academicJournals

Vol. 10(29), pp. 2835-2840, 16 July, 2015
DOI: 10.5897/AJAR2015.10064
Article Number: F47BE7954197
ISSN 1991-637X
Copyright ©2015
Author(s) retain the copyright of this article
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Effect of different sources of lipids in diet on the qualitative characteristics of *Longissimus thoracis* muscle of cattle finished in feedlots

Erico da Silva Lima[1]*, Jozivaldo Prudêncio Gomes de Morais[2], Roberto de Oliveira Roça[3], Ernani Nery de Andrade[4], Tiago Neves Pereira Valente[5], Quézia Pereira Borges da Costa[6] and Bruno Borges Deminicis[7]

[1]Programa de Mestrado em Saúde Ambiental, FMU, São Paulo, SP, Brazil.
[2]Agricultural Sciences Center at UFSCar, Araras/SP, Brazil
[3]UNESP/FCA, Botucatu/SP, Brazil.
[4]Faculdade de Ensino Superior e Formação Integral – FAEF, Garça/SP, Brazil.
[5]Instituto Federal Goiano, Posse Campus /GO, Brazil.
[6]Instituto Federal do Mato Grosso, Campo Novo do Parecis Campus/MT, Brazil.
[7]University of Southern Bahia, Teixeira de Freitas/ BA, Brazil.

Received 24 June, 2015; Accepted 13 July, 2015

The objective of this study was to determine the effect of the dietary inclusion of lipid-based diets (whole cottonseed and protected fat) on the pH, meat color and fat, tenderness and cooking yield in *Longissimus thoracis* muscle of cattle feedlot. Were used 39 Nellore cattle uncastrated with average initial body weight of 494.1 ± 10.1 kg and 36 months of age were housed for 63 days in pens with thirteen animals each. A completely randomized design with three treatments and thirteen replications was used. The treatments evaluated were: Feed with 2.50% whole cottonseed (control diet); feed with 11.50% whole cottonseed; and feed with 3.13% whole cottonseed added of protected lipid (PL), all on a dry matter basis. No differences were found for pH 24 h post mortem, meat color and fat, tenderness or cooking yield. The values of shear force of meat the animals presented differences (P <0.05), and the animals fed with 11.50% of cottonseed had greater value than those fed 2.50% on the diet, in relation to dry matter. The study came to the conclusion that the protected lipid does not influence the qualitative characteristics of meat and the amount of 11.50% of cottonseed in the cattle diet does not contribute to the improvement of texture and tenderness of the meat.

Key words: Color, cooking yield, shear force, whole cottonseed.

INTRODUCTION

The livestock beef cattle production is important activities of the agribusiness in Brazil, being one of the largest exporters of beef in the world. The farms seek to produce efficiently and with this new demand for quality meat. The

*Corresponding author. E-mail: ericozoo1@yahoo.com.br, Tel: +55 19 982153505.
Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

consumers search products competitiveness and require the availability of low cost and better quality (Ruviaro et al., 2014).

To Brazil, maintaining this condition each year has expanded the studies on nutrition of ruminants on the performance and carcass characteristics and meat. One of the main problems encountered in the feeding of cattle confined is related to metabolic disorders caused by the excess of high carbohydrates such as starch fermentation in rumen. The increase in the supply of lipid can be an alternative to reduce the inclusion of starch, maintaining the same energy level of the diet. Thus, the cottonseed has long been used in the feeding of ruminants with this purpose.

However, excess dietary lipid can cause negative effect on fiber digestion in the rumen and influence on quality of meat (Rogério et al., 2003). One way to avoid this negative effect of lipid on the microorganism that digests fiber in the rumen is the supply of protected lipid in the rumen biohydrogenation (Aferri et al., 2005). However, in the literature there are few results the use of protected lipid on the characteristics of quality of meat.

The objective of evaluation the influence of whole cottonseed and of protected lipid on pH, color of meat and fat, the tenderness and cooking the *Longissimus thoracis* muscle of cattle finished in feedlots.

MATERIALS AND METHODS

Study location

The study was carried out in the Chapéu de Couro Farm, located in the city of Aguaí/SP, Brazil, at 22°04′00″ South, 47°09′03″ West, average altitude of 615 m above sea level. The region is characterized by a hot and humid seasons from October to March, followed by a cold and dry season from May to September. The climate of the region is Cwa in the Köppen classification (mesothermal, with hot and humid summers and dry winters).

Animal management and treatment

A group of 39 uncastrated, Nellore animals raised in *Brachiaria humidicola* pastures was used in the study. Mean age of the animals was 36 months and initial mean live weight was 494.1 ± 10.1. Animals were identified and dewormed with Ivermectin 1% before the beginning of the trial. Then, animals were randomly assigned to one of three treatments, based on dry matter: feed with 2.50% CS (control diet), feed with 11.50% CS, and feed with 3.13%% CS added of 1.77% protected lipid (PL). Animals were confined for 63 days (experimental period) in collective pens of 247 m^2 (19 m^2 per animal). The confinement facility was made up of three pens with sand floors, with 13 animals per pen. Feeders and drinkers in these pens were provided with roofs and animals had free access to them. Feeders were made of concrete, and the length available per animal was 0.70 m. A 10-day period was used for the adaptation to the diet and management prior experimental period, in which concentrate was gradually added to the feed, until a 50:50 forage:concentrate ratio was reached. The experimental diets were formulated in the CNCPS software 4.0 (CNCPS, 2000) for uncastrated finishing cattle to provide weight gains of 1.4 kg/animal/day. Forage:concentrate ratio was 50:50 on a dry matter basis. All the concentrate ingredients and forage were weighted in order to prepare the experimental diets, using electronic weighing scale kg. Sugar cane chopped was used as forage, and concentrate was made up of urea, cracked corn kernels, citrus pulp, cotton meal, CS and/or PL. The PL used in this study was made from soybean vegetable oil and had fatty acid calcium salts in its composition. Animals were fed twice a day at 8 am and 4 pm, in a total mix diet, with about 5% leftovers that were weighted in the morning for diet adjustment. Nutritional composition of the diets is shown in Table 1.

Procedures for data collection

After thawing, composite samples of a 21-day period were obtained. Samples of feed and forage were weighted and pre-dried at 60°C for 72 h. Then, they were weighted again in a mill with 1-mm sieves, and stored in plastic bags. Samples of the experimental diets were sugar cane and concentrate which were collected every seven days, placed in plastic bags and stored in at -4°C for subsequent measurements.

The samples were analyzed for Proximate Analysis according to AOAC (1990) and NDFom and ADFom (excluding ash) according to procedures of Van Soest et al., 1991), and lignin by the sulphuric acid method Lignin (sa), after a sequential neutral-acid detergent extraction (Van Soest et al., 1991). In the NDF analyses, thermostable α-amylase was used without sodium sulfite (Mertens, 2002). Non-fiber carbohydrates (NFC) in the ingredients of the diets were determined by the following equation, according to Sniffen et al. (1992), NFC = 100 - (%NDFcp + %CP + %EE + %MM). Due to the presence of urea in the diets, NFC in them were calculated as indicated by Hall (2000): NFC = 100 - [(%CP - %CP from urea + %urea) + %NDFcp + %EE + %Ash]. Estimated metabolizable energy (ME) in Mcal/kg of DM was determined according to the NRC (1996) recommendations, considering that 1 kg of total digestible nutrients (TDN) contains 4.409 Mcal of digestible energy (DE), using 0.82 as the conversion factor to transform DE in ME. Analyses of the feed samples were carried out in the Food Analysis Laboratory at the Animal Nutrition and Improvement Department of Faculdade de Medicina Veterinária e Zootecnia at Universidade Estadual Paulista, Botucatu campus. Results of these analyses are shown in Tables 2 and 3.

Slaughter procedures and sample preparations

After 63 days of the study, animals were weighted for the last time after a 14-h solid food fasting. Mean final live weight was 577.01 kg ± 11.34. Soon after being weighted, animals were taken to a slaughterhouse (FRIGONOBRE, in the city of Torrinha, state of São Paulo), 166 km from the study site, in solid food fasting until the moment they were slaughtered. Animals were slaughtered according to the regular flow of the industry.

After slaughter, carcasses were identified and divided into two halves that were kept in a cold chamber for 24 h at 2°C. Using pH meter was determined *post-mortem* pH in *Longissimus thoracis* muscle between the 12^{th} and 13^{th} rib of the left half carcass. After, part of each animal was removed, and divided in three samples (steaks). Steaks were 2.5 cm thick and were identified and stored individually in plastic bags under vacuum. Samples were frozen in a freezer at -18°C at Universidade Estadual Paulista, Faculdade de Ciências Agronômicas, Botucatu campus, at the Animal Products Technology Laboratory.

Chemical analysis of the meat and fat color

Samples of *Longissimus thoracis* muscle of each animal were

Table 1. Chemical composition of the experimental diets on a dry matter basis.

Ingredients (%)	Dietary treatments		
	2.50% CS (control)	11.50% CS	3.13% CS + PL
Sugar cane	50.00	50.00	50.00
Cracked corn	14.64	13.07	13.12
Citrus pulp	21.61	17.81	20.61
Cottonseed	2.50	11.50	3.13
Cottonseed meal	9.30	5.78	9.42
Urea	0.83	0.83	0.83
Protected fat	-	-	1.77
Mineral mix[1]	0.83	0.83	0.83
Potassium chloride	0.28	0.17	0.28
Ionophores	0.01	0.01	0.01

[1]Composition /kg: P = 60g; Ca = 180g; Mg = 5 g; S = 17 g; Na = 135 g; Cu = 650 mg; Mn = 500 mg; Z n= 2400 mg; I= 48 mg; Co = 38 mg; Se = 12 mg; CS = cottonseed; PL = protected lipid.

Table 2. Mean chemical composition of ingredients used in the experimental diets as percentage dry matter.

Ingredients	DM (%)	% dry matter						
		CP	EE	NFC	NDFmo	ADFmo	LIG	MM
Sugar cane	30.27	2.82	2.93	29.06	62.43	39.56	6.85	2.76
Cracked corn	87.02	8.73	4.46	71.46	14.42	5.32	2.75	0.93
Citrus pulp	87.94	5.87	3.5	64.78	21.38	16.75	7.52	4.47
Cottonseed	91.00	19.67	20.83	1.36	54.65	45.44	17.03	3.49
Cottonseed meal	87.24	46.08	1.94	0.12	45.66	28.32	9.91	6.20
Protected lipid	95.47	-	85.21	-	-	-	-	14.79
Urea	99.51	287.84	-	-	-	-	-	-

NFC according to Sniffen et al. (1992).

Table 3. Mean chemical composition of experimental diets used in different levels of cotton seed.

Items	Diets		
	2.50% CS (control)	11.50% CS	3.13% CS + PL
DM (%)	58.09	58.50	58.26
CP (% of dry matter)	11.11	10.90	11.11
EE (% of dry matter)	3.57	5.18	5.11
NFC (% of dry matter)	38.61	35.03	36.88
NDFom (% of dry matter)	43.56	45.83	43.52
MM (% of dry matter)	3.15	3.06	3.38
TDN[1]	67.55	68.16	68.99
ME[2]	2.44	2.46	2.49

NFC according to Hall (2000); [1]Estimated in the feed composition according to the CQBAL 3.0 (2012) and the NRC (2001)[2] ME = estimated metabolizable energy, in Mcal/kg of DM, according to the NRC (1996).

thawed in refrigerator, then removed from the packaging and exposed to the air for 30 min to allow oxygenation surface. The color of the meat was determined by the Minolta colorimeter CR-410 and the color of the subcutaneous fat, using the optional Milnolta CR-400 second Honikel (1998). The parameters evaluated were L*, a* and b* the CIELab system, where L* is brightness, a* represents intensity of red and b* intensity of yellow.

Cooking yield and shear force (aged beef)

The samples were weighed in the balance semi-analytical and

Table 4. Characteristics aging times of meat and subcutaneous fat color the Nellore cattle fed with different diets.

Characteristics	Diets				
	2.50% CS (control)	11.50% CS	3.13% CS + PL	SE	P-value[1]
Meat					
pH 24 h	5.66	5.54	5.57	0.06	0.34
Shear force (kg)	5.10[b]	6.30[a]	5.83[ab]	18.45	0.02
Cooking yield (%)	83.13	76.57	79.82	10.11	0.14
Brightness L*	38.51	39.83	39.57	4.92	0.19
Intensity the red a*	15.52	15.93	16.36	8.08	0.26
Intensity of yellow b*	3.44	4.33	4.26	28.03	0.09
Fat					
Brightness L*	64.80	65.64	65.59	6.08	0.83
Intensity the red a*	10.88	9.77	10.90	28.72	0.55
Intensity of yellow b*	8.89	8.85	8.97	25.41	0.99

[1]According to Tukey test (P< 0.05); [a, b] Different letters in line indicate significant difference. CS = cottonseed; PL= protected lipid; SE = standard error.

submitted to cooking on a grid until they reach the automatic internal temperature of 71°C, as measured by a digital thermometer in the geometric centre of the sample. The evaluation of proceeds in cooking was made by the difference between the weights of the samples before and after cooking according to the methodology of Honikel (1998). The same samples cooked were refrigerated by 12 h the 4°C, and then cut into cylinders 1.10 Øcm with the support of a drill press avoiding fats and nerves. Shear force was calculated in these samples cut into cylinders through the Brookfield texture CT3 Texture Analyzer 25 k equipped with a set of blade Warner-Bratzler according to the methodology of Savell et al. (2015).

Statistical procedures and model evaluation

A completely random design with 3 treatments and 13 repetitions was used, according to the Yij = μ + Ti + eij model, where: Yij is the value observed in the j^{th} experimental unit (animal) that received the i^{th} treatment; μ is the overall mean; Ti is the fixed effect of the i^{th} treatment; eij is the experimental error related to the experimental unit. Data were analyzed by means of the Generalized Linear Models Procedures (GLM). The averages were adjusted by the method of least squares (Least Squares Means). Statistical analyses were performed using the SAS program (2002), and means were compared using Tukey test at a 5% significance level.

RESULTS

The characteristics the meat and subcutaneous fat the Nellore cattle was shown in Table 4. No differences in pH 24 h after slaughter were observed in the meat of Nellore cattle fed different sources of fat (Table 4), and mean value for this variable was 5.59. Difference was not observed (P > 0.05) to cooking yield of muscle *Longissimus thoracis* the Nellore cattle fed lipid sources. However, for the shear force differences (P < 0.05) were founded. For diet control the lowest value found 5.10 (kg) while for the treatment with 11.50% CS the great value found was 6.30 (kg). It may be observed in Table 4, for Brightness L*, intensity the red a*, intensity of yellow b* that there were no differences (P>0.05) between the treatments for characteristics the meat or fat.

DISCUSSION

After 24 h analysis of pH *post-mortem* of the Nellore cattle the mean value for this variable was 5.59. In the same way as, findings similar to those of the present study were reported by Aferri et al. (2005), who studied the use of additional fat in the diets of confined crossbred beef steers. These authors did not find any differences between the diets containing or not the lipid source, either. They reported a mean pH value of 5.56 after 24 h of slaughter.

As uncastrated animals are more easily stressed, according to Luchiari Filho (2000), inadequate management during management, transportation, and slaughter may lead to dark, firm and dry carcasses. This condition is always observed when pH is greater than 6.0. In Brazil, slaughterhouse export only meat with pH is lowers than 5.8, determined directly on the *Longissimus thoracis* muscle 24 hours after slaughter (Fernandes et al., 2008). Mean pH 24 h after slaughter in the present study (Table 4) suggests that stress was not too high before slaughter, as muscle acidification was inside the expected range.

For shear force different the results observed in this study, Costa et al. (2013) found no differences in shear force on *Longissimus thoracis thoracis* muscle of cattle fed growing Nellore whole cottonseed levels in the diet, as well as Aferri et al. (2005) and Andrade et al. (2014) also did not observe differences by including whole cottonseed or rumen protected lipid in diet. Second, Labrune et al. (2008) as worked with a lipid-rich diet and

not observed change in shear force on tenderness or succulence of meat from steers. High shear force values mean greater texture of meat that indicates less tenderness. The texture of the meat can be influenced by age, weight to the slaughter of animals. For cattle breed Nellore *Bos taurus indicus* more high value of shear force (Shackelford et al., 1994).

For cooking yield of cattle fed lipid sources showed no differences. Similar results were founded for Aferri et al. (2005), Costa et al. (2013) and Andrade et al. (2014) did not observe differences to the loss by cooking to feed cattle with whole cottonseed or protected lipid. When cooking meat compounds losses include free amino acids, peptides, reducing sugars, vitamins and lipids (Watanabe et al., 2015).

In studies with brightness the meat second Suman et al. (2014) to improve beef color and attempted to logically explain the fundamental mechanisms involved. However, the surface color and its stability are critical traits leading the marketability of fresh beef when sold, while internal cooked color is utilized as an indicator for doneness at the point of consumption. For brightness L*, intensity the red a*, intensity of yellow b* the muscle initial red color intensity increased whereas both mitochondrial oxygen consumption and color stability decreased. The decrease in mitochondrial oxygen consumption associated with longer aging times will increase initial color intensity (Mancini and Ramanathan, 2014). Similar result founded in study case Costa et al. (2013) no differences in this characteristics is this feature evaluated for cattle fed with increasing levels of whole cottonseed in the diet. Same results were observed for Oliveira et al. (2012) with meat color composition evaluated from Nellore cattle fed fat protected lipids and did not view an alteration in these parameters, due to the consistency in the breed, age and meat pH of the animals.

Conclusion

The supply of protected lipid in the diet of cattle does not influence the quality of the meat. The whole cottonseed does not contribute to the improvement of texture and tenderness of the meat.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study.

ACKNOWLEDGMENTS

The authors would like to thank the owner of Chapéu de Couro farm, Mr. Raul Schwinden, for the confinement area for the animals; Mr. Cirlei and José Benedito for providing the animals for the study, and FRIGONOBRE slaughterhouse for providing the area for meat evaluation. Thanks to the UNESP/FMVZ/Botucatu and IFGoiano for support.

REFERENCES

Aferri G, Leme PR, Silva S, Putrino SM, Pereira ASC (2005). Performance and carcass characteristics of steers fed with diets containing different sources of lipids, Braz. J. Anim. Sci. 34:1651-1658.

Andrade EN, Polizel Neto A, Roça RO, Faria MH, Resende FD, Siqueira GR, Pinheiro RSB (2014). Beef quality of young Angus × Nellore cattle supplemented with rumen-protected lipids during rearing and fatting periods. Meat Sci. 98:591-598.

AOAC (1990). Association of Official Analytical Chemists. Official methods of analysis (5th ed.). Arlington: AOAC.

Cornell Net Carbohydrate and Protein System – CNCPC (2000). The net carbohydrate and protein system for evaluating herd nutrition and nutrients excretion, Version 4.0, Ithaca.

Costa DPB, Roça RO, Costa QPB, Lanna DPD, Lima ES, Barros WM. (2013). Meat characteristics of Nellore steers fed whole cottonseed. R. Bras. Zootec. 42(3):183-192.

CQBAL 3.0. (2012) Chemical composition feedstuff and Brazilian Guide Ruminant Nutrition Viçosa Federal University- Brazil. (in English).

Fernandes ARM, Sampaio AAM, Henrique W, Oliveira EA, Tullio RR, Perecin D (2008). Characteristics of carcass and meat of bovine animals under different diets in confinement. Brazilian Arquive Vet. Med. Anim. Sci. (in English) 60:139-147.

Hall MB (2000). Calculation of non-structural carbohydrate content of feeds that contain non-protein nitrogen, (University of Florida, Gainesville).

Honikel KO (1998). Reference methods for the assessment of physical characteristics of meat. Meat Sci. Barking. 49(4):447-457.

Labrune HJ, Reinhardt CD, Dikeman ME, Drouillard JS (2008). Effects of grain processing and dietary lipid source on performance, carcass characteristics, plasma fatty acids, and sensory properties of steaks from finishing cattle. J. Anim. Sci. 86(1):167-172.

Luchiari FA (2000). Beef cattle, 1. ed., São Paulo. (in English) 134 pp.

Mancini RA, Ramanathan R (2014). Effects of postmortem storage time on color and mitochondria in beef. Meat Sci. 98:65-70.

Mertens DR (2002). Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beaker or crucibles: collaborative study. J. AOAC Int. 85:1217-1240.

National Research Council – NRC (1996). Nutrient requirements of beef cattle, 7.ed., (National Academic Press, Washington).

National Research Council – NRC (2001). Nutrients requirements of dairy cattle, 7.ed., (National Academy of Sciences, Washington).

Oliveira EA, Sampaio AAM, Henrique W, Pivaro T M, Rosa BL, Fernandes AR M, Rogério MCP, Borges I, Santiago GS, Teixeira DAB (2003). Use of cottonseed in ruminant feed, Veterinary Science and zoology file, UNIPAR. 6:85-90.

Ruviaro CF, Barcellos JOJ, Dewes H (2014). Market-oriented cattle traceability in the Brazilian Legal Amazon. Land Use Policy. 38:104-110.

SAS/STAT (2002). User's Guide for windows environment, version 9.0, (SAS Inst. Inc., Cary).

Savell J, Miller R, Wheeler T, Koohmaraie M, Shackelford S, Morgan B, Calkins C, Miller M, Doleza G, Henning B, Busboom J, West R, Parrish F (2015). Standardized Warner-Bratzler shear force procedures for genetic evaluation. <http://meat.tamu.edu/shearstand.html>. Access in 24 jun 2015.

Shackelford SD, Koohmarie M, Cundiff LV, Gregory KE, Rohrer GA, Savell JW (1994). Heritabilities and phenotypic and genetic correlations for bovine postrigor calpastatin activity, intramuscular fat content, Warner Bratzler shear force, retail product yield, and growth rate. J. Anim. Sci. 72(4):857-863.

Sniffen CJ, O'Connor DJ, Van Soest PJ, Fox DG, Russel JB (1992). A net carbohydrate and protein system for evaluating cattle diets: II: carbohydrate and protein availability. J. Anim. Sci. 70:3562-3577.

Suman SP, Hunt MC, Nair MN, Rentfrow G (2014). Improving beef color

stability: Practical strategies and underlying mechanisms. Meat Sci. 98:490-504.
Van Soest PJ, Robertson JB, Lewis BA (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition, J. Dairy Sci. 74:3583-3597.
Watanabe A, Kamada G, Imanari M, Shiba N, Yonai M, Muramoto T (2015). Effect of aging on volatile compounds in cooked beef. Meat Sci. 107:12-19.