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PRODUCING QUALITY MEAT IS POSSIBLE USING RESOURCES FROM INTEGRATED CROP-LIVESTOCK SYSTEM

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ABSTRACT

The objective of this work was to evaluate the fatty acid (FA) profile of *Longissimus thoracis* (LT) muscle from cattle finished in feedlot, fed with grains and silage produced in an integrated crop-livestock system (ICL). Nellore (IBW = 344.4 ± 30 kg, n = 25) and Angus x Nellore (IBW = 426.5 ± 27 kg, n = 25) crossbred young bulls were used, and the diet had a concentrate: roughage ratio of 65:35. The crossbred animals had higher levels of saturated FA (SFA) (P = 0.05) and lower levels of unsaturated FA (UFA) (P = 0.02) and monounsaturated FA (MUFA) (P = 0.04). There was no significant difference for the concentrations of PUFA, Ω-6, Ω-3, and PUFA/SFA and Ω-6/Ω-3 ratio between the breed compositions (P > 0.05). Nellore produced meat with a better fatty acid profile due to the physiological maturity stage at which this group was slaughtered. The production of quality meat through ICL resources is an interesting strategy for adding value to the system.

Key words: Agricultural system; Beef cattle; Fatty acid profile

INTRODUCTION

Many producers have adopted beef cattle production in a crop-livestock integration system (ICL) to produce grains and animal products with high efficiency. This production system makes it possible to provide a quality diet to the animals throughout the year, as it allows the production of annual crops and grass for livestock exploitation. The system becomes more technified and intensive with beef cattle finished in feedlots, using forages and grains resources from ICL's.

The feedlot is a strategy that can be used in ICL systems through the use of forage resources and grains produced at ICL (SOARES et al., 2018). There are several benefits obtained from this strategy: removal of heavier animals from pastures during the dry season of the year, an increase of the weight gain of animals during the period of lower food supply, reduction in age at slaughter, greater payment to the producers, in addition to carcass and meat quality benefits.

The crossbreed between *B. Taurus* and *B. indicus* animals have frequently been used in beef cattle production systems in Brazil to reduce the age at slaughter, increase carcass weight, and improve body fat deposition and meat quality (LOPES et al., 2012).

There is a growing concern on the part of consumers regarding the excessive consumption of fats, especially saturated fats (LOCKE et al., 2018). However, beef is a source of MUFA such as oleic acid (C18:1, *cis*-9) and polyunsaturated fatty acids (PUFA) such as linoleic (C18:2, Ω-6) and linolenic acid (C18:3, Ω-3) that act to protect the cardiovascular system, as they help to reduce LDL and total cholesterol (BRESSAN et al., 2016; BRIGGS et al., 2017).

The objective of this work was to evaluate the fatty acid (FA) profile of *Longissimus thoracis* (LT) muscle from beef cattle finished in feedlot, fed with grains and silage produced in an integrated crop-livestock system.

MATERIAL AND METHODS

All experimental procedures were approved by the Ethics Committee for Animal Use of the Federal University of Minas Gerais.

The experiment was conducted in the ICL System demonstration unit installed in the experimental field at Embrapa Maize and Sorghum, Sete Lagoas/MG, Brazil. The crops were established in an integrated agricultural and livestock production system in 22 hectares (ha). The crop-livestock system included the rotation of corn and soybeans for grains and corn for silage with a pasture of *Megathyrsus maximum*. The corn used for silage was sown under a no-tillage system in a consortium with the grasses *Urochloa brizantha* and *Megathyrsus maximum*.

The feedlot began between May and June (2017), ending in October (2017). For the feedlot, 50 animals (25 Nellore and 25 Angus x Nellore) with approximately 20 months of age were used, with an initial body weight (IBW) of 344.4 ± 30 kg and 426.5 ± 27 kg to Nellore and crossbred, respectively. The diet contained corn silage (35%), ground corn (54%), soybean grain (5%) and mineral mix (6%), with a concentrate: roughage ratio of 65:35. The animals were fed over 107 (Crossbred) and 128 days (Nellore).

The corn silage, corn grains and soybean used in the diets were produced in the ICL System demonstration unit area. The animals belonged to the same herd and came from the same breeding season. Before the feedlot, the animals were kept on a pasture of *Megathyrsus maximum* with protein and energy supplement intake of 0.2% of body weight. All animals were drenched with an anthelmintic agent before the feedlot start.

In the feedlot, the animals were divided into groups according to the breed composition. They were allocated into collective pens measuring 20 x 12 m, equipped with feed lanes and drinkers. The animals were adapted to the experimental diets for 21 days. They were fed three times per day – at 07, 11, and 16 h. The diet was adjusted daily to maintain 5 to 10% refusals and was formulated to allow for 1.5 kg of average daily weight gain (VALADARES FILHO et al., 2010).

A day before slaughter, animals were weighed after 16 hours fasting period and sent to the commercial slaughterhouse, where they were kept fasting for 24 hours with only *ad libitum* water access. The slaughter was conducted according to humanitarian procedures required by Brazilian legislation, following the official rules of RIISPOA (BRASIL, 1997).

A sample of *Longissimus thoracis* muscle from each animal (n=50) was taken between the 12th and 13th ribs to analyze the FA profile of intramuscular fat. The samples were homogenized in a multiprocessor, and the FA extraction was performed according to the methodology described by Folch et al. (1957). The FA profile determination followed the procedures established by Hartman and Lago (1973).

The analyzes were performed using the statistical analysis software R (R Core Team, 2020). The assumptions of normal distribution of standardized residues were assessed by the Shapiro-Wilk test and by visual analysis of the distribution of residues with a Q-Q graph. The premises of homoscedasticity were evaluated by Bartlett's test and visual analysis of standardized residues. When the assumptions of homoscedasticity were not met, a different variance structure was selected based on the visualization of the residuals as a function of the predictor variables and values predicted by the model. The means were compared by Fisher's test.

RESULTS AND DISCUSSIONS

There were differences between the two breed compositions for the percentage of SFA, UFA, and MUFA (Table 1). The NEL animals had a lower concentration of SFA (P = 0.05) and a higher concentration of both UFA (P = 0.02) and MUFA (P = 0.04) compared to AN animals. However, there was no significant difference for the concentrations of PUFA, Ω-6, and Ω-3 and polyunsaturated/saturated and Ω-6/Ω-3 ratio between the breed compositions ($P > 0.05$).

Ruminal microorganisms strongly influence the FA profile of ruminant meat. Several studies have already reported that the content of FA in beef can be modified, mainly by feeding management and by the diet provided (VAHMANI et al., 2020). Also, distinct genetic groups may present different fat deposition patterns and FA profiles in meat, as some of these groups start fat deposition earlier than others.

Table 1. Means and standard errors of the means of the sum and ratios of fatty acids in the *Longissimus thoracis* muscle from Nellore and Angus x Nellore crossbred young bulls finished in feedlot.

Item	Breed composition		*P*-value
	NEL	AN	
Σ Saturated[1] (%)	41.3 (1.85)	48.4 (3.65)	0.05
Σ Unsaturated[2] (%)	58.7 (2.08)	51.6 (3.88)	0.02
Σ Monounsaturated[3] (%)	51.6 (1.74)	45.4 (3.85)	0.04
Σ Polyunsaturated[4] (%)	7.1 (1.21)	6.2 (1.21)	0.59
Ω-6[5] (%)	5.67 (0.79)	5.35 (0.79)	0.84
Ω-3[6] (%)	0.61 (0.07)	0.50 (0.07)	0.81
Polyunsaturated/saturated	0.17 (0.03)	0.13 (0.03)	0.16
Ω-6/Ω-3	9.3 (0.21)	10.7 (0.21)	0.89

SFA[1] = (C8:0 + C10:0 + C11:0 + C12:0 + C13:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0 + C20:0 + C22:0);

UFA[2] = (C10:1 + C12:1 + C14:1 *cis*-9 + C16:1 *cis*-9 + C17:1 *cis*-9 + C18:1 *trans*-11 + C18:1 *cis*-9 + C18:1 *cis*-11 + C18:1 *cis*-12 + C 18:1 *cis*-13 + C 18:1 *cis*-15 + C18:1 *trans*-16 + C18:2 n-6 + C18:2 *cis*-9, *trans-11*+ C18:3 n-3 + C20:1 + C20:2 n-6 + C20:3 n-6 + C20:4 n-6 + C24:1 + C22:5 n-3);

MUFA[3] = (C10:1 + C12:1 + C14:1 *cis*-9 + C16:1 *cis*-9 + C17:1 *cis*-9 + C18:1 *trans*-11 + C18:1 *cis*-9 + C18:1 *cis*-11 + C18:1 *cis*-12 + C 18:1 *cis*-13 + C 18:1 *cis*-15 + C18:1 *trans*-16 + C20:1 + C24:1);

PUFA[4] = (C18:2 n-6 + C18:2 *cis*-9, *trans-11* + C18:3 n-3 + C20:2 n-6 + C20:3 n-6 + C20:4 n-6 + C22:5 n-3);

Ω-6[5] = (C18:3 n-3 + C22:5 n-3);

Ω-3[6] = (C18:2 n-6 + C20:2 n-6 + C20:3 n-6 + C20:4 n-6).

Generally, animals with higher zebu breed percentages have higher concentrations of PUFA in intramuscular fat due to their fibre composition characteristics and the increase in muscle membranes (ITO et al., 2012). According to Gruffat et al. (2013), discrepancies in PUFA concentrations can be explained by genetic differences in the expression of genes that influences the activity of enzymes involved in FA biosynthesis.

The current recommendations to reduce SFA intake in humans are based on the findings of studies from the mid-20th century, which eluded that dietary SFA causes an increase in total serum and LDL cholesterol and, therefore, increases the risk of CVD (STEINBERG, 2005). More recently, some studies have questioned the current dietary recommendations against consuming SFA and have revealed that SFA intake is not associated with an increased CVD risk (LAWRENCE et al., 2013; PUASCHITZ et al., 2015).

The Ω-3 FA helps prevent various diseases like arthritis, depression, cancer, and even Alzheimer's disease. The Ω-6 FA has some essential functions in blood pressure regulation and circulation to prevent inflammation (KIM et al., 2016). The Ω -6 FA that has been widely studied in the last years is the conjugated linoleic acid (CLA).

Several studies have demonstrated the benefits of CLA in human health. It is a potent anticarcinogenic agent, has anti-diabetic effects, and improves the immune system and bone mineralization. Besides, CLA is found only in animal products, and, therefore, ruminant fat is the richest natural source of these essential AGs (GEBAUER et al., 2015; VAHMANI et al., 2020).

The PUFA/SFA and the Ω-6/Ω-3 ratios are essential indexes to assess the nutritional value of fats for human consumption. PUFA/SFA ratio should be as large as possible since PUFA is the most beneficial to human health. Nevertheless, it must be considered that the meat from ruminants has a lower PUFA/SFA ratio due to the hydrogenating action of ruminal microorganisms.

According to FAO and WHO (2010), the consumption of PUFA should stay between 6 and 11%, with a total intake of Ω-3 varying between 0.5 to 2%, and the input of Ω-6 ranging between 2.5 to 9%. There are no recommendations for the Ω-6/ Ω-3 ratio intake, as long as Ω-6 and Ω-3 are within the recommended.

CONCLUSIONS

The production of quality meat through ICL is an interesting strategy for adding value, increasing income, and intensifying production in rural properties that adopt the integrated crop-livestock system.

Nellore produced meat with a better fatty acid profile due to the physiological maturity stage at which this group was slaughtered.

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REFERENCES

BRASIL. **Decreto n. 30.691** - 5 jul. 1997. Alterado pelos Decretos n. 1.255 - 25 jun. 1962, n. 1.236 - 02 set. 1994, n. 1.812 - 08 Fev. 1996 e n. 2.244 - 04 jun. 1997. Approves the industrial and sanitary inspection regulation for products of animal origin (RIISPOA). Diário Oficial da União, seção I, p. 11.555. Brasília, 5 jul. 1997.

BRESSAN, M. C.; RODRIGUES, E. C.; DE PAULA, M. DO L.; RAMOS, E. M.; PORTUGAL, P. V.; SILVA, J. S.; BESSA, R. B.; DA GAMA, L. T. Differences in intramuscular fatty acid profiles among Bos indicus and crossbred *Bos taurus* × *Bos indicus* bulls finished on pasture or with concentrate feed in Brazil. **Italian Journal of Animal Science**, v.15, n.1, p.10–21, 2016.

BRIGGS, M. A., PETERSEN, K. S., KRIS-ETHERTON, P. M. Saturated fatty acids and cardiovascular disease: Replacements for saturated fat to reduce cardiovascular risk. **Healthcare**, v.5, p.1-29, 2017.

FAO-WHO. **Fats and fatty acids in human nutrition**. Rome: FAO Food and nutrition paper # 91. Report of an expert consultation. Geneva, November 10-14, 2010.

FOLCH, J.; LEES, M.; SLOANE-STANLEY, G. H. A simple method for the isolation and purification of total lipids from animal tissues. **Journal of Biological Chemistry**, v.226, p.497-509, 1957.

GEBAUER, S. K.; DESTAILLATS, F.; DIONISI, F.; KRAUSS, M. R.; BAER, D. J. Vaccenic acid and trans fatty acid isomers from partially hydrogenated oil both adversely affect LDL cholesterol: a double-blind, randomized controlled trial. **The American journal of clinical nutrition**, v.102, n.6, p.1339-1346, 2015.

GRUFFAT, D.; CHERFAOUI, M.; BONNET, M.; THOMAS, A.; BAUCHART, D.; DURAND, D. Breed and dietary linseed affect gene expression of enzymes and transcription factors involved in n-3 long chain polyunsaturated fatty acids synthesis in *Longissimus thoracis* muscle of bulls. **Journal of Animal Science**, v.91, p.3059-3069, 2013.

HARTMAN, L.; LAGO, R. C. Rapid preparation of fatty acid methyl esters from lipids. **Lab Practice**, v.22, p.475-476, 1973.

ITO, R. H.; DO PRADO, I. N.; ROTTA, P. P.; DE OLIVEIRA, M. G.; DO PRADO, R. M.; MOLETTA, J. L. Carcass characteristics, chemical composition and fatty acid profile of longissimus muscle of young bulls from four genetic groups finished in feedlot. **Revista Brasileira de Zootecnia**, v.41, n.2, p.384–391, 2012.

KIM, J. H.; KIM, Y.; KIM, Y. J.; PARK, Y. Conjugated Linoleic Acid: Potential Health Benefits as a Functional Food Ingredient. **Annual Review of Food Science and Technology**, v.7, p.221–244, 2016.

LAWRENCE, G. D. Dietary fats and health: dietary recommendations in the context of scientific evidence. **Advances in Nutrition**, v.4, p.294-302, 2013.

LOCKE, A.; SCHNEIDERHAN, J.; ZICK, S. M. Diets for Health: Goals and guidelines. **American Academy of Family Physicians**, v.97, p.721-728, 2018. Available at: https://www.aafp.org/afp/2018/0601/afp20180601p721.pdf

LOPES, L. S.; LADEIRA, M. M.; RODRIGUES, O.; NETO, M.; RAMOS, M.; VEIGA, P.; PAULINO, R.; CHIZZOTTI, M. L.; GUERREIRO, M. C. Chemical composition and of fatty acids of the muscle longissimus dorsi and backfat of Red Norte and young Nellore bulls. **Revista Brasileira de Zootecnia**, v.41, n.4, p.978–985, 2012.

PUASCHITZ, N. G.; STRAND, E.; NOREKVÅL, T. M.; DIERKES, J.; DAHL, L.; SVINGEN, G. F. T.; ASSMUS, J.; SCHARTUM-HANSEN, H.; ØYEN, J.; PEDERSEN, E. K. R.; DREVON, C. A.; TELL, G. S.; NYGÅRD, O. Dietary intake of saturated fat is not associated with risk of coronary events or mortality in patients with established coronary artery disease. **Journal of Nutrition**, v.145, p.299-305, 2015.

R CORE TEAM. **R:** A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2020. URL https://www.R-project.org/.

SOARES, M. S.; AGUILAR, P. B.; DE OLIVEIRA, F. M.; SILVA, L. G.; DA CRUZ, W. F. G. Produção de bovinos de corte e leite em sistema de integração lavoura-pecuária. **Revista Acadêmica Ciência Animal**, v.16, p.1-13, 2018.

STEINBERG, D. Thematic review series: the pathogenesis of atherosclerosis. An interpretive history of the cholesterol controversy: part II: the early evidence linking hypercholesterolemia to coronary disease in humans. **Journal of Lipid Research**, v.46, p.179-190, 2005.

VAHMANI, P.; PONNAMPALAM, E. N.; KRAFT, J.; MAPIYE, C.; BERMINGHAM, E. N.; WATKINS, P. J.; PROCTOR, S. D.; DUGAN, M. E. R. Bioactivity and health effects of ruminant meat lipids. Invited Review. **Meat Science***,* v.165, 108114, 2020.

VALADARES FILHO, S. C.; MARCONDES, M. I.; CHIZZOTTI, M. L.; PAULINO, P. V. R. **Exigências nutricionais de puros e cruzados** - BR-CORTE. Viçosa: Suprema. 193p. 2010.