Energy supplementation on meat chemical composition and fatty acids of steers grazing black oat pasture

Suplementação energética sobre a composição química e de ácidos graxos da carne de novilhos terminados em pastagem de aveia preta

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Abstract

This work was carried out to evaluate the meat chemical composition (moisture, ash, crude protein, fat and cholesterol) and fatty acids contents of *Longissimus dorsi* muscle of cuts without and with backfat, of steers grazing black oat pasture split into two treatments: without or with daily energetic supplementation (400 g of cassava meal and 400 g of canola seeds per animal). There was no treatment effect on meat chemical composition. The fatty acids contents were similar between treatments on cuts without backfat. The cuts with backfat of supplemented animals presented lower n-6/n-3 relationship. The *Longissimus dorsi* cholesterol contents were similar to the values described for light meats like chicken and turkey breast. From the fatty acids presented in bovine meat, approximately 15% can be considered as potentially dangerous for the development of human cardiovascular diseases.
Key words: Bovine meat, canola, cassava, fatty Acids, forage

Resumo

O objetivo deste trabalho foi avaliar composição química da carne (umidade, cinzas, proteína bruta, gordura e colesterol) e a composição em ácidos graxos do músculo *Longissimus dorsi* com e sem gordura de cobertura de novilhos terminados em pastagem de aveia preta divididos em dois tratamentos: sem ou com suplementação energética diária (400 g de farinha de mandioca e 400g de canola em grão por animal). Não houve efeito do tratamento sobre a composição química da carne. A composição em ácidos graxos dos cortes sem gordura de cobertura foi semelhante entre os tratamentos. Os animais suplementados apresentaram menor relação n-6/n-3 nos cortes com a gordura de cobertura. Os níveis de colesterol do músculo *Longissimus dorsi* foram semelhantes aos valores descritos para carne magras como peito de frango ou de peru. Dos ácidos graxos presentes na carne bovina, aproximadamente 15% pode ser considerado como potencialmente perigoso para o desenvolvimento de doenças cardiovasculares no homem.
Palavras-chave: Ácidos graxos, canola, carne bovina, forragem, mandioca

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Introduction

Bovine meat has an excellent nutritional quality because it has protein of high biological value, is rich vitamin contents, specially B-complex vitamins and is associated to a high content of minerals, especially iron, present in the meat in high bio availability form (SAUCIER, 1999). Bovine meat contains all the essential amino acids in the right ratio to maintain the needs of the human organism (PENSEL, 1998).

However, bovine meat has been mentioned as one of the factors that may lead to the development of human cardiovascular diseases, obesity, hypertension and cancer, especially due to the presence of saturated fat and cholesterol. However, low fat contents (less than 5% in the muscular portion) and low cholesterol contents (less than 75 mg/100 g) have been observed in bovine meat chemical analyses, achieving from one third to one half of the daily recommended cholesterol intake (JIMÉNEZ-COLMENERO; CARBALLO; COFRADES, 2001).

The bovine meat fat presents approximately 48% of saturated fat and 52% of unsaturated fat (JIMÉNEZ-COLMENERO; CARBALLO; COFRADES, 2001). Since saturated fatty acids are not essential and have been associated to health problems (JIMÉNEZ-COLMENERO; CARBALLO; COFRADES, 2001) bovine meat consumption may be lower due to the search for healthier diets. However, some researches demonstrated that animal diet manipulation has decreased the meat saturated fatty acids proportion.

French et al. (2000), in their work with steers slaughtered at similar slaughter weight and carcass fat, tested different levels of concentrate in the diet. The results showed linear saturated fatty acids decrease and a linear polyunsaturated fatty acids increase of intramuscular fat as the concentrate in the diet decreased. Once forage is rich in polyunsaturated fatty acids (French et al., 2000), steers fed only forages could result in a fat deposition with a higher amount of polyunsaturated fatty acids, which would led to a healthier aliment, with lower saturated fat contents. By the same way, the animal supplementation with seed rich in polyunsaturated fatty acids could result in a meat production with higher proportions of these fatty acids. Petit et al. (1997) demonstrated that the fat of lambs supplemented with canola seeds presented lower palmitic acid (C16:0) and higher linolenic acid (C18:3) proportion when compared to the fat of lambs supplemented with soy seeds.

This works objective was to evaluate the effect of canola seeds and cassava meal supplementation on meat chemical composition, and fatty acids contents of Longissimus dorsi muscle (cuts between 12th and 13th ribs without or with backfat) of steers grazing black oat pasture.

Materials and methods

The experiment was carried out between the months of July and August in a private ranch located in Centenário do Sul, Paraná State, Brazil (22°51'south latitude, 51°33' longitude W-GR).

Twelve Nelore steers were used, with an average initial body weight of 398 kg. The animals were kept in a black oat pasture, and at the beginning of the experiment, they were split into two treatments: black oat pasture without supplementation; black oat pasture with energetic supplementation. The energetic supplement was a mix of 400 g animal^{-1} of canola seeds and 400 g animal^{-1} of cassava meal. The supplement was supplied daily. The canola seeds presented 17% of crude protein and 30% of ethereal extract and the cassava meal presented 2% of crude protein and 80% of starch.

Two black oat pastures (*Avena strigosa* cv. IAPAR 61) were used, in a total area of 4 ha. The pastures were sown in April/30th with a 10 N : 20 P : 20 K fertilizer. Fifty days after, the pasture were fertilized with 50 kg of nitrogen per hectare in the form of urea.

The animals were put in these pastures on July/10th, where they stayed during 28 days. Each

treatmente stayed in each pasture during fourteen days. The management used was the continuous grazing and the stocking rate was of 2.78 AU ha^{-1}. The average forage availability was 1225 kg of dry matter ha^{-1}. The black oat pasture presented average levels of 19% of crude protein and 43% of neutral detergent fiber.

The animals were slaughtered 28 days after the beginning of the supplementation, with an average body weight of 437 kg. Shortly after the slaughter, the carcasses were identified and chilled for 24 hr at 2°C before the *Longissimus dorsi* muscle samples were collected from the area between the 12th and 13th rib. The samples were frozen for future chemical analysis. Four months later, the samples were thawed at ambient temperature and separated in two portions. All backfat was removed from one of the samples, and only the *Longissimus dorsi* muscle was analysed (intramuscular fat). The backfat of the other sample was maintained and analysed along with the muscle portion (intramuscular and subcutaneous fat). These two cuts were grounded and the moisture, ash, crude protein and fat contents were analysed according to the AOAC (1980) methodology.

The cholesterol extraction was made according to the method described by Al-Hasani, Hlavac and Carpenter (1993). The cholesterol quantification was made by a Shimadzu 14A chromatograph, equipped with flame ionisation detector and fused silica capillary column (25 cm x 0.25 mm and 0.20 m of SE-30). The temperatures of the injector, column and detector were of 260, 300 and 300°C, respectively. The gas fluxes were 1.5mL/min for the carrier gas (H_2), 25mL/min for the make-up gas (N_2); 300 mL/min and 30 mL/min for the flame gases, synthetic air and H_2, respectively. The split used was of 1/150. The peak areas were determined by the CG-300 Computing Integrator and the cholesterol identification was made according to the patterns determined by Sigma (USA).

The total fat matter was separated (BLIGH; DYER, 1959) and the lipids were transesterified to form fatty acids methyl esters (ISO, 1978). The fatty acids were analysed on a Shimadzu 14A gas chromatograph equipped with flame ionisation detector and fused silica capillary column (25 cm x 0.25 mm and 0.20 mm of Carbowax 20M). The temperatures of the injector and detector were of 220 and 245°C, respectively. The gas fluxes were of: 1.2mL/min for the carrier gas (H_2), 30mL/min for the make-up gas (N_2); 300 mL/min and 30 mL/min for the flame gases, synthetic air and H_2, respectively. The split used was of 1/100. The peak areas were determined by the CG-300 Computing Integrator. The identification of the main peaks was made according to the patterns determined by Sigma (USA).

The statistical analysis was made using the Statistical and Genetic Analysis System (SAEG, 1983). The Tukey test (5% of probability) was used for means test.

Results and discussion

There was no difference ($P>0.01$) between treatments on meat moisture, ash, crude protein, fat, and cholesterol contents in the cuts without or with backfat (Table 1). Silva et al. (2001) have not detected difference on the meat chemical composition of heifeirs ½ Nelore x ½ Red Angus finished in feedlot during 84 days using as an energetic source the citrus pellets as a gradual corn substitution in the diet.

By the same way, Silva et al. (2002) have not observed difference on the meat chemical composition of heifers ½ Nelore x ½ Limousin finished in feedlot during 84 days receiving a diet with cotton meal or yeast as protein source and corn or cassava meal as energetic source. Therefore, different sources of protein or energy seems have not an influence on cattle *Longissimus dorsi* chemical composition, when the diet levels of protein and energy were similar.

Table 1. Moisture, ash, crude protein and fat percentage (%) and cholesterol contents (mg in 100 g of muscle) of meat without or with backfat of steers finished in black oat pasture without or with energetic supplementation.

	Moisture	Ash	Protein	Fat	Cholesterol
Treatments			Meat without backfat		
Black oat pasture	71.70	0.95	20.46	4.26	41.26
Black oat pasture + supplement	73.29	0.98	20.28	3.67	42.22
Variation Coeficient, %	3.86	4.88	7.01	28.68	19.13
			Meat with backfat		
Black oat pasture	68.24	0.87	18.59	10.50	40.53
Black oat pasture + supplement	66.08	0.81	18.60	11.24	46.59
Coeficient of Variation, %	6.09	10.36	9.43	36.96	12.39

P>0.05

However, Moreira et al. (2003), evaluating different pasture systems, observed higher fat percentage on meat with backfat of steers finished in millet (*Pennisetum americanum)* pasture (15%) when compared to meat with backfat of steers finished in cynodon (*Cynodon plectostachyrus* Pilger) pasture (8% of fat). This was attributed to the higher energy levels in millet when compared to cynodon pasture, which resulted in a higher deposition of the backfat and a higher fat deposition in the cuts with backfat. In this study, although the supplemented steers have received a higher energy level in the diet, there was no difference on the meat fat deposition. This could be attributed to the low supplementation level (0.19% of body weight).

Moreira et al. (2003) did not observed differences on cholesterol *Longissimus dorsi* contents of steers finished in different pasture systems. Rule; Macneil; Short (1997) reported that factors like breed, nutrition, and sex do not affect the cholesterol concentration of bovine skeletal muscle. The present study further confirms that energy supplementation of steers finished in black oat pasture did not alter cholesterol content of *Longissimus dorsi* muscle.

When comparing the cuts without and with backfat, the cuts with backfat presented higher fat and lower moisture, ash and crude protein percentage. However, the cholesterol contents were similar in both cuts evaluated (Table 2). The cut with backfat showed higher fat values because it deposited two types of fat: intramuscular and subcutaneous fat.

The cuts without backfat presented an average value of 3.96% of fat and the cuts with backfat presented an average value of 10.87% of fat. Silva et al. (2001) described values of 4 and 14% of fat in the *Longissimus dorsi* without and with backfat of heifers ½ Nelore ½ Red Angus finished in feedlot. Silva et al. (2002) observed values of 2% of fat in *Longissimus dorsi* muscle without backfat of ½ Nelore ½ Simental heifers finished in feedlot. Moreira et al. (2003) described fat values of 2 and 11% in the *Longissimus dorsi* muscle without and with backfat of steers finished in pasture systems. These results suggest that factors like age, breed, sex or the finishing management can influence the muscle fat deposition.

Table 2. Moisture, ash, crude protein and fat percentage (%) and cholesterol contents (mg in 100 g of muscle) of meat without or with backfat of steers finished in black oat pasture without or with energetic supplementation.

	Moisture	Ash	Protein	Fat	Cholesterol
Without backfat	72.49a	0.96a	20.37a	3.96b	41.74
With backfat	67.15b	0.84b	18.59b	10.87a	43.56
Coeficient of Variation, %	4.81	7.12	7.97	38.00	16.53

Means in the same column followed by different letters are different by Tukey test (P<0.05).

The mean cholesterol level found in the cut without backfat was 41.7 mg in 100 g of muscle and 43.6 mg in 100 g of muscle with backfat. These values were higher than the ones described by Silva et al. (2001) for ½ Nelore ½ Angus heifers (29 and 25 mg in 100 g of muscle without and with backfat) and higher than the ones described by Moreira et al. (2003) for Nelore steers finished in pasture systems (38 and 31 mg in 100 g of muscle with and without backfat). However the level found were similar to the ones observed by Silva et al. (2002) in ½ Nelore ½ Simental and ½ Nelore ½ Limousin heifers (39 mg in 100 g of muscle).

Chizzolini et al. (1999), reviewing the cholesterol levels in different animal meat, described mean cholesterol content of 45 mg in 100 g of swine *Longissimus dorsi*, 43 and 61 mg in 100 g of chicken breast without and with skin, 84 and 85 mg in 100 g of chicken upper leg without and with skin, 44 and 51 mg in 100 g of turkey breast without and with skin. So, the cholesterol contents described in cattle *Longissimus dorsi* muscle (41.74 mg in 100 g of muscle) were similar to the ones described for light meats like turkey or chicken breast without skin.

The *Longissimus dorsi* without backfat fatty acids composition (intramuscular fatty acids) was similar between treatments. However, the *Longissimus dorsi* with backfat fatty acids composition (intramuscular and subcutaneous fatty acids) presented some differences between treatments (Table 3). The steers receiving energetic supplementation presented higher palmitoleic acid (C16:1) percentage and lower n-6/n-3 relationship (Table 3). Regardless the treatment or the cut evaluated, the fatty acids found in higher proportion were the oleic acid (C18:1 – 42%), palmitic acid (C16:0 – 28%) and stearic acid (C18:0 – 15%).

French et al. (2000), analyzing steers finished in pasture, observed 41% of oleic acid in *Longissimus dorsi* without backfat. Silva et al. (2001), studying heifers finished in feedlot, found 41% of oleic acid, 27% of palmitoleic acid and 18% of stearic acid. Silva et al. (2002) also found similar proportion of these fatty acids in heifers finished in feedlot. Prado et al. (2003) described 39, 24, and 16% of oleic, palmitic, and stearic acids for *Longissimus dorsi* muscle of steers finished in pasture systems. Therefore, animals from different finishing system (feedlot or pasture) and from different sex (heifers or steers) presented the majority of fatty acids as oleic, palmitoleic and stearic acids.

The saturated fatty acids consumption is associated with an increase in human serum cholesterol and low-density protein (LDL) concentration, which could result in cardiovascular problems and a negative effect on human health (PENSEL, 1998). However, the oleic acid and the PUFA are correlated to a reducing in the human serum cholesterol levels and an increase in the human serum high density lipoprotein (HDL) (PENSEL, 1998), while the stearic acid appears not to affect cholesterol or LDL serum content, witch will not led to human cardiovascular injurious. The beef meat presented approximately 85% of fatty acid as stearic acid, MUFA and PUFA; which will not represent a fat that could supply fatty acids potentially responsible for cardiovascular diseases.

When comparing the fatty acid composition of cuts without and with backfat, the former presented higher linoleic (C18:2) and linolenic (C18:3) fatty acids proportion, higher PUFA and higher n-6/n-3 relationship (Table 4). Silva et al. (2001) have not observed difference on fatty acid composition when comparing cuts without or with backfat. However, Prado et al. (2003) observed higher PUFA and higher n-6/n-3 relationship for the cuts without backfat.

Table 3. Fatty acids composition (%) of *Longissimus dorsi* muscle, of steers finished in black oat pasture, without (NS) or with (ES) energetic supplementation

	Meat without backfat				Meat with backfat			
Fatty acids	NS	ES	CV[4]	P	NS	ES	CV[4]	P
14:0	3.36	3.35	10.42	P>0.10	3.74	3.31	32.44	P>0.10
15:0	1.12	1.10	35.94	P>0.10	1.24	1.54	32.09	P>0.10
16:0	28.26	28.40	5.00	P>0.10	28.58	26.86	16.35	P>0.10
16:1	3.17	2.90	40.03	P>0.10	3.15b	4.05a	17.93	P<0.05
17:0	2.01	1.44	17.61	P>0.10	2.03	2.18	23.35	P>0.10
18:0	15.00	15.20	15.10	P>0.10	16.28	13.90	16.11	P>0.10
18:1	42.72	42.25	13.50	P>0.10	41.07	44.08	10.16	P>0.10
18:2n-6	1.55	1.79	33.26	P>0.10	1.16	0.87	22.57	P=0.06
18:3n-3	0.89	1.06	39.23	P>0.10	0.71	0.64	12.66	P>0.10
18:4n-3	0.76	0.64	32.73	P>0.10	0.73	0.92	17.53	P=0.06
PUFA[1]	3.15	3.18	25.02	P>0.10	2.85	2.70	9.19	P>0.10
MUFA[2]	46.16	47.84	6.98	P>0.10	45.27	49.34	7.47	P=0.09
SFA[3]	50.70	48.79	5.47	P>0.10	51.88	47.80	6.82	P=0.08
n-6	1.37	1.33	33.26	P>0.10	1.16	0.87	22.52	P=0.06
n-3	1.55	1.63	31.82	P>0.10	1.44	1.56	13.13	P>0.10
PUFA/SFA	0.06	0.06	24.68	P>0.10	0.06	0.06	12.00	P>0.10
n-6/n-3	0.88	0.82	31.65	P>0.10	0.81a	0.56b	24.47	P<0.05

[1]Polyunsaturated fatty acids; [2]Monounsaturated fatty acids; [3]Saturated fatty acids; [4] Coefficient of variation; Means in the same row followed by different letters are different by Tukey test (P<0.05).

Table 4. Fatty acids composition (%) of *Longissimus dorsi* muscle, without or with backfat of steers finished in black oat pasture without and with energetic supplementation.

Fatty acids	Cut without backfat	Cut with backfat	VC[4]	P
14:0	3.35	3.50	25.63	P>0.10
15:0	1.11	1.39	32.70	0.07
16:0	28.33	27.72	16.20	P>0.10
16:1	3.03	3.60	30.13	0.08
17:0	1.72	2.10	21.13	P>0.10
18:0	15.10	14.98	16.58	P>0.10
18:1	42.48	42.57	8.67	P>0.10
18:2n-6	1.35a	1.01b	34.09	0.01
18:3n-3	0.97a	0.67b	36.50	0.04
18:4n-3	0.70	0.83	28.03	P>0.10
PUFA[1]	3.16a	2.77b	15.01	0.02
MUFA[2]	47.00	47.30	7.15	P>0.10
SFA[3]	49.74	49.84	6.79	P>0.10
n-6	1.35a	1.01b	34.09	0.01
n-3	1.59	1.5	17.33	P>0.10
PUFA/SFA	0.06	0.06	15.10	0.02
n-6/n-3	0.85a	0.68b	49.04	0.01

[1]Polyunsaturated fatty acids; [2]Monounsaturated fatty acids; [3]Saturated fatty acids; [4]Variation coefficient; Means in the same row followed by different letters are different by Tukey test (P<0.05).

Marbling fat and lipids present in the cellular membrane forms the intramuscular fat. The cellular membrane is basically made up of phospholipids. Subcutaneous fat is made up of adipose tissue, and its main energy source is in the triacylglycerols form. Once the saturation degree of triacylglycerols is higher than phospolipids (DE SMET et al., 2000), the adipose tissue will have the higher saturated fatty acids proportion, which explains the results that were obtained in this experiment.

Fatty acids composition can alter the flavour and the aroma of the meat. The flavour is positively related to the oleic acid, while the linolenic acid is negatively related to the flavour and aroma of the meat (MANDELL et al., 1998). The oleic:linolenic acid ratio was of 43.79 for the meat without backfat and 63.54 for the meat with backfat, which could explain why most of consumers have a preference for meat with backfat.

Conclusions

The *Longissimus dorsi* cholesterol contents were not influenced by treatments and were similar to the values described for light meats like chicken and turkey breast.

The *Longissimus dorsi* muscle with backfat of steers finished in black oat pasture with energetic supplementation presented lower n-6/n-3 relationship when compared to the *Longissimus dorsi* muscle with backfat of steers finished in black oaot pasture without energetic supplementation.

From the fatty acids presented in bovine meat, approximately 15% can be considered as potentially dangerous for the development of human cardiovascular diseases.

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