	0.12	0.00	0.00
$C_{18:0}$	16.6	20.8	17.7	17.3	16.6
$C_{18:1\omega9c}$	29.1	24.5	25.1	28.0	28.3
$C_{18:1\omega9t}$	11.3	14.4	16.0	14.5	11.3
$C_{18:3\omega6}$	0.02	0.09	0.00	0.00	0,00
$C_{20:0}$	0.78	0.39	2.75	0.47	0.40
$C_{20:1}$	0.25	0.00	0.00	0.92	0.00
$C_{22:1\omega9}$	1.34	0.62	3.22	0.00	2.76
UN[2]	1.73	0.55	2.07	1.83	1.91

[1]3S and 5S = 3 and 5% of EE on diet, with soybean as fat source; 3CB, 4CB e 5CB = 3, 4 and 5% of EE on diet, with cottonseed byproducts as fat source, respectively.
[2]Unidentified

To evaluate the fatty acid composition the meat fatty material was extracted using chloroform and methanol, and esters of fatty acids were evaluated in a Shimadzu gas chromatograph with a fused silica capillary column, according methods described by Hartman and Lago [3].
Fatty acid composition data were analyzed using PROC GLM, by model I: $Y = \mu + D + B + e$; where: μ = a constant data inherent; D = diet effect; B = block effect (animal initial weight); e = error. Sensory data were analyzed using repeated measures (meat aging process effect), by model II: $Y = \mu + D + A + A*D + B + e$; where: μ = a constant data inherent; D = diet effect; A = aging process (0 and 21 d); B = block effect (panelist); e = error.

Means were tested using four non-orthogonal contrasts, the first two for purpose of examining whether, in the same diet EE level, CB differed from S: C1 = 3S versus 3CB and C2 = 5S versus 5CB; the third aimed to evaluate the CB extreme levels: C3 = 3CB versus 5CB; and last aimed to evaluate if the intermediate level of CB differed from the average of the extremes: C4 = 3CB and 5CB versus 4CB.

Additionally, when significance was shown in C3 and/or C4, the relationship among the variables and CB inclusion was studied by linear regression using PROC REG. All data were analyzed using Statistical Analysis System - SAS 9.0 [4] and contrasts were tested by Scheffé test at 5% of probability.

III. RESULTS AND DISCUSSION

In Table 2 results of the aroma sensory analysis were presented. There was an influence of the aging process on fresh beef aroma, but this difference was not noticed in cooked meat. Classic studies of meat quality attribute more intense flavor in aged meat due to an increase in free fatty acids [5], hydrocarbons and benzenoics compounds [6].

Diet fat source changed the strange aroma attribute in aged and cooked meat. For aged meat, there was a higher intensity of strange odor in cooked meat from animals fed with greater proportions of CB on diet (1.44 to 3CB; 3.11 to 5CB).

An increase in strange odor was observed with the increase of fatty acid (Table 3). In studies conducted by Nute *et al*. [7], differences in meat smell due to the use of flaxseed oil, fish oil and protected lipids as fat sources were detected in confined lambs. The authors also observed a decrease in meat flavor proper, probably related to the increase in linoleic acid (C18:2,6), and increase in "off flavor" in meat of animals fed with fish oil and protected lipids. Costa [8] evaluated whole cottonseed addition in feedlot diets for Nellore cattle; at 27.51% of cottonseed inclusion, based on dry matter, they observed meat with a high strange odor presence.

Table 2. Aroma sensory analysis of the loin (*M. longissimus thoracis*) from Nellore bulls fed with cottonseed byproducts in three fat levels on diet

Age	Mean	Treatments[1]					P^+			
		3S	5S	3CB	4CB	5CB	C1	C2	C3	C4
In Natura Beef Aroma Intensity (1 – 9)										
0d	5.1b	5.6	4.5	5.3	4.7	5.6	ns	ns	ns	ns
21d	6.2a	6.1	6.1	5.6	6.8	6.4	ns	ns	ns	ns
In Natura Beef Strange Odor Intensity (1 – 9)										
0d	2.3	2.0	2.8	2.2	2.1	2.6	ns	ns	ns	ns
21d	2.2	2.0	2.4	3.3	1.3	2.0	ns	ns	ns	ns
Cooked Beef Aroma Intensity (1 – 9)										
0d	6.4	6.2	5.7	6.7	7.0	6.3	ns	ns	ns	ns
21d	6.6	6.5	6.7	6.7	6.8	6.6	ns	ns	ns	ns
Cooked Beef Strange Odor Intensity (1 – 9)										
0d	2.2	1.7	2.8	2.3	2.1	1.9	ns	ns	ns	ns
21d	2.1	2.4	1.8	1.4	1.8	3.1	ns	ns	*	ns

[1]3S and 5S = 3 and 5% of EE on diet, with soybean as fat source; 3CB, 4CB e 5CB = 3, 4 and 5% of EE on diet, with cottonseed byproducts as fat source, respectively.
[+]C1 = 3S *vs* 3CB; C2 = 5S *vs* 5CB; C3 = 3CB *vs* 5CB; C4 = 3CB + 5CB *vs* 4CB.

In contrast, Gibb *et al*. [9], evaluating the effect of sunflower seeds in feedlot cattle did not find changes in meat flavor, and Gill *et al*. [10], evaluating feedlot cattle fed with flaked corn and wet distillers residue, found no difference in sensory assessment of meat.

The C3 significance becomes less important when no significance in C1 and C2 was detected, despite of CB increase on diet, raises the strange odor in aged and cooked meat, because the increase did not differ from meat produced with S fat source, having no significance in C1 and C2.

The meat fatty acid composition is shown in Table 3. Differences were observed just for heptadenoic acid ($C_{17:0}$) and linoleic acid ($C_{18:2,6}$).

Table 3. Fatty acid composition of the loin (*M. longissimus thoracis*) from Nellore bulls fed with cottonseed byproducts in three fat levels on diet

%	Treatments[1]					P^+			
	3S	5S	3CB	4CB	5CB	C1	C2	C3	C4
$C_{4:0}$	0.13	0.15	0.12	0.17	0.15	ns	ns	ns	ns
$C_{6:0}$	0.23	0.04	0.29	0.27	0.04	ns	ns	ns	ns
$C_{8:0}$	0.51	0.21	0.51	0.10	0.26	ns	ns	ns	ns
$C_{10:0}$	0.53	0.20	0.53	0.14	0.21	ns	ns	ns	ns
$C_{11:0}$	1.06	0.40	1.27	0.29	0.39	ns	ns	ns	ns
$C_{12:0}$	1.69	0.18	0.83	0.17	0.24	ns	ns	ns	ns
$C_{14:0}$	4.97	4.61	6.16	4.37	4.60	ns	ns	ns	ns
$C_{14:1}$	4.70	3.52	2.19	3.98	5.59	ns	ns	ns	ns
$C_{15:0}$	3.43	2.27	1.50	2.55	3.81	ns	ns	ns	ns
$C_{15:1}$	1.48	1.21	0.80	1.46	2.29	ns	ns	ns	ns
$C_{16:0}$	18.7	22.6	22.5	22.1	19.5	ns	ns	ns	ns
$C_{16:1}$	3.53	2.33	1.30	2.84	4.30	ns	ns	ns	ns
$C_{17:0}$	3.24	1.74	1.36	1.22	2.38	*	ns	ns	ns
$C_{17:1}$	0.62	0.21	0.14	0.25	0.72	ns	ns	ns	ns
$C_{18:0}$	11.8	22.7	19.6	22.6	16.3	ns	ns	ns	ns
$C_{18:1\omega9c}$	28.8	29.5	29.0	27.8	27.8	ns	ns	ns	ns
$C_{18:1\omega9t}$	1.31	1.01	1.55	1.19	1.76	ns	ns	ns	ns
$C_{18:2\omega6c}$[2]	0.19	0.07	0.01	0.08	0.41	ns	*	*	ns
$C_{18:2\omega6t}$[3]	0.13	0.13	0.08	0.17	0.30	ns	*	*	ns
$C_{18:3\omega3}$	1.18	0.22	0.31	0.40	0.69	ns	ns	ns	ns
$C_{18:3\omega6}$	0.83	0.52	0.57	0.50	0.67	ns	ns	ns	ns
$C_{20:0}$	0.49	0.17	0.31	0.42	0.53	ns	ns	ns	ns
$C_{20:1}$	1.30	0.79	1.02	1.01	1.44	ns	ns	ns	ns
$C_{20:2}$	1.49	1.82	1.54	1.53	1.94	ns	ns	ns	ns
$C_{20:3\omega3}$	0.71	0.14	0.16	0.25	0.61	ns	ns	ns	ns
$C_{20:3\omega6}$	0.37	0.26	0.18	0.29	0.30	ns	ns	ns	ns
$C_{20:4\omega6}$	0.05	0.02	0.08	0.02	0.10	ns	ns	ns	ns
$C_{20:5\omega3}$	0.12	0.01	0.03	0.09	0.04	ns	ns	ns	ns
$C_{21:0}$	0.08	0.00	0.00	0.03	0.03	ns	ns	ns	ns
$C_{22:0}$	0.05	0.05	0.01	0.08	0.06	ns	ns	ns	ns
$C_{22:1\omega9}$	0.95	0.11	0.95	0.19	0.21	ns	ns	ns	ns
$C_{22:2}$	0.14	0.15	0.24	0.24	0.21	ns	ns	ns	ns
$C_{22:6n3}$	0.06	0.07	0.04	0.05	0.05	ns	ns	ns	ns
$C_{23:0}$	0.00	0.00	0.00	0.00	0.01	ns	ns	ns	ns
$C_{24:0}$	0.38	0.68	0.54	0.45	0.43	ns	ns	ns	ns
$C_{24:1}$	0.00	0.00	0.00	0.01	0.00	ns	ns	ns	ns
UN[4]	4.66	1.90	4.27	2.54	1.60	ns	ns	ns	ns

[1]3S and 5S = 3 and 5% of diet EE, with soybean as fat source; 3CB, 4CB e 5CB = 3, 4 and 5% of diet EE, with cottonseed byproducts as fat source, respectively.
[2]$C_{18:2n6c}$ = -0.63 + 0.2*diet EE with CB (R^2=0.31; P=0.004)
[3]$C_{18:2n6t}$= -0.24 + 0.11*diet EE with CB (R^2=0.27; P=0.008)
[4]Unidentified
[+]C1 = 3S *vs* 3CB; C2 = 5S *vs* 5CB; C3 = 3CB *vs* 5CB; C4 = 3CB + 5CB *vs* 4CB.

The CB diet fat source caused a lower proportion of heptadenoic fatty acid ($C_{17:0}$) in meat, when compared to S diet fat source, particularly in diets with 3% EE (C1). Gill *et al*. [10] also observed a difference in heptadenoic acid proportions in meat of cattle, when contrasting flaked corn and wet distillers residue. They also reported that the increase of this fatty acid is of little importance, since it does not induce changes in blood cholesterol in humans [10].

The CB increase in animal diet, inhibited ruminal lipolysis and biohydrogenation, leading to a linear increase in meat linoleic acid proportion ($C_{18:2.6}$); *cis* (0.010%, 0.079% and 0.411%), and *trans* (0.084%, 0.172% and 0.298%) configurations, respectively, with 3%, 4% and 5% of EE in the diet, with CB as the fat source. Nute *et al*. [7] also found an increase of the same fatty acid and meat sensory differences with lambs. Thus, this study confirms that the fatty acid composition may affect the meat sensory traits, being mainly influenced by linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) acid, according to Larick and Turner [11].

The average capric acid ($C_{10:0}$) proportion was similar to that observed by Jenschke *et al*. [12], in study with 185 confined crossbred cattle. However, the myristic acid ($C_{14:0}$) proportion found in this experiment was higher than the proportion reported by the same authors. Palmitic acid ($C_{16:0}$) proportion detected by Jenschke *et al*. [12] was lower than the proportion found in this study, probably due to diet characteristics; animals fed with a more concentrated diet may have increased myristic acid incorporation and palmitic acid reduction.

IV. CONCLUSION

The cottonseed byproduct inclusion in animal diets increases strange odor and linoleic acid proportion in meat. However, the beef aroma from cattle fed with high levels of cottonseed byproduct did not differ from beef from cattle fed with soybean products.

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