South African Journal of Animal Science 2024, VOL 54

SHORT COMMUNICATION

Moderate inclusion of licuri cake (*Syagrus coronate*) in the diet improves the quality of meat from cull cows finished in the feedlot

M. da Conceição Santos[1], F. F. da Silva[1], L. V. Santos[1], T. R. Paixão[1], A. P. Gomes da Silva[1], J. W. Dias Silva[1], W. Y. Sanchez Duenez[2], D. M. de Lima Júnior[3#], R. R. Silva[1]

[1]State University of Southwest Bahia, Itapetinga, Bahia 45700-000, Brazil
[2]Federal University of Viçosa, Viçosa, Bahia 36570-900, Brazil
[3]Rural Federal University of the Semi-arid, Mossoró, Rio Grande do Norte, 59625-900, Brazil

(Submitted 2 October 2023; Accepted 31 May 2024; Published 24 June 2024)

Abstract

This study aimed to evaluate the effect of licuri (*Syagrus coronate*) cake (LC) on the chemical composition, cholesterol content, and fatty acid profile of meat from cull cows finished in a high-grain feedlot. We used 40 Zebu cull cows of 108 months of age and with an initial weight of 318 ± 38.17 kg. The animals were distributed into four treatments in a completely randomized design: control (0 g/kg LC), 50, 100, and 150 g/kg LC in the total dry matter of the total diet, and were confined for 105 d. The inclusion of LC influenced the content of total lipids and total cholesterol of the beef. The inclusion of LC influenced the concentrations of fatty acids (C12:0, C14:0, C14:1, C16:0, and C17:1) in the meat of cull cows. There was an effect of the inclusion of LC on the fatty acids C18:2n6t, C18:2n6, and C18:3n3 of the meat of cull cows finished in the feedlot. The inclusion of up to 50 g/kg LC in the diet of cows provided lower values for the sum (∑) of saturated fatty acids and higher values for ∑ monounsaturated fatty acids in the meat. The ∑ polyunsaturated fatty acids decreased with the inclusion of LC in the diet. We recommend using up to 50 g/kg of licuri cake inclusion in the diet of cull cows finished in the feedlot.

Keywords: meat fatty acids; meat cholesterol; meat fat; *Syagrus coronate*
[#]Corresponding author: juniorzootec@yahoo.com.br

The termination of cull cows in the feedlot is a strategy used worldwide to increase intramuscular fat and improve the acceptability of meat of this animal category (Utama *et al*., 2020; Nchama *et al*., 2022). High grain diets (proportion of concentrate greater than 800 g/kg dry matter) ensure carcass fattening and reduce the confinement period (Alqaisi *et al*., 2021). However, large volumes of grain, which could be used for human food, are employed in these operations (Van Cleef *et al*., 2021). In this context, the use of agroindustry byproducts in the diets of cattle in the feedlot can reduce competition with human food and production costs (Salami *et al*., 2019).

The licuri cake (LC) is a byproduct of the biodiesel agroindustry derived from the extraction of drupe oil from *Syagrus coronata*, a palm tree native to the Caatinga biome and the east coast of Brazil (Guerin *et al*., 2020; Teixeira *et al*., 2022). The LC has high neutral detergent fiber content (474 ± 97 g/kg) and small amounts of ether extract (112 ± 37 g/kg) and crude protein (235 ± 18 g / kg) (Oliveira *et al*., 2022). High levels of NDF and EE are promising in termination diets for cattle (Joy et al., 2016;

URL: http://www.sasas.co.za
ISSN 0375-1589 (print), ISSN 2221-4062 (online)
Publisher: South African Society for Animal Science
http://dx.doi.org/10.4314/sajas.v54i2.08

Warner *et al*., 2020). In addition, LC ether extract is rich in saturated medium-chain fatty acids (C12:0, C14:0, and C16:0), which can interfere with ruminal fermentation and animal performance (Cavalcanti *et al*., 2022). Some studies were conducted to test the effects of LC on the quality of goat (Silva *et al*., 2020), sheep (Costa *et al*., 2018), and steer meat (Silva *et al*., 2022), but the results are vague and somewhat inconclusive. No studies test the effects of LC on the quality of meat from cull cows.

We hypothesized that including up to 150 g/kg of LC in the diet of cull cows fed in feedlot would increase the intramuscular fat of the meat without compromising the fatty acid profile and its nutritional quality. Thus, this study aimed to evaluate the effect of licuri cake (LC) on the chemical composition, cholesterol content, and fatty acid profile of meat from cull cows finished in a high-grain feedlot.

The experiment was conducted according to the standards of the Ethics Committee in Animal Use of the Universidade Estadual do Sudoeste da Bahia (CEUA/UESB), Itapetinga campus, under protocol 108/2015, approved on April 15th, 2015. The field research was conducted in the southwest region of the state of Bahia, Brazil (15º09′07″ S, 40º15′32″ W), at an altitude of 709 m, characterized by a tropical, humid climate according to the Köppen classification, with average annual precipitation of 800 mm and average annual temperature of 27 ºC.

Forty crossbred cows with a mean age of 108 months and a mean live weight of 318 kg ± 38.17 kg were used, tagged, vaccinated, and dewormed. Subsequently, the animals were randomly distributed into a completely randomized design (DIC) of four treatments and ten replicates. The treatments consisted of a diet with the inclusion of 0 (control), 50, 100, or 150 g/kg DM of licuri cake. The cows were confined in partially-covered, collective stalls of 10 m × 10 m with concrete floors, and provided with feeders and drinkers. The experimental period consisted of 120 d, with the first 15 d for the adaptation of animals to diets, facilities, and management and 105 d for data collection.

The diets were formulated according to the NRC (1996) to meet the nutritional requirements for a daily gain of 1.0 kg/day. The animals were fed sugarcane bagasse *in natura* and concentrate in a forage:concentrate ratio of 20:80, which was fed *ad libitum,* divided into two daily meals (07:00 and 16:00, 60% of the total in the morning and 40% in the afternoon), to allow 10% of leftovers (Table 1). Information on the determination of consumption, digestibility, performance, and carcass characteristics can be obtained from Silva *et al*. (2022).

The animals were slaughtered at the end of the experiment in a commercial slaughterhouse in Itapetinga-BA, Brazil, according to the standards established by Normative Instruction #3 of January 17th, 2000, of the Ministry of Livestock, Agriculture, and Supply, following the normal slaughter process of the slaughterhouse.

A cross-section was performed between the 12th and 13th ribs in the right half of the carcass to expose the *Longissimus dorsi* (LD) muscle*.* The 200 g of LD was removed 24 h after death for meat quality analysis. The meat were initially packed with film paper, then with aluminum foil to prevent frostbite, identified and stored individually in plastic bags, and immediately stored at -10 ºC for future analysis. The samples were thawed at room temperature (20 ºC), crushed, homogenized, and analyzed (proximal composition: moisture, mineral matter, and protein; fatty acids; and cholesterol profile).

The moisture, mineral matter, and protein contents were determined according to the AOAC (2012) methodology. Total lipids were determined using the methodology proposed by Bligh & Dyer (1959). Cholesterol in meat was determined according to the methodology described by Saldanha *et al*. (2004). The transesterification of triacylglycerols followed the methodology described by Bannon *et al*. (1982). The fatty acid esters were analyzed using gas chromatography in a Shimadzu GC-2010 Plus chromatograph with a flame ionization detector and an Rt-2560 fused silica capillary column (100 m, 0.25 mm ID). The gas flow rates (White Martins) were 40 mL/min for the carrier gas (H_2), 30 mL/min for the auxiliary gas (N_2), and 400 mL/min for the synthetic air of the flame. The sample split ratio was 90:10. The operating parameters were established after checking the best resolution condition. Injector and detector temperatures were set at 225 and 260 °C, respectively. The column temperature was set at 140 °C for 5 min, followed by a ramp of 3 °C/min until reaching 245 °C for 20 min. The total analysis time was 60 min. Injections were performed in duplicate, with an injection volume of 1.0 µL. The peak areas of fatty acid methyl esters were determined using GCSolution® software.

Table 1 Proportion of the dietary ingredients, chemical composition, and fatty acid profiles of four inclusions of licuri cake fed to cull cows in the feedlot

Item	Licuri cake level (g/kg DM)			
	0	50	100	150
Proportion of ingredients (g/kg DM[1])				
Sugar cane bagasse	200	200	200	200
Ground sorghum grain	693.3	667.2	640.5	623.3
Licuri cake	0.0	54.4	109.1	155.1
Soybean meal	84.2	57.0	28.6	0.0
Sodium bicarbonate	12.0	12.0	12.0	12.0
Mineral salt[2]	4.8	4.8	4.8	4.8
Limestone	5.8	5.4	5.1	4.8
Total	1000	1000	1000	1000
Chemical composition of the diets (g/kg DM)				
Dry matter	706	707	706	706
Crude protein	984	948	906	865
Ether extract	246	296	345	388
NDFcp[3]	254	281	308	330
NDFi[4]	122	135	148	159
NFCcp[5]	571	548	523	506
Lignin	330	430	531	616
TDN[6]	684	681	681	680
Composition of fatty acids (g/100 g FAME)				
Saturated Fatty Acids (SFA)				
C12:0	1.35	1.82	2.87	3.97
C14:0	0.13	0.57	1.35	2.01
C16:0	16.13	15.06	18.23	16.05
C18:0	1.84	2.80	2.34	2.32
Monounsaturated fatty acids (MUFA)				
C14:1	0.02	0.09	0.02	0.02
C16:1	0.43	0.64	0.29	0.49
C18:1 n-9	30.16	31.37	27.04	29.68
Polyunsaturated fatty acids (PUFA)				
C18:2n6c	46.31	44.01	39.58	36.08
C18:3n6	0.15	0.12	0.26	0.25
C18:3n3	1.36	0.73	0.77	1.37
C20:2	0.21	0.14	0.17	0.44
C20:3n6	0.16	0.4	0.28	0.27
C20:4n6	0.93	1.31	4.19	4.25
C20:5n3	0.06	0.05	0.2	0.13
C22:6n3	0.76	0.89	2.41	2.67
ΣSFA	19.45	20.25	24.79	24.35
ΣMUFA	30.61	32.10	27.35	30.19
ΣPUFA	49.94	47.65	47.86	45.46

[1]Dry Matter; [2]Composition: Calcium 140 g, phosphorus 65 g, sodium 148 g, magnesium 5 g, sulphur 12 g, cobalt 107 mg, copper 1550 mg, iodine 150 mg, manganese 1400 mg, nickel 30 mg, selenium 18 mg, zinc 4500 mg, fluorine (maximum) 650 mg; [3]NDF_{CP}, neutral detergent fiber corrected for ash and protein; [4]NDFi, indigestible neutral detergent fiber; [5]NFC_{CP}, non-fibrous carbohydrates corrected for ash and protein; [6]TDN, total digestible nutrients

Fatty acid methyl esters were identified by comparing the retention time of the sample constituents with a mixture of standards of fatty acid methyl esters (Mix C4-C24-18919-1 AMP, Supelco) and by comparing the retention times with the standards of methyl esters containing the c9-t11 and t10-c12 geometric isomers of linoleic acid (O-5632 Sigma, USA) (Ackman, 1972). The quantification of fatty acid methyl esters was based on the normalization of the area (Visentainer & Franco, 2006), the concentration being expressed as the relative percentage of the total fatty acid methyl esters identified. Methodology adapted from Folch *et al*. (1957) was used to extract the fat matter from the forage and concentrate samples. The moisture content was corrected to 80%.

We also calculated the total saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), omegas 3 and 6 (n-3 and n-6, respectively), and the ratios MUFA:SFA, PUFA:SFA, and n-6:n-3, based on the identified fatty acid profiles of each sample.

The nutritional quality of the lipid fraction of meat *in natura* was evaluated using the atherogenicity index (AI) and thrombogenicity index (TI), based on the results obtained for the fatty acids found in the samples. The calculations were performed according to the descriptions of Ulbricht & Southgate (1991). The desirable fatty acids were calculated by adding the acids (C18:0+MUFA+PUFA). After identifying the fatty acids, the Δ^9 desaturase indices were determined according to the equations proposed by Bichi *et al*. (2012) and Malau-Aduli *et al*. (1997).

The data were evaluated using analysis of variance and regression using the Statistical and Genetic Analysis System. The statistical models were chosen according to the significance of the regression coefficients, using the "F " test at a 5% probability and coefficient of determination (R^2), according to the statistical model:

$$Y_{ijk} = \mu + l_i + c_j + t_{k(ij)} + e_{ijk} \quad (1)$$

where Yijk = observed value of the variable; μ = general mean; li = effect of row i; cj = effect of column j; tk (ij) = effect of treatment k; and eijk = random error (residue).

The inclusion of licuri cake (LC) in the diet of cows influenced (P <0.05) the total lipid contents (minimum point estimated with the inclusion of 65.1 g/kg LC and increased (P <0.05) the total cholesterol of the meat (Table 2).

Table 2 Proximal composition and cholesterol content of meat (*Longissimus dorsi*) from cull cows fed licuri cake

	Licuri cake level (g/kg DM)				SEM[1]	P[2]	
	0	50	100	150		L	Q
Moisture, %	70.96	71.55	73.36	71.12	0.52	0.340	0.012[a]
Mineral matter, %	1.15	1.09	1.17	1.06	0.28	0.133	0.316
Protein, %	22.89	22.38	21.49	22.37	0.33	0.110	0.046[b]
Total lipids, %	4.10	4.05	3.03	5.17	0.53	0.472	0.049[c]
Cholesterol, mg/100g	26.38	25.31	31.06	32.04	1.68	0.006[d]	0.772

[1]Standard error of the mean; [2]Significant probabilities at the 5% level for the linear or quadratic model
Regression equations: [a]$y = -0.028x^2 + 0.473x + 70.697$, $R^2 = 0.62$; [b]$y = 0.014x^2 + 0.258x + 22.998$, $R^2 = 0.77$; [c]$y = 0.022x^2 - 0.284x + 4.303$, $R^2 = 0.63$; [d]$y = 0.455x + 25.285$, $R^2 = 0.77$

The inclusion of LC in the diet of cull cows did not produce changes in body weight at slaughter (437.3 ± 6.6 kg), average daily gain (1.12 ± 0.05 kg/day), warm carcass weight (210.9 ± 3.1 kg), and subcutaneous fat thickness (3.15 ± 0.1 mm) (Silva et al., 2022). Therefore, we can attribute the increase in lipid content observed in the meat to the increased intake of ether extract (46% increase in EE between levels of zero and 150 g/kg of LC) from the diet with the inclusion of LC. The increase in cholesterol content can be attributed to the increase in C14:0 and C16:0 fatty acid contents with the inclusion of LC in the diet. According to Smith (2016), saturated fatty acids increase blood cholesterol because they reduce the activity of the LDL-cholesterol receptor.

The inclusion of LC in the diet produced a negative quadratic effect (P <0.05) on the concentrations of capric (C10:0), lauric (C12:0), myristic (C14:0), palmitic (C16:0), linolelaidic (C18:2n6t), alpha-linoleic (C18:3n6), linolenic (C18:3n3), and eicosadienoic (C20:2) and behenic (C22:0) acids of the meat of cull cows confined with high grain diet (Table 3).

Table 3 Fatty acid profile and meat nutritional quality indices (*Longissimus dorsi*) of cull cows fed licuri cake

Fatty acids (g/100g of FAME)	Licuri cake level (g/kg DM)				SEM[1]	P[2]	
	0	50	100	150		L	Q
Saturated Fatty Acids (SFA)							
C10:0	0.09	0.07	0.03	0.08	0.26	0.083	0.000[a]
C12:0	0.11	0.09	0.10	0.17	0.18	0.066	0.020[b]
C14:0	3.18	3.13	2.54	5.14	0.25	0.000	0.000[c]
C15:0	0.11	0.12	0.07	0.10	0.37	0.241	0.327
C16:0	24.45	25.49	22.66	28.81	0.92	0.020	0.010[d]
C17:0	1.05	0.93	1.18	1.08	0.37	0.975	0.429
C18:0	13.82	13.99	15.10	14.16	0.81	0.777	0.749
C20:0	0.51	0.71	0.57	0.54	0.18	0.056	0.077
C22:0	0.05	0.04	0.02	0.04	0.38	0.084	0.013[e]
Monounsaturated fatty acids (MUFA)							
C14:1	1.28	1.26	0.96	1.57	0.16	0.599	0.035[f]
C16:1	2.66	2.54	2.65	2.35	0.31	0.070	0.439
C17:1	0.68	0.67	0.88	0.79	0.13	0.007[g]	0.496
C18:1n9t	0.60	0.53	0.80	0.50	0.15	0.983	0.856
C18:1n9c	46.85	45.90	48.55	41.62	0.94	0.586	0.235
C20:1	0.12	0.11	0.07	0.10	0.13	0.114	0.185
Polyunsaturated fatty acids (PUFA)							
C18:2n6t	0.05	0.04	0.03	0.05	0.34	0.295	0.000[h]
C18:2n6c	1.62	1.59	1.39	1.33	0.17	0.290	0.944
C18:3n6	0.02	0.02	0.01	0.02	0.16	0.979	0.007[i]
C18:3n3	0.65	0.58	0.55	0.69	0.16	0.622	0.025[j]
C18:2c9t11	0.28	0.37	0.27	0.26	0.13	0.466	0.240
C18:2t10c12	0.07	0.09	0.07	0.06	0.16	0.765	0.241
C20:2	0.02	0.02	0.02	0.01	0.19	0.084	0.013[k]
C20:3n6	0.18	0.15	0.18	0.15	0.20	0.938	0.868
C20:4n6	0.58	0.40	0.35	0.22	0.25	0.000	0.021[l]
C20:5n3	0.05	0.06	0.05	0.04	0.36	0.040[m]	0.065
C22:6n3	0.13	0.13	0.14	0.12	0.31	0.941	0.266
Sum and indices of nutritional quality							
SFA[3]	43.37	44.57	42.27	50.12	0.87	0.000	0.001[n]
MUFA[4]	52.98	51.98	54.67	46.93	0.87	0.000	0.001[o]
PUFA[5]	3.65	3.45	3.06	2.95	0.19	0.020[p]	0.974
MUFA:SFA[6]	1.22	1.17	1.29	0.94	0.13	0.001	0.001[q]
PUFA:SFA[7]	0.08	0.08	0.07	0.06	0.15	0.002[r]	0.207
Desirable fatty acids	70.45	69.42	72.83	64.04	0.91	0.061	0.752
Atherogenicity index	0.66	0.69	0.57	1.00	0.29	0.075	0.756
Thrombogenicity index	1.44	1.52	1.37	1.90	0.18	0.245	0.064
h:H[8]	1.94	1.87	2.18	1.45	0.20	0.006	0.001[s]
n-6[9]	2.45	2.20	1.96	1.77	0.18	0.360	0.999
n-3[10]	0.83	0.77	0.74	0.85	0.13	0.804	0.885
n-6:n-3[11]	2.65	2.86	2.65	2.08	0.78	0.072	0.787
Δ^9 desaturase 14	28.08	28.44	26.76	23.39	2.28	0.135	0.580
Δ^9 desaturase 16	9.83	9.20	10.56	7.55	0.48	0.017	0.019[t]
Δ^9 desaturase 18	77.44	76.85	76.57	74.84	1.21	0.100	0.742

[1]Standard error of the mean; [2]Significant probabilities at 5% for the linear or quadratic model. [3]Sum of saturated fatty acids; [4]Sum of monounsaturated fatty acids; [5]Sum of polyunsaturated fatty acids; [6]Monounsaturated fatty acids:saturated fatty acids ratio; [7]Polyunsaturated fatty acids:saturated fatty acids ratio; [8]Hypocholesterolemic: hypercholesterolemic fatty acid ratio; [9]Sum of omega-6 fatty acids; [10]Sum of omega-3 fatty acids; [11]Omega-6:omega-3 ratio. Regression equations: [a]$y = 0.001x^2 - 0.012x + 0.096$, $R^2 = 0.71$; [b]$y = 0.001x^2 - 0.010x + 0.112$, $R^2 = 0.99$; [c]$y = 0.027x^2 – 0.292x + 3.367$, $R^2 = 0.82$; [d]$y = 0.051x^2 - 0.562x + 25.093$, $R^2 = 0.59$; [e]$y = 0.000x^2 - 0.006x + 0.053$, $R^2 = 0.74$; [f]$y = 0.006x^2 - 0.083x + 1.340$, $R^2 = 0.62$; [g]$y = 0.011x + 0.674$, $R^2 = 0.49$; [h]$y = 0.000x^2 - 0.005x + 0.052$, $R^2 = 0.84$; [i]$y = 0.000x^2 - 0.002x + 0.022$, $R^2 = 0.40$; [j]$y = 0.0021x^2 - 0.0297x + 0.6565$, $R^2 = 0.93$; [k]$y = -0.0001x^2 + 0.0009x + 0.020$, $R^2 = 0.93$; [l]$y = - 0.023x + 0.557$, $R^2 = 0.96$; [m]$y = -0.0008x + 0.056$, $R^2 = 0.40$; [n]$y = 0.067x^2 - 0.639x + 44.053$, $R^2 = 0.74$; [o]$y = -0.067x^2 + 0.702x + 52.274$, $R^2 = 0.70$; [p]$Y = -0.050x + 3.651$, $R^2 = 0.96$; [q]$y = -0.003x^2 + 0.031x + 1.188$, $R^2 = 0.69$; [r]$Y = -0.001x + 0.084$, $R^2 = 0.60$; [s]$y = -0.007x^2 + 0.076x + 1.869$, $R^2 = 0.64$; [t]$Y = -0.024x^2 + 0.247x + 9.512$, $R^2 = 0.59$

The increase observed in the contents of C12:0, C14:0, and C16:0 fatty acids and in the sum of saturated fatty acids in beef is possibly due to the increase in these fatty acids in the diet of animals with the inclusion of LC (Bionaz *et al*., 2020). Licuri is an oleaginous palm with oil rich in saturated medium-chain fatty acids (C12:0, C14:0, and C16:0), and the cake still has residual oil after processing (Lisboa *et al*., 2020). However, even with the increase in the contents of these acids in the meat, including LC in the diet did not affect the atherogenicity (AI) and thrombogenicity (TI) indices.

The levels of inclusion of LC in the diet caused a negative quadratic effect (P <0.05) in the sum of saturated fatty acids and a positive quadratic in the sum of monounsaturated fatty acids, with minimum and maximum points estimated at 48.0 and 52.1 g/kg LC in the diet, respectively. The sum of polyunsaturated fatty acids decreased (P <0.05) with the inclusion of LC in the diet of cull cows.

The increase in the sum of saturated fatty acids and the decrease in the sum of polyunsaturated fatty acids is possibly due to changes in ruminal fermentation and kinetics. LC is a food rich in NDF and EE, with a predominance of C16:0 in its lipid fraction (Oliveira *et al*., 2022). The increasing inclusion, greater than 50 g/kg, of this coproduct may have reduced the rate of ruminal disappearance (both by passage and degradation) of the high-grain diet, increasing the ruminal biohydrogenation of polyunsaturated fatty acids (Glasser *et al*., 2008).

Including up to 50 g/kg of licuri cake in the diet elevates monounsaturated fatty acids, reduces saturated fatty acids, and does not influence the nutritional indices of meat from high-grain-fed cull cows. We recommend moderate levels (50 g/kg in dry matter) of inclusion of licuri cake in the diet of cull cows finished in feedlot with high grain diets.

Acknowledgements

The authors would like to thank the Coordination for the Improvement of Higher Education Personnel (CAPES) and the Bahia State Research Support Foundation (FAPESB).

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Santos, M.C.; Silva, F.F.; Santos, L.V.; Paixão, T.R.; Silva, A.P.G.; Peruna, A.B.; Silva, M.L.F.; Silva, J.W.D.; Duenez, W.Y.S.; Devia, D.C.; Lima Júnior, D.M. and Silva, R.R. The first draft of the manuscript was written by Santos, M.C.; Silva, F.F.; Santos, L.V.; Paixão, T.R.; Silva, A.P.G.; Peruna, A.B.; Silva, M.L.F.; Silva, J.W.D.; Duenez, W.Y.S.; Devia, D.C.; Lima Júnior, D.M. and Silva, R.R all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that there are no competing interests.

References

Ackman, R.G., 1982. The analysis of fatty acids and related materials by gas-liquid chromatography. Prog. Chem. Fats other Lipids. 12, 165–284.

Alqaisi, O., Ali H., Al-Abri, M., Johnson, E.H., & Al-Marzooqi, W., 2021. Effect of dietary concentrate content on feed intake, feed efficiency, and meat quality of Holstein steers fattened in a hot environment. Anim. Sci. J. 92, 13547. https://doi:10.1111/asj.13547.

Association of Official Analytical Chemistry - AOAC., 2012. Official Methods of Analysis. Washington, DC, USA, 19th ed.

Bannon, C.D., Craske, JD., Hai, N.T, Harper, N.L., & O' Rourke, K.L., 1982. Analysis of fatty acid methyl esters with high accuracy and reliability. J. Chromatography. A, 247, 63–69. https://doi.org/10.1016/S0021-9673(00)84856-6.

Bichi, E., Toral, P.G., Hervás, G., Frutos, P., Gómez-Cortés, P., Juárez, M., & Fuente, M.A., 2012. Inhibition of Δ9-desaturase activity with sterculic acid: Effect on the endogenous synthesis of cis-9 18: 1 and cis-9, trans-11 18:2 in dairy sheep. J. Dairy Sci. 95, 5242–5252. https://doi.org/10.3168/jds.2012-5349.

Bionaz, M., Vargas-Bello-Pérez, E., & Busato, S., 2020. Advances in fatty acids nutrition in dairy cows: From gut to cells and effects on performance. J. Anim. Sci. Biotechnol. 11, 110. https://doi.org/10.1186/s40104-020-00512-8.

Bligh, E.G., & Dyer, W.J., 1959. A rapid method of total lipid extraction and purification. Canadian J. Biochem. Physi. 37, 911–917. https://doi.org/10.1139/o59-099.

Chloé, G., Julien, S., Rommel, M., Virginie, V., Aldecinei, B.S., Tristan, D.G., James, T.F.M., & Stéphane, D., 2020. Palm seed and fruit lipid composition: Phylogenetic and ecological perspectives. Ann. Bot. 125, 157–172. https://doi.org/10.1093/aob/mcz175.

Cavalcanti, C.P.L., Macedo, T.J.S., Gois, G.C., Menezes, V,G., Monte, A.P.O., Silva, A.D., Silva, D.J.M., Silva, E.O., Araújo, G.G.L., Rodrigues, R.T.S., Wischral, A., Matos, M.H.T., & Queiroz, M.A.A., 2022. Licuri oil improves feedlot performance and modifies ruminal fauna of Santa Inês ewes. Livestock Sci. 265, 105093. https://doi.org/10.1016/j.livsci.2022.105093.

Costa, J.B., Oliveira, R.L., Silva, T.M., Barbosa, A.M., Borja, M.S., Pellegrini, C.B., Oliveira, V.S., Ribeiro, R.D.X., & Bezerra, L.R., 2018. Fatty acid, physicochemical composition and sensory attributes of meat from lambs fed diets containing licuri cake. Plos One. 13, 0206863. https://doi.org/10.1371/journal.pone.0206863.

Van Cleef, E.H.C.B.V., Oliveira, P.S.N., Galati, R.L., Ferreira, D.S., Santos, V.C., Homem Júnior, A.C., Pereira Júnior, S.A.G., Pardo, R.M.P., & Ezequiel, J.M.B., 2021. High concentrate diets with fibrous by-products for feedlot Nellore heifers. Anais Acad. Bras. Cie. 93. https://doi.org/10.1590/0001-3765202120190731.

Glasser, F., Schmidely, P., Sauvant, D., & Doreau, M., 2008. Digestion of fatty acids in ruminants: A meta-analysis of flows and variation factors. 2. C18 fatty acids. Animal. 2, 691–704. https://doi.org/10.1017/S1751731108002036.

Folch, J., Lees, M., & Stanley, G.H.S., 1996. A simple method for the isolation and purification of total lipides from animal tissues. Biological Chem. 226, 497–509.

Joy, F., Górka, P., McKinnon, J.J., Hendrick, S., Burciaga, R.L.O., & Penner, G.B., 2016. Evaluation of a phase-feeding strategy utilizing high-lipid high-fibre byproduct pellets in diets for feedlot steers. Canadian J. Anim. Sci. 96, 232–242. https://doi.org/10.1139/cjas-2015-0152.

Lisboa, M.C., Wiltshire, F.M.S., Fricks, A.T., Dariva, C., Carrière, F., Lima, Á.S., & Soares, C.M.F., 2020. Oleochemistry potential from Brazil northeastern exotic plants. Biochimie. 178, 96–104. https://doi.org/10.1016/j.biochi.2020.09.002.

Malau-Aduli, A.E.O., Siebert, B.D., Bottema, C.D.K., & Pitchford, W.S., 1997. A comparison of the fatty acid composition of triacylglycerols in adipose tissue from Limousin and Jersey cattle. Austral. J. Agricul. Res. 48, 715–722. https://doi.org/10.1071/A96083.

Nchama, C.N.N., Fabro, C., Baldini, M., Saccà, E., Foletto, V., Piasentier, E., Sepulcri, A., & Corazzin, M., 2022. Hempseed by-product in diets of Italian Simmental cull dairy cows and its effects on animal performance and meat quality. Animals. 12, 1014. https://doi.org/10.3390/ani12081014.

Nutrient Requirements of Beef Cattle – NRC., 1996. 7th ed. National Academic Press, Washington, DC, USA, pp 242.

Oliveira, A.B., Silva, F.F., Silva, J.W.D., Carvalho, G.G.P., Santos, L.V., Paixão, T.R., Silva, A.P.G., Souza, S.O., Soares, C., Lima Júnior, D.M., & Silva, R.R., 2022. Inclusion of licuri cake in high-grain diets for steers: Intake, digestibility, carcass characteristics, and meat quality. S. Afri. J. Anim. Sci. 52. http://dx.doi.org/10.4314/sajas.v52i5.04.

Salami, S.A., Luciano, G., O'Grady, M.N., Biondi, L., Newbold, C.J., Kerry, J.P., & Priolo, A., 2019. Sustainability of feeding plant by-products: A review of the implications for ruminant meat production. Anim. Feed Sci. Technol. 251, 37–55. https://doi.org/10.1016/j.anifeedsci.2019.02.006.

Saldanha, T., Mazalli, M.R., & Bragagnolo, N., 2004. Avaliação comparativa entre dois métodos para determinação do colesterol em carnes e leite. Food Sci. Technol. 24, 109–113.

Silva, L.F., Barbosa, A.M., Silva Júnior, J.M., Oliveira, V.S., Gouvêia, A.A.L., Silva, T.M., Lima, A.G.V.O., Nascimento, T.V.C., Bezerra, L.R., & Oliveira, R.L., 2022. Growth, physicochemical properties, fatty acid composition and sensorial attributes from *Longissimus lumborum* of young bulls fed diets with containing licuri cake: Meat quality of bulls fed licuri cake. Livestock Sci. 255, 104775. https://doi.org/10.1016/j.livsci.2021.104775.

Silva, M.L.F., Carvalho, G.G.P., Silva, F.F., Santos, L.V., Santos, M.C., Silva, A.P.G., Danieleto, A.S., Mandinga, T.C.S., Paixão, T.R., Lima Júnior, D.M., & Silva, R.R., 2022. Effect of dietary inclusion of licuri cake on intake, feeding behavior, and performance of feedlot cull cows. Trop. Anim. Health Prod. 54, 1–8. https://doi.org/10.1007/s11250-022-03253-0.

Silva, W.P., Santos, S.A., Cirne, L.G.A., Pina, D.S., Alba, H.D.R., Rodrigues, T.C.G.C., Araújo, M.L.G.M.L., Lima, V.G.O., Galvão, J.M., Nascimento, C.O., Rodrigues, C.S., & Carvalho, G.G.P., 2021. Carcass characteristics and meat quality of feedlot goat kids fed high-concentrate diets with licuri cake. Livestock Sci. 244, 104391. https://doi.org/10.1016/j.livsci.2020.104391.

Smith, S.B., 2016. Marbling and its nutritional impact on risk factors for cardiovascular disease. Korean J. Food Sci. Anim. Res. 36, 435–444. https://doi.org/10.5851/kosfa.2016.36.4.435.

Teixeira, G.L., Ibañez, E., & Block, J.M., 2022. Emerging lipids from Arecaceae palm fruits in Brazil. Molec. 27, 4188. https://doi.org/10.3390/molecules27134188.

Ulbricht, T.L.V., & Southgate, D.A.T., 1991. Coronary heart disease: Seven dietary factors. The Lancet. 338, 985–92. https://doi.org/10.1016/0140-6736(91)91846-M.

Utama, D.T., Kim, Y.J., Jeong, H.S., Kim, J., Barido, F.H., & Lee, S.K., 2020. Comparison of meat quality, fatty acid composition and aroma volatiles of dry-aged beef from Hanwoo cows slaughtered at 60 or 80 months old. Asian-Austral. J. Anim. Sci. 33, 157. https://doi.org/10.5713/ajas.19.0205.

Visentainer, J.V., & Franco, M.R., 2006. Ácidos Graxos em Óleos e Gorduras: Identificação e Quantificação, 1ª Ed. Unicamp, Campinas, SP.

Warner, A.L., Beck, P.A., Foote, A.P., Pierce, K.N., Robison, C.A., Hubbell, D.S., & Wilson, B.K., 2020. Effects of utilizing cotton byproducts in a finishing diet on beef cattle performance, carcass traits, fecal characteristics, and plasma metabolites. J. Anim. Sci. 98. https://doi.org/10.1093/jas/skaa038.