DOI: 10.5433/1679-0359.2016v37n4Supl1p2321

Fatty acid profile in meat of culling ewes in different feedlot periods fed diets containing levels of inclusion of linseed

Perfil de ácidos graxos na carne de ovelhas de descarte alimentadas com dietas contendo níveis de inclusão de linhaça, confinadas por diferentes períodos

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Abstract

Linseed plays an important role in animal nutrition as it contains long-chain fatty acids in its composition, which, once absorbed, are incorporated into meat and milk. For evaluate the concentration of fatty acids in the Longissimus dorsi muscle of culling ewes fed diets containing levels of inclusion of linseed, 88 culling ewes were used with an average initial body weight of 37.65 ± 6.98 kg were distributed in a completely randomized design with 12 treatments. Treatments consisted of the interaction between levels of linseed (0, 5, 10, and 15%) and days in feedlot (30, 45, and 60). The most present fatty acids in the composition of the muscle *L. dorsi* were palmitic (27.32 g 100 g^{-1}) and stearic (17.77 g 100 g^{-1}). Saturated acids remained at low levels as the animals were fed greater levels of linseed, demonstrating the importance of introducing quality foods in animal feeding. Oleic acid was the most present monounsaturated fatty acid, with 40 g 100 g^{-1}. Palmitoleic and elaidic fatty acids increased linearly as the linseed inclusion in the diet was increased. Polyunsaturated acids increased with the presence of linseed in the diet. For the linolenic acid (C18: 3n3), the best result was with inclusion of 10% of linseed in the total diet. All groups of animals that received linseed obtained better n6:n3 ratios, which varied from 1.81 to 4.14. The higher CLA values obtained in this study are related to the higher amounts of inclusion of linseed in the sheep diet, varying from 1.15 to 5.72 g 100 g^{-1}. It is recommended culling ewes supplemented with inclusion of 10% linseed, for 60 days in feedlot, because they comprise a larger number of favorable traits regarding to the profile fatty acids of *Longissimus dorsi*.
Key words: Polyunsaturated acid. Saturated acid. CLA. n6:n3.

Resumo

Grãos de linhaça desempenham um papel importante na alimentação dos animais, uma vez que contêm em sua composição, ácidos graxos de cadeia longa que, uma vez absorvidos, são incorporados a carne

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Recebido para publicação 14/07/15 Aprovado em 15/01/16

e ao leite. Para avaliar a concentração de ácidos graxos no músculo *Longissimus dorsi* de ovelhas de descarte alimentadas com linhaça foram utilizadas 88 ovelhas, com peso corporal inicial médio de 37,65 ± 6,98 kg, distribuídas em delineamento inteiramente casualizado em 12 tratamentos. Os tratamentos constavam da interação entre níveis de linhaça (0, 5, 10 e 15%) e dias de confinamento (30, 45 e 60 dias). Os ácidos graxos observados em maior quantidade na composição do músculo *L. dorsi* foram o palmítico (27,32 g 100 g^{-1}) e esteárico (17,77 g 100 g^{-1}). Os ácidos saturados mantiveram-se em baixas concentrações na carne quando os animais foram alimentados com maiores teores de linhaça, demonstrando a importância da introdução de alimentos de qualidade na alimentação de animais. O ácido graxo monoinsaturado em maior quantidade foi o ácido oleico com 40 g 100g^{-1} de ácidos graxos. Os ácidos graxos palmitoléico e elaídico aumentaram linearmente com a inclusão dos grãos de linhaça. Os níveis de ácidos graxos poli-insaturados aumentaram com a presença de grãos de linhaça na ração dieta. Para os ácido linolênico (C18:3n3), o melhor resultado foi com inclusão de 10% de grãos de linhaça na dieta total. Todos os grupos de animais que receberam grãos de linhaça obtiveram melhores proporções de n6:n3, variando entre 1,81 e 4,14. Os maiores valores de CLA obtidos neste trabalho estão relacionados com as maiores taxas de inclusão da linhaça na dieta das ovelhas, variando de 1,15 a 5,72 g 100 g^{-1}. Recomendam-se dietas para ovelhas de descarte com a inclusão de 10% de linhaça por 60 dias em confinamento porque compreenderam um maior número de características favoráveis em relação ao perfil de ácidos graxos no *Longissimus dorsi*.

Palavras-chave: Ácidos graxos poli-insaturados. Ácidos graxos saturados. CLA. n6:n3.

Introduction

Given the important role of meat, its estimated growing consumption over the years and the concerns about its role in human health, many studies have been conducted aimed at improving its lipid composition (MOLONEY et al., 2012; JANDASEK et al., 2014).

In addition to elevating the energy density of the diet, the use of feeds containing lipids inert in the rumen provides better efficiency in the use of energy by ruminants, which may foster improvements in the production of these fatty acids in the end product (milk or meat). Among the sources of good-quality fatty acids are the oilseeds, in which linseed stands out. Linseed has long-chain (unsaturated and saturated) fatty acids in its composition, which enables its passage through the rumen without their being modified, so it can be available for digestion and absorption (SCERRA et al., 2011).

For Jerónimo et al. (2009), ruminant meat can also be a good source of some nutrients, providing benefits to the human health, including some long-chain fatty acids and polyunsaturated fatty acids (PUFA), among which conjugated linoleic acid (CLA) stands out.

The physical and chemical properties of lipids have a direct impact on nutritional characteristics, sensory, and preservation of meat. Furthermore, studies have shown that the branched chain fatty acids with methyl group, is the main source of the characteristic flavor of certain species (MADRUGA et al., 2003), as is the case of sheep.

Excessive consumption, especially saturated fat is considered risk factors for heart disease and diabetes mellitus (NOVELLO et al., 2006). On the other hand, the unsaturated fatty acids (UFA) increase the oxidation potential, which has a direct influence on the shelf life and meat palatability (WOOD et al., 2003). Meats from animals at an advanced age are undervalued because of their sensory properties such as strong aroma and flavor. Linseed as excellent fatty acid composition also provides protein, fiber and energy (CUPERSMID et al., 2012) to improve the productive performance of the animals.

In order to change the lipid profile of sheep meat, the use of supplementation with high levels of polyunsaturated fatty acids is indispensable, observing, concurrently, the feedlot time for a change in the composition. Thus, sheep farmers have the option to step up production and provide quality meat to the market.

The objective of this study was to evaluate the fatty acid profile of culling ewes in different feedlot periods fed diets containing inclusion of levels of linseed.

Materials and Methods

The experiment was conducted in the Universidade Estadual de Maringá (UEM), located in Maringá, PR, Brazil. The study was accepted by the Ethics Committee on Animal Use in Experimentation, under protocol DZO 073/2014 issued by the university itself.

Eighty-eight culling ewes with an average initial body weight of 37.65 ± 6.98 kg were distributed in a completely randomized design with 12 treatments. Treatments consisted of the interaction between levels of linseed (0, 5, 10 and 15%) and days in feedlot (30, 45, and 60), as shown in Table 1. During the experimental period, the animals were housed in covered stalls with slatted suspended floors, containing feed troughs and water bunks. Each group received feed *ad libitum* from their respective treatment. Feed was supplied in the morning (07h30) at the proportion of 3.5% dry matter in relation to the animal's body weight, such that leftovers would be 10%. The diets had a roughage:concentrate ratio of 70:30, recommended by the NRC (2007) for finishing ewes (Table 2). The total diet was pelleted to prevent selection of feeds, and waste.

Table 1. Experimental design.

Feedlot		Proportion of linseed inclusion (%)			
		0	5	10	15
Treatment Days	30	L0-30 (n=7)	L5-30 (n=8)	L10-30 (n=7)	L15-30 (n=6)
	45	L0-45 (n=8)	L5-45 (n=7)	L10-45 (n=7)	L15-45 (n=8)
	60	L0-60 (n=8)	L5-60 (n=7)	L10-60 (n=7)	L15-60 (n=8)

n= number of animals per treatment.

Table 2. Ingredients and chemical composition of the experimental diets.

Item (g kg^{-1} of DM)	Diet (% inclusion of linseed)			
	0	5	10	15
Coast cross hay	208.00	208.70	201.00	209.70
Ground corn	245.10	210.60	200.00	135.10
Soybean hulls	503.20	504.50	490.00	505.2
Soybean meal	43.70	26.20	9.00	0.00
Linseed	0.00	50.00	100.00	150.00
Chemical Composition				
Dry matter	89.00	89.00	90.00	90.00
Crude protein	16.00	16.20	15.76	16.21
Ether extract	3.30	4.62	6.04	7.39
Neutral detergent fiber	60.5	64.36	66.79	72.36
SFA	55.76	54.57	51.5	51.07
MUFA	42.31	44.42	46.1	46.74
PUFA	1.93	1.01	2.4	2.19

SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

The feed samples collected were dried in a forced-ventilation oven for 72h00 at 55 ºC, and then ground in a knife mill with 1 mm sieve. The chemical composition of the diet was determined according to AOAC (2000) methodologies.

Total lipids were extracted using the technique described by Bligh and Dyer (1959). For the transesterification of triacylglycerols, method 5509 from ISO (1978) was adopted, in a solution of n-heptane and KOH methanol^{-1}.

Fatty acid methyl esters were analyzed in a gas chromatograph (Cromatógrafo Trace GC Ultra, ThermoScientific, EUA) autosampler equipped with flame ionization detector at 235 ºC and fused silica capillary column (100 m length, 0.25 mm internal diameter and 0.20 μm df, Restek 2560). The gas flow was 350 mL min^{-1} synthetic air, 35 mL min^{-1} H_2 (carrier gas), and 30 mL min^{-1} N_2 (auxiliary gas). The initial column temperature was set at 165 ºC, held for 8 minutes, raised to 185 ºC at a rate of 4 ºC min^{-1}, held for 4 minutes, reaching 220 ºC final temperature, and then elevated at a rate of 5 ºC min^{-1} and held for 17 minutes. The fatty acids of the sample were quantified by comparison the retention time of the fatty acid methyl esters of standard samples Sigma Aldrich.

The statistical analyses of the studied variables were performed using the PROC MIXED procedure of Statistical Analysis System – SAS software. Supplementation levels, feedlot periods, and their interaction were considered, and initial weight was taken as co-variable.

The data were analyzed according to the following model:

$$Y_{ij} = b0 + b1G1F1 + b2G2F2 + IW + e_{ij}$$

where:

Y_{ij} = observation of the variable studied in animal j, receiving treatment i;

b0 = general constant;

b1 = linear regression coefficient as a function of the variables;

G = level of inclusion of linseed;

F = days in feedlot;

b2 = quadratic coefficient of regression as a function of the variables;

IW = initial weight; and

e_{ij} = random error associated with each observation.

Results and Discussion

In this experiment, the feed conversion of the ewes was determined, and the best results were detected in the treatments with 15% linseed with 30 days for finishing (4.35), and 10% linseed and 30 days for finishing (4.42).

The results for SFA (Table 3) indicated that linseed levels had a significant effect on palmitic, margaric, stearic, and arachidic acids ($p<0.05$). The feedlot days did not influence the saturated fatty acids. Probably the feedlot time was not enough to change this profile. For Moloney et al. (2012), myristic (14:0) and palmitic (16:0) acids may increase the synthesis of cholesterol and promote accumulation of low-density lipoproteins, which represents a risk factor for cardiovascular diseases.

Several researches have claimed that there is a correlation between the intake of saturated fatty acids and serum cholesterol levels in the diet with cardiovascular disease (HOOPER et al., 2012), establishing a reduced consumption of SFA as one of the main sources of dietary advice to reduce these diseases. On the other hand, a few recent research studies state that there is no evidence of this relationship (SKEAFF; MILLER, 2009; SIRI-TARINO et al., 2010), indicating only that an excess of this type of feeding may result in damage to health, especially because of the sedentary lifestyle that most consumers have led in current days.

There is evidence that the presence of a high concentration of myristic acid in sheep and goat meat is responsible for the characteristic flavor or odor, contributing to rancid aromas (MADRUGA et al., 2003). Probably the amount of linseed added to the diet increases the proportion of PUFA on culling ewes meat and thus decreases the volatile compounds of specific aromas that influence the rejection by the consumer. In this study, as more was the inclusion of linseed added in the diets, the lower the amount of palmitic acid (16:0) obtained in the fatty acid profile of the meat, intensifying this information.

Table 3. Saturated fatty acid profile of the *longissimus dorsi* muscle of culling ewes fed diets with levels of linseed for different periods.

Treatment	Saturated fatty acid (g 100 g^{-1})				
	C14:0	C16:0	C18:0	C20:0	C22:0
L0-30	2.87	29.24	19.95	0.46	0.76
L0-45	3.01	28.15	16.58	0.52	0.39
L0-60	3.01	28.51	17.41	0.55	0.43
L5-30	3.28	26.82	15.98	0.77	0.56
L5-45	2.83	26.06	18.36	0.74	0.30
L5-60	2.65	27.04	17.00	0.57	1.04
L10-30	2.87	28.50	15.45	0.95	0.95
L10-45	3.32	27.39	17.64	0.84	0.39
L10-60	3.06	26.62	15.17	0.62	0.56
L15-30	2.29	26.21	17.69	0.96	0.61
L15-45	2.52	26.24	17.77	0.98	0.58
L15-60	2.87	26.68	19.86	0.76	1.29

	Equation	R^2	CV
C14:0	$\hat{Y} = 2.87$	0.84	11.38
C16:0	$Y = 27.3200 - 1.1179x$	0.94	4.07
C17:0	$Y = 0.511 - 0.046x + 0.026x^2 + 0.031y - 0.0003y^2$	0.99	19.75
C18:0	$Y = 17.891 - 0.444x + 0.0307x^2$	0.88	9.16
C20:0	$Y = 0.767 + 0.0257x$	0.97	21.96
C22:0	$\hat{Y} = 0.6539$	n.s.	48.94

C14:0 = myristic acid; C16:0 = palmitic acid; C18:0 = stearic acid; C20:0 = arachidic acid; C22:0 = behenic-docosanoic acid; x = linseed inclusion levels; y = feedlot days.

The SFA observed at highest amounts were palmitic (C16:0) and stearic (C18:0), corroborating Pelegrini et al. (2007), who worked with sheep from the same animal category. Meantime, the same authors, obtained lower values than those presented in this study for palmitic and stearic acids in culling ewes.

According to Willians (2000), stearic acid (C18:0) is considered a neutral acid and does not have any effect on cholesterol, so it cannot be related to cardiac disorders.

For saturated fatty acids of long chain there was a positive linear effect for the arachidic acid (C20:0). For the behenic acid-docosanoic acid (C22: 0), nor supplementation nor the days of feedlot influenced the profile of this acid.

Sheep meat has about 45% of monounsaturated fatty acids in its composition (SENEGALHE et al., 2014). In the results for monounsaturated fatty acids (MUFA; Table 4), the feedlot time not induced the results of this study. The linseed supplementation levels influenced the acids palmitoleic (C16:1n9), palmitoleate (C16:1n7), and cetoleic (C18:1n7).

Table 4. Monounsaturated fatty acid profile of the *longissimus dorsi* muscle of culling ewes fed diets containing levels of linseed for different periods.

Treatment	Monounsaturated fatty acid (g 100 g^{-1})					
	C16:1n-9	C16:1n-7	C16:1n-5	C18:1t-9	C18:1n-9	C18:1n-7
L0-30	0.26	1.76	0.24	1.72	38.22	0.71
L0-45	0.37	2.06	0.41	1.82	42.01	0.71
L0-60	0.31	1.89	0.38	2.07	40.93	0.66
L5-30	0.38	2.31	0.35	5.72	38.61	0.91
L5-45	0.32	1.86	0.35	2.44	41.33	0.85
L5-60	0.25	1.73	0.23	1.15	42.38	0.75
L10-30	0.43	2.20	0.44	2.12	39.68	0.73
L10-45	0.38	1.86	0.35	2.85	39.37	0.49
L10-60	0.30	1.94	0.23	2.91	40.18	0.45
L15-30	0.47	1.86	0.40	2.28	42.35	0.71
L15-45	0.48	1.74	0.41	5.70	36.81	0.81
L15-60	0.41	1.55	0.35	1.98	37.67	0.59

	Equation	R²	CV
C16:1n-9	$\hat{Y} = 0.400 + 0.089x$	0.99	19.75
C16:1n-7	$\hat{Y} = 1.896$	n.s.	15.43
C16:1n-5	$\hat{Y} = 0.345$	n.s.	20.08
C18:1t-9	$\hat{Y} = 3.632 + 0.0929x$	n.s.	10.50
C18:1n-9	$\hat{Y} = 39.99$	n.s.	4.27
C18:1n-7	$\hat{Y} = 0.954 - 0.043x$	0.82	11.52

C16:1n-9 = palmitoleic acid; C16:1n-7= palmitoleate; C16:1n-5 = palmitoleic; C18:1t 9 = elaidic acid; C18:1n-9 = oleic acid; C18:1n-7 = vaccenic acid; x = linseed inclusion levels.

Palmitoleic and palmitoleate acids showed a positive linear effect with the levels of inclusion of linseed for the animals, demonstrating greater contents in those that received a diet with 15% of linseed. Meanwhile, cetoleic acid obtained opposite behavior. So that was added linseed levels, the concentration of this acid decreased.

The MUFA observed at highest amount in this study was oleic acid (C18:1-n9c). According to Pelegrini et al. (2007), one of the main fatty acids present in the *longissimus dorsi* muscle of culling ewes is oleic acid (C18:1-n9c), recognized as a hyperlipidemic acid.

The results for PUFA in the *longissimus dorsi* muscle of culling ewes fed linseed for different periods (Table 5) showed a significant effect in relation to the levels of linseed supplied to the animals.

Linoleic acid had a quadratic response, increasing in the treatments with 5 and 10% of inclusion of linseed. Linoleic acid (C18:2n6) is essential to maintain the cell membranes, brain functions, and nerve impulses under normal conditions (SENEGALHE et al., 2014). Of all the treatments, the best peak was for ewes supplemented with 10% linseed and 60 days of feedlot. Probably, an increased amount of linseed (15%) may have caused toxicity to microorganisms in the rumen, increasing the biohydrogenation process of this acid.

Table 5. Polyunsaturated fatty acid profile in the *longissimus dorsi* muscle of culling ewes fed diets containing levels of linseed for different periods.

	Parameter	
Treatment	C18:2n-6	C18:3n-3
L0-30	2.44	0.31
L0-45	2.46	0.45
L0-60	2.25	0.44
L5-30	2.49	0.83
L5-45	2.61	0.92
L5-60	3.58	0.87
L10-30	3.34	1.44
L10-45	2.83	1.31
L10-60	4.73	2.46
L15-30	2.42	0.78
L15-45	3.06	1.69
L15-60	3.25	1.16
Equation	$\hat{Y} = 3.456 + 0.237x - 0.013x^2$	$\hat{Y} = 0.010 + 0.070x$
R^2	0.82	0.83
CV	22.97	15.14

C18:2 n6 = linoleic acid; C18:3n3 = α-linolenic acid; CV = coefficient of variation; x = linseed inclusion levels.

However, for the acid linolenic acid (C18:3n3) increased linearly with the higher linseed intake. Despite presenting different behavior of linoleic acid, the largest concentration of this acid was similar (10% supplementation of linseed with 60 days feedlot). The linolenic and α-linolenic acid are considered essential, and because they are not produced by animals, it is recommended to supplement them through vegetables (JERÓNIMO et al., 2012). According to Pelegrini et al. (2007), the PUFA located in the cell membranes are precursors of different eicosanoids (prostaglandins, thromboxanes and leuco-trienes), which act as cellular messengers and metabolic regulators, whose specific functions are particularly of great interest in the study of cardiovascular diseases.

Unlike some SFA, the MUFA and PUFA are considered effective in reducing the blood cholesterol level in humans, with a few exceptions. The PUFA are not prone to modification by ruminal microorganisms, which promotes an increased deposition of these fatty acids in the muscle, which in turn improves the nutritional and functional quality of the meat (PONNAMPALAM et al., 2001).

The use of linseed proves to be effective in reducing SFA and increased PUFA in meat of culling ewes. The lowest amounts of SFA were observed at the levels of 5 and 10% of inclusion of linseed, unlike PUFA that showed a linear behavior with the inclusion of linseed (Table 6). The reduction in the concentration of SFA in the *longissimus dorsi* muscle of sheep may promote a healthier meat for human consumption (BANSKALIEVA et al., 2000). The values of PUFA obtained in this study are similar to those observed by Díaz et al. (2011), who analyzed the effect of linseed in sheep meat and obtained an average 3.80 mg 100 g^{-1} of muscle.

Table 6. Proportion of different groups of fatty acids in the *longissimus dorsi* muscle of culling ewes fed diets containing levels of linseed for different periods.

Treatment	Parameter					
	SFA	MUFA	PUFA	PUFA SFA^{-1}	n6 : n3	CLA
L0-30	54.32	42.93	2.75	0.05	7.78	1.72
L0-45	49.72	47.38	2.90	0.06	5.49	1.82
L0-60	51.06	46.25	2.69	0.05	5.12	2.07
L5-30	48.39	48.30	3.32	0.07	2.99	5.72
L5-45	49.33	47.14	3.53	0.07	2.85	2.44
L5-60	49.06	46.49	4.45	0.09	4.14	1.15
L10-30	49.63	45.59	4.77	0.10	2.32	2.12
L10-45	50.57	45.29	4.14	0.08	2.16	2.85
L10-60	46.79	46.01	7.20	0.15	1.92	2.91
L15-30	48.74	48.07	3.20	0.07	3.11	2.28
L15-45	49.14	45.97	4.75	0.10	1.81	5.70
L15-60	52.37	42.55	4.41	0.08	2.80	1.98

	Equation	R^2	CV
SFA	$\hat{Y} = 1.146 + 0.237x - 0.0126x^2$	0.92	12.33
MUFA	$\hat{Y} = -0.216 + 0.2094x - 0.009x^2$	0.89	4.29
PUFA	$\hat{Y} = 4.0091 + 0.1157x$	0.92	7.63
PUFA SFA^{-1}	$\hat{Y} = 0.0808 + 0.1013x - 0.5161x^2$	0.97	21.72
n6:n3	$\hat{Y} = 3.5408 - 0.8219x + 0.3721x^2$	0.90	4.44
CLA	$\hat{Y} = 2.73 + 0.8338x$	0.83	3.21

SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; CLA = conjugated linoleic acid; x = linseed inclusion levels.

For PUFA:SFA ratio, Wood et al. (2003) recommend more than 0.4 g g^{-1} as ideal to prevent diseases associated with the consumption of foods without fat. Lower values were described by Banskalieva et al. (2000) in sheep meat, which ranged from 0.07 to 0.26 which is an outcome attributed mainly to the bio hydrogenation of dietary PUFA by the rumen microorganisms. In this study, this ratio increased as the inclusion of linseed in the diets for the animals was increased. The best amount of this ratio was observed at the level of 10% of inclusion of linseed with 60 days feedlot.

The n6:n3 ratio had a negative quadratic effect with inclusion of linseed in the diets, and better results were found when the levels of 10 and 15% of inclusion of linseed were adopted. This result is the proportional reversal of n6: n3 when added 10% linseed grains in the diet of culling ewes (Table 5).

All groups of animals receiving linseed obtained better results as compared with those which did not receive it: the group that received 15% linseed for 45 days in feedlot averaged 1.81, the group that received 10% linseed for 60 days in feedlot averaged 1.92, while the group without linseed slaughtered at 30 days in feedlot averaged 7.78. Based on animal experimentation, the satisfactory n6:n3 ratio in the meat is 1:1 (WHO, 2003; WOOD et al., 2003), which emphasized the importance of supplying linseed to sheep; the n6:n3 ratio 1.81 obtained here is close to the recommended 1:1 ratio. Among those treatments that showed the best results in the fatty acid profile, the best acceptance in relation to consumption, was the group that received 10% flaxseed for 60 days in confinement. The inclusion of 15% of linseed presented rejection due to excess lipids, which caused a certain rancidity in feed.

Conjugated linoleic acid (CLA) had a positive linear response according to the levels of linseed included in the diet. The highest CLA values in this study were found in the animals that received linseed in their diet. Justifying the inclusion of linseed in diets for culling ewes, CLA is utilized to represent a set of geometric and positional isomers with anti-carcinogenic and antioxidant properties and the ability to reduce the development of the fat tissue in the organism, in addition to acting in the prevention of cardiovascular diseases and diabetes (BLANKSON et al., 2000). This response corroborates Peng et al. (2010), who observed greater amounts of CLA in sheep meat as they increased the lipid supplementation in their diet.

Ewes fed linseed, irrespective of the time in feedlot, showed positive results for the proportions of PUFA in the *longissimus dorsi* muscle, an adequate n6:n3 ratio, and an increased amount of conjugated linoleic acid (CLA). Inclusion of linseed in the feeding of the ewes provided a meat with a fatty acid profile within the recommendations of the World Health Organization (WHO, 2003).

Conclusions

It is recommended culling ewes supplemented with inclusion of 10% linseed, for 60 days in feedlot, because they comprise a larger number of favorable traits regarding to the profile fatty acids of *Longissimus dorsi*.

References

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTIS - AOAC. Official methods of analysis. 13th ed. Arlington: AOAC International, 2000. 989 p.

BANSKALIEVA, V.; SAHLU, T.; GOETSCH, A. L. Fatty acid composition of goat muscles and fat depots: a review. *Small Ruminants Research*, Bloemfontein, v. 37, n. 3, p. 255-268, 2000.

BLANKSON, H.; STAKKESTAD, J. A.; FAGERTUN, H.; THOM, E.; WADSTEIN, J.; GUDMUNDSEN, O. Conjugated linoleic acid reduces body fat mass in overweight and obese humans. *The Journal of Nutrition*, Bethesda, v. 130, n. 12, p. 2943-2948, 2000.

BLIGH, E. G.; DYER, W. J. A rapid method for total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology,* Ottawa, v. 37, n. 8, p. 911-917, 1959.

CUPERSMID, L.; FRAGA, A. P. R.; ABREU, E. S.; PEREIRA, I. R. O. Linhaça: composição química e efeitos biológicos. *e-Scientia*, Belo Horizonte, v. 5, n. 2, p. 33-40, 2012.

DÍAZ, M. T.; CAÑEQUE, V.; SÁNCHEZ, C. I.; LAUZURICA, S.; PÉREZ, C.; FERNÁNDEZ, C.; ÁLVAREZ, I.; DE LA FUENTE, J. Nutritional and sensory aspects of light lamb meat enriched in *n*−3 fatty acids during refrigerated storage. *Food Chemistry*, Reading, v. 124, n. 1, p. 147-155, 2011.

HOOPER, L.; SUMMERBELL, C. D.; THOMPSON, R.; SILLS, D.; ROBERTS, F. G.; MOORE, H. J.; DAVEY, S. G. *Reduced or modified dietary fat for preventing cardiovascular disease* (Review). Bristol: Cochrane Heart Group, 2012. 223 p.

ISO R-937. Meat and meat products - determination of nitrogen content. Method ISO R-937. Geneva: International Organization for Standardization, 1978.

JANDASEK, J.; MILERSKI, M.; LICHOVNIKOVA, M. Effect of sire breed on physico-chemical and sensory characteristics of lamb meat. *Meat Science*, Barking, v. 96, n. 1, p. 88-93, 2014.

JERÓNIMO, E.; ALFAIA, C. M. M.; ALVES, S. P.; DENTINHO, M. T. P.; PRATES, J. A. M.; VASTAM V.; SANTOS-SILVA, J.; BESSA, R. J. B. Effect of dietary grape seed extract and *Cistus ladanifer L.* in combination with vegetable oil supplementation on lamb meat quality. *Meat Science*, Barking, v. 92, n. 4, p. 841-847, 2012.

JERÓNIMO, E.; ALVES, S. P.; PRATES, J. A. M.; SANTOS-SILVA, J.; BESSA, R. J. Effect of dietary replacement of sunflower oil with linseed oil on intramuscular fatty acids of lamb meat. *Meat Science*, Barking, v. 83, n. 3, p. 499-505, 2009.

MADRUGA, M. S.; SOUZA, J. G.; ARRUDA, S. G. B.; NARAIN, N. Carne caprina de animais mestiços: estudos do perfil aromático. *Ciência e Tecnologia de Alimentos,* Campinas, v. 23, n. 3, p. 323-329, 2003.

MOLONEY, A. P.; KENNEDY, C.; NOCI, F.; MONAHAN, F. J.; KERRY, J. P. Lipid and colour stability of M. longissimus muscle from lambs fed camelina or linseed as oil or seeds. *Meat Science*, Barking, v. 92, n. 1, p. 1-7, 2012.

NATIONAL RESEARCH COUNCIL - NRC. Nutrient requirements of small rumiants, Washington, D.C.: National Academy Press. 2007. 362 p.

NOVELLO, D.; FREITAS, R. J. S.; QUINTILIANO, D. A. Teor de Gordura e colesterol na carne suína, bovina e de frango. *Journal Brazilian Society for Food Nutrition*, São Paulo, v. 31, n. 2, p. 103-121, 2006.

PELEGRINI, L. F. V.; PIRES, C. C.; KOZLOSKI, G. V.; TERRA, N. N.; BAGGIO, S. R.; CAMPAGNOL, P. C. B.; GALVANI, D. B.; CHEQUIM, R. M. Perfil de ácidos graxos da carne de ovelhas de descarte de dois grupos genéticos submetidas a dois sistemas de manejo. *Ciência Rural*, Santa Maria, v. 37, n. 6, p. 1786-1790, 2007.

PENG, Y. S.; BROWN, M. A.; WU, J. P.; LIU, Z. Different oilseed supplements alter fatty acid composition of different adipose tissues of adult ewes. *Meat Science*, Barking, v. 85, n. 3, p. 542-549, 2010.

PONNAMPALAM, E. N.; SINCLAIR, A. J.; EGAN, A. R.; BRAKELEY, S. J.; LI, D.; LEURY, B. J. Effect of dietary modification of muscle long-chain n-3 fatty acid on plasma insulin and lipid metabolites, carcass traits, and fat deposition in lambs. *Journal Animal Science*, Champaign, v. 79, n. 3, p. 895-903, 2001.

SCERRA, M.; LUCIANO, G.; CAPARRA, P.; FOTI, F.; CILIONE, C.; GIORGI, A.; SCERRA, V. Influence of stall finishing duration of Italian Merino lambs raised on pasture on intramuscular fatty acid composition. *Meat Science*, Barking, v. 89, n. 3, p. 238-242, 2011.

SENEGALHE, F. B. D.; BURIN. P. C.; FUZIKAWA, I. H. S.; PENHA, D. S.; LEONARDO, A. P. Ácidos graxos na carne e gordura de ovinos. *Enciclopédia Biosfera*, Goiânia, v. 10, n. 18; p. 80-102, 2014.

SIRI-TARINO, P. W.; SUN, Q.; HU, F. B.; KRAUSS, R. M. Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. *The American Journal of Clinical Nutrition*, Bethesda, v. 91, n. 1, p. 535-546, 2010.

SKEAFF, C. M.; MILLER, J. Dietary fat and coronary heart disease: summary of evidence from prospective cohort and randomised controlled trials. *Annals of Nutrition and Metabolism*, Munich, v. 55, n. 1-3, p. 173-201, 2009.

WILLIANS, C. M. Dietary fatty acids human health. *Annales de Zootechnie,* Le Ulis Cedex, v. 49, n. 1, p. 165-180, 2000.

WOOD, J. D.; RICHARDSON, G. R.; NUTE, A. V.; FISHER, A. V.; CAMPO, M. M.; KASAPIDOU, E.; SHEARD, P. R.; ENSER, M. Effects of fatty acids on meat quality: a review. *Meat Science*, Barking, v. 66, n. 1, p. 21-32, 2003.

WORLD HEALTH ORGANIZATION - WHO. Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation. Geneva: WHO Technical Report Series 916, 2003. 160p.