

EATING QUALITY OF BEEF PRODUCED WITH CO-PRODUCTS FROM THE BRAZILIAN AGRIBUSSINESS

A. Guerrero^{1*}, C.E. Eiras¹, K.A. Souza¹, J.A. Pardo², Mottin¹, C. and I.N. Prado¹

¹Department of Animal Science, State University of Maringá, Av. Colombo, 5790, 87020-900, Maringá, Paraná, Brazil

²Facultad de Veterinaria y Zootecnia, Universidad del Tolima, Santa Helena Parte Alta -730006299, Ibagué, Tolima, Colombia.

[*guerreroabarrado@gmail.com](mailto:guerreroabarrado@gmail.com)

Abstract – The aim of this study was to evaluate eating quality of beef from 30 crossbreed (½ Simmental - ½ Nellore) young bulls finished with high grain diets based on co-products from Brazilian agribusiness. Three diets with three different levels of cottonseed hull (CH21, CH27 and CH33 with 210 g/kg, 270 g/kg and 330 g/kg of cottonseed hull/kg DM respectively) were compared. *Longissimus* steaks aged for 1, 7 or 14 days from the three studied diets were used to analyzed consumer acceptability of beef. Brazilian consumers (n=120) evaluated tenderness, flavor and overall acceptability of meat from the 3 diets and 3 points of aging using a hedonic nine point scale. Cottonseed hull diets did not affect meat quality scores; however aging time was a significant factor ($P \leq 0.001$) on tenderness acceptability: beef with 1 day of aging presented significant lower scores than beef aged 7 or 14 days. Cluster analyses evidenced different consumer groups with different preferences for tenderness, acceptability and appraisal. In conclusion, meat originating from anyone of diets evaluated based on co-product presented a good acceptability by consumers, which was improve with aging time.

Key Words –Alternative feeds, high grain system, beef preference

I. INTRODUCTION

Brazil is one of the main beef producer, exporter, and consumer of beef [1]. Traditional production systems were extensive (pasture) with zebuine breeds as Nellore [2]. However intensification and technical advances on feeding, production systems and rear of crossbreed are increasing [3]. Fed is one of the main costs on beef production when feedlot systems are used, and Brazil had a high availability of co-products derivate from agribusiness and/or biodiesel industry [4]. The utilization of those co-products for finishing young

bulls in feedlots is possible without reduction of meat and carcasses quality [5].

Changes in the diet, different production systems or origin of animals could imply differences in consumer's beef sensory scores [6,7]. However, consumers' assessment may vary depending of their personal background or consumption habits. Usually, in European countries aging influence eating quality scores, increasing beef tenderness and overall liking [8], however studies about beef palatability evaluated by Brazilian consumer are scarce.

The aim of the current work was to evaluate eating quality at consumer level of meat from crossbreed young bulls finished on high-grain systems with co-products from Brazilian agribusiness and with different times of aging.

II. MATERIALS AND METHODS

Thirty crossbreed young bulls (½ Simmental - ½ Nellore) of 319 ± 12.5 kg live weight were randomly assigned to one of three diets ($n=10$ per treatment) based on high grain systems which co-products of Brazilian agribusiness. Diets used (soybean hull pellets, ground corn, sugarcane bagasse pellets, corn gluten meal, cottonseed hull, yeast, urea, limestone and mineral salt) were formulated to be isonitrogenous and isoenergetics according to NRC recommendations [9] to provide a weight gain of 1.0 kg/day (Table 1). Three different levels of cottonseed hulls were studied: 'CH21, CH27 and CH33 (210 g/kg; 270 g/kg and 330 g/kg of cottonseed hull on DM basis, respectively).

Animal were fed *ad libitum* during 162 days until they reach commercial live weight (423.6 ± 6.5 kg). Afterwards, they were slaughtered in a

commercial abattoir according to cattle routine rules in Brazil.

Table 1. Chemical composition of the three studied diets (g/kg DM) given to young bulls in high grain system

	Cottonseed hull diets		
	CH21	CH27	CH33
DM	905	905	906
Ash	51.9	52.3	52.9
OM	938	938	937
CP	110	110	110
EE	24.1	23.5	22.7
NDF	559	579	604
ADF	363	367	376
TC	819	820	822
NFC	256	237	214
Lignin	64.7	66.5	68.9
ME	10.5	10.5	10.5

DM: Dry matter; OM: Organic matter; CP: Crude protein; EE: Ether extract; TC: Total carbohydrate; NFC: Non fibrous carbohydrate; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ME: Metabolizable energy (MJ kg⁻¹ DM) was calculated from NRC, 2000 model.

The left *Longissimus thoracis* and *lumborum* (LTL) muscles were removed from each carcass 24 h after slaughter and cut into 2 cm-thick steaks from the 7th *thoracis* vertebrae. Each sample was vacuum packaged and aged for 1, 7 or 14 days before frozen at -18°C for consumer sensory evaluation. Samples for consumers test were thawed at 4°C during 24 h prior to the analysis. Each piece was covered with aluminum foil codified with a random 3 digit-code and cooked in a pre-heated grill at 200°C until reaching an internal temperature of 70°C monitored with a penetration thermocouple. Each steak was cut 2 x 2 cm cubes and kept warm (50°C) until consumer evaluation.

Consumer test was performed during a National Livestock Exhibition in Maringá-PR (Brazil) and involved 120 local consumers divided in groups of ten people by session. Average profile of consumers was similar to Brazilian national profile [10]: 50.4% women and 49.6% men, 26.1% between 18-25 years of age, 30.2% between 26-40

years of age; 24.3% between 41-55 years of age and 19.4% older than 56 years.

Each consumer evaluated nine samples (one of each diet and aging time) following a randomized design to avoid order and carry-over effects [11]. For each sample, consumers evaluated three different attributes: tenderness score, flavor score and overall liking using a structured hedonic on a 9 point scale ranging from (1 = 'dislike extremely' to 9 = 'like extremely') where the intermediate point corresponding to 5 'neither like nor dislike' was excluded [7].

Meat attributes were assessed by analysis of variance using a General Lineal Model (GLM) Procedures with SPSS (v15.0). Diets and aging time were considered as fixed effects, and consumer as a random effect. Differences between means were evaluated using Tukey's test ($P \leq 0.05$). To identify similarities among consumers, a hierarchical cluster analysis was used to determine the different segments of participants depending on their tenderness score using XLSTAT (v.7.5.3). The number of clusters was selected from the dendrogram, trying to find a compromise between homogeneity within clusters and heterogeneity between clusters.

III. RESULTS AND DISCUSSION

As it is compiled on Table 2, the inclusion of different levels of cottonseed hull did not affect scores of tenderness, flavor or overall liking. However, aging time was a significant factor ($P \leq 0.001$) affecting tenderness score. There was not interaction between the dietary factor and aging time.

Table 2. *P*-values of the inclusion of co-products from Brazilian agribusiness on the diet and aging on consumer beef sensory scores

	Diets	Aging time	D x A
Tenderness	0.430	0.001	0.743
Flavor	0.531	0.056	0.841
Overall	0.605	0.054	0.261

Diets effects were determined by cottonseed hull level: CH21 CH27, CH33; Aging time effect was determined by 1, 7 and 14 aging days; D x A: Interaction Diets x Aging time.

As it is showed in Table 3, the three diets presented scores for all studied attributes higher

than 6.8 on a 9 point scale, which correspond with 'like moderately'. As it was expected and according to other consumer studies [8,12], aging time improved tenderness score, especially during the first week when the main changes in the myofibrillar structure occurs, although it is dependent on the studied breed [13].

Table 3. Effects of cottonseed hull diets and aging time on consumer acceptability (n=119)

	Cottonseed hull diets			Aging time		
	CH21	CH27	CH33	1-d	7-d	14-d
Tenderness	7.09	7.24	7.14	6.85 ^b	7.26 ^a	7.36 ^a
Flavor	6.99	6.86	6.95	6.84	7.11	6.85
Overall	6.99	7.07	7.07	6.84	7.16	7.12

CH21; CH27 and CH33: cottonseed hull 210; 270 and 330g/kg on a DM basis, respectively. a, b: indicate statistical differences in the same row between aging time ($P \leq 0.05$).

Tenderness contributes to eating satisfaction [14], although in this study differences in overall palatability between aging times were not significant. However, the importance of this attribute is well known and it has been reported that consumers willing to pay is higher if meat tenderness is guaranteed [6].

There are several groups of consumers that differ for acceptability perception, and they constitute significant market segments. The consumer segmentation also occurs when consumption habits, preferences for meat choice and attitudes to certain meat attributes are considered [7] and this knowledge is important to identify different market niches.

In relation to tenderness, four different clusters of consumers were found with the current data (Table 4). The segmentation of consumers based on tenderness score by a cluster analysis showed that not only aging became a significant factor, but also the diet (level of cottonseed hull).

The largest consumers' cluster (number 1) (57.8%) showed differences on tenderness between diets, and consumers preferred intermediate levels of cottonseed hull addition (CH27) compared to the highest levels (CH33). However the three diets were scored with a high punctuation, near 8 or 'like very much'. Related to aging time, it was not a significant factor for cluster 1. However it showed the highest scores

in comparison with the other consumer groups, with an average of 7.8 points on a 9 point scale (Table 5). The cluster 1 included the higher percentage of men (55.6%) than women (44.4%) and it had a similar proportion of people on each of four age intervals.

Table 4. *P*-values of the inclusion of co-products from Brazilian agribusiness on the diets and aging time effect on tenderness consumer clusters.

	% sample	Diets	Aging time	D x A
Cluster 1	57.8	0.001	0.204	0.022
Cluster 2	16.5	0.001	0.000	0.006
Cluster 3	16.5	0.051	0.107	0.316
Cluster 4	9.17	0.002	0.082	0.000

Diets effects were determined by cottonseed hull level: CH21, CH27, CH33; Aging time effect was determined by 1, 7 and 14 aging days; D x A: Interaction Diets x Aging time.

For cluster 2 (16.5% of participant) the preferred meat was the one from CH33 diet. Beef of 1 day of aging was scored significantly lower than those from 7 or 14 days. The cluster 2 was composed by a higher percentage of women (55.6%) than men (44.4%), and 83.3% of consumers of this group were younger than 41 years, and no one had more than 56 years old.

Table 5. Effects of cottonseed hull diets and aging time on tenderness score - consumer clusters segmentation

	Cottonseed hull diets			Aging time		
	CH21	CH27	CH33	1-d	7-d	14-d
Cluster1	7.86 ^{ab}	7.97 ^a	7.55 ^b	7.69	7.80	7.89
Cluster 2	6.39 ^b	6.57 ^b	7.65 ^a	5.39 ^B	7.61 ^A	7.61 ^A
Cluster 3	5.52	5.07	6.02	5.74	4.94	5.92
Cluster 4	5.70 ^b	7.43 ^a	5.40 ^b	5.93	6.77	5.83

CH21; CH27 and CH33: cottonseed hull 210; 270 and 330g/kg on a DM basis, respectively. a,b: indicate statistical differences in the same row between diets ($P \leq 0.05$). A,B: indicate statistical differences in the same row between aging ($P \leq 0.05$).

The Cluster 3 (which represents 16.5% of participants), did not show differences on tenderness score between diets or aging times. The group presented the lowest punctuations for beef, ranging between 4.9 and 6.0 points. The cluster included 44.4% of man and 55.6% of woman; and 66.6% of people was younger than 41 years.

The last group of consumers (cluster 4: 9.1% consumer sample) preferred the meat from CH27 in comparison with the other diets and they did not show differences between aging times as observed

for Cluster 1. However tenderness scores for cluster 4 were lower than those reported for cluster 1.

Results show that Brazilian consumers have different preferences on tenderness. The different characteristics of clusters evidence the diversity of beef market niches. Beef production from young bulls finished with agribusiness co-products presented on general good acceptability; the CH27 diets had the highest tenderness scores. However aging was the most important effect and it improves tenderness acceptability afterwards 7 day of aging.

IV. CONCLUSION

Current results about eating quality of beef from young bulls finished with co-products from Brazilian agribusiness on high-grain systems showed a good acceptability by local consumers. The results are encouraging about the use of this kind of coproduct on beef diets in order to reduce the production costs. For the improvement of tenderness and a greater acceptability of meat of crossbred animals mostly recommend at least 7 days of aging.

ACKNOWLEDGEMENTS

This work was supported by the Araucaria Foundation and the Brazilian Council for Research and Technological Development (CNPq). Authors thank fellowship (BJT-CNPq). The authors gratefully acknowledge the FORTMIX animal technology® (Maringá, Paraná, Brazil) for providing the co-products used in this research.

REFERENCES

1. FAPRI. (2014). Food and Agricultural Policy Research Institute. In Food and Agricultural Policy Research Institute (Database, W. A. O., ed.), Iowa State University and University of Missouri-Columbia Ames, IA, USA.
2. Ferraz, J.B.S. & De Felício, P.E. (2010). Production systems-An example from Brazil. *Meat Science* 84: 238-243.
3. Lobato, J.F.P., Freitas, A.K., Devincenzi, T., Cardoso, L.L., Tarouco, J.U., Vieira, R.M., Dillenburg, D.R. & Castro, I. (2014). Brazilian beef produced on pastures: Sustainable and healthy. *Meat Science* 98: 336-345.
4. Eiras, C. E., Marques, J. A., Prado, R. M., Valero, M. V., Bonafé, E. G., Zawadzki, F., & Prado, I. N. (2014). Glycerine levels in the diets of crossbred bulls finished in feedlot: Carcass characteristics and meat quality. *Meat Science* 96: 930-936.
5. Eiras, C. E., Ornaghi, M. G., Valero, M. V., Rivaroli, D. C., Guerrero, A., Carvalho, C. B., & Prado, I. N. (under review). Cottonseed hull content from Brazilian agribusinesses on carcass characteristics and meat quality of bulls finished in a high-grain system. *Animal Feed Science and Technology*.
6. Realini, C.E., Font i Furnols, M., Guerrero, L., Montossi, F., Campo, M.M., Sañudo, C., Nute, G.R., Alvarez, I., Cañeque, V., Brito, G. & Oliver, M.A. (2009). Effect of finishing diet on consumer acceptability of Uruguayan beef in the European market. *Meat Science* 81: 499-506.
7. Realini, C.E., Font i Furnols, M., Sañudo, C., Montossi, F., Oliver, M.A. & Guerrero, L. (2013). Spanish, French and British consumers' acceptability of Uruguayan beef, and consumers' beef choice associated with country of origin, finishing diet and meat price. *Meat Science* 95: 14-21.
8. Pérez Juan, M., Realini, C.E., Barahona, M., Sarries, M.V., Campo, M.M., Beriain, M.J., Vitale, M., Gil, M. & Albertí, P (2014). Effects of enrichment with polyunsaturated fatty acids (Omega-3 and Conjugated Linoleic Acid) on consumer liking of beef aged for 7 or 21 d evaluated at different locations. *Journal of Food Science* 79: 2377-2382.
9. NRC. (2000). Nutrient Requirements of Beef Cattle. 7th ed. Natl. Acad. Press, Washington, DC.
10. IBGE. Instituto Brasileiro de Geografia e Estatística. Brazilian population 2014. <http://www.ibge.gov.br>
11. Macfie, H.J., Bratchell, N., Greehoff, K. & Vallis, L.V. (1989). Designs to balance the effect of order of presentation and first order carry over effect in hall tests. *Journal of Sensory Studies* 4: 129-148.
12. Monsón, F., Sañudo, C. & Sierra, I. (2005). Influence of breed and aging time on the sensory meat quality and consumer acceptability in intensively reared beef. *Meat Science* 71: 471-479.
13. Monsón, F., Sañudo, C. & Sierra, I. (2004). Influence of cattle breed and aging time on textural meat quality. *Meat Science* 68: 595-602.

14. Font-i-Furnols, M. & Guerrero, L. (2014). Consumer preference, behaviour and perception about meat and meat products: an overview. *Meat Science*: 98, 361-371.