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Orange peel silage in lamb feeding improves meat fatty acid profile

Silagem de bagaço de laranja na alimentação de cordeiros melhora o perfil de ácidos graxos da carne

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Highlights

Orange peel silage in lamb diets increases by 2.5 times the content of Σn-3 in meat.
Orange peel silage in lamb diets increases by 2.5 times the content of CLA in meat.
The replacement level of 66% of orange peel silage by corn is the most recommended.

Abstract

Considering its nutritional quality and low cost compared to traditional foods, the orange peel has been used to replace grains in ruminant diets. This research was developed to evaluate the fatty acid profile of meat from lambs finished with diets containing orange peel silage (OPS) in replacement of corn (0, 33, 66 and 100%). Twenty Santa Inês lambs (five replicates per treatment), approximately five months old and body weight of 25.37 ± 1.94 kg, were distributed in a completely randomized design and the data obtained compared by the Tukey test at 0.05 of significance. There was a linear increase in the concentration of fatty acid capric ($P = 0.026$) and a quadratic increase for palmitic, palmitoleic, stearic, oleic, linoleic, conjugated linoleic (CLA) and α-linolenic acid, saturated, unsaturated, monounsaturated, polyunsaturated, Σn-6, Σn-3 fatty acids and desirable fatty acids in the meat of lambs fed with OPS ($P<0.05$). The replacement of corn by OPS in 66% in the diet of finishing lambs improves the fatty acid profile of the meat.

Key words: Σn-3. By-product. Conjugated linoleic acid. Nutraceutical food. Sheep meat.

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Resumo

Considerando sua qualidade nutricional e baixo custo em relação aos alimentos tradicionais, a casca de laranja vem sendo utilizada em substituição aos grãos na dieta de ruminantes. Esta pesquisa foi desenvolvida para avaliar o perfil de ácidos graxos da carne de cordeiros terminados com dietas contendo silagem de bagaço de laranja (SBL) em substituição ao milho (0, 33, 66 e 100%). Vinte cordeiros Santa Inês (cinco repetições por tratamento), com aproximadamente cinco meses de idade e peso corporal de 25,37 ± 1,94 kg, foram distribuídos em um delineamento experimental inteiramente casualizado e os dados obtidos comparados pelo teste Tukey a 0,05 de significância. Houve aumento linear na concentração do ácido graxo cáprico (P = 0,026) e de forma quadrática (P<0,05) para o palmítico, palmitoleico, esteárico, oleico, linoleico, linoleico conjugado (CLA) e α-linolênico; dos ácidos graxos saturados, insaturados, monoinsaturados, poliinsaturados, Σn-6, Σn-3 e dos ácidos graxos desejáveis na carne de cordeiros alimentados com SBL. A substituição do milho pela SBL em 66% na dieta de cordeiros em terminação melhora o perfil de ácidos graxos da carne.
Palavras-chave: Σn-3. Ácido linoleico conjugado. Alimentos nutracêuticos. Carne ovina. Coprodutos.

Introduction

In animal production systems, feeding is generally responsible for the highest costs and due to this, the use of agroindustry by-products in ruminant feed has been increased constantly (Bezerra et al., 2016; Costa et al., 2018; Lima et al., 2018), considering its nutritional quality and low cost compared to traditional foods (Santos et al., 2015), in addition to being a sustainable destination for these residues (Valença et al., 2016).

Brazil produced 16.7 million tons of oranges in 2020, being the largest producer of the fruit in the world, as well as the largest exporter of orange juice (Wadhwa & Bakshi, 2013) and orange peel, a by-product of orange processing, appears as an interesting alternative source, since its nutritional value for feeding ruminants is similar to conventional grains, with around 7.8% crude protein, 32% neutral detergent fiber, 21% acid detergent fiber, 5.2% ash and 97% in vitro dry matter digestibility (Rego et al., 2012; Valença et al., 2017; Grizotto et al., 2020).

Meat is a protein of high biological value, associated with other essential nutrients such as fat, minerals, and vitamins. Some polyunsaturated fatty acids, such as linoleic (omega-6), linolenic (omega-3) and conjugated linoleic (CLA), essential, found in meat, and not synthesized by humans, are recognized for their many benefits to human health such as obesity, bone health, treatment and control of depression, blood pressure, arteriosclerosis, cardiovascular health, cancer, diabetes, among others (Alabdulkarim, et al., 2012; Simopoulos, 2016; Hartigh, 2019).

The use of alternative foods in sheep production which can improve the lipid components of meat must be evaluated via nutrition, since, in this way, it is possible to manipulate the profile of fatty acids in the muscle, making the meat healthier (Costa et al., 2018; Lima et al., 2018; Valença et al., 2020), reducing the risk of diseases and improving people's quality and life expectancy.

Despite the vast study on the use of orange pell, or pelleted citrus pulp in ruminant feed, as far as is known, there are no studies that investigated the influence of orange pell in sheep feed on the fatty acid profile of the meat. Guzmán et al. (2020), observed improvement in the indices related to the nutritional value of meat for human health (thrombogenicity index, PUFA/SFA ratio and n-6/n-3 ratio) of kids fed milk from goats fed with dry orange pulp. Salzano et al. (2021) included red orange and lemon extract (rich in anthocyanins) in the diet of kids and observed lower concentrations of saturated fatty acids and higher monounsaturated and polyunsaturated fatty acids in the meat of these animals, which also had lower atherogenic and thrombogenic indices compared to animals who did not receive the extract.

Orange peel has complexes such as catechol, dimethoxy phenol, cyclohexane, coumarin, acetic acid, stigmasterol, sitosterol and vitamin E which are accountable for its antioxidant feature (Shanthi, et al., 2019). According to Sir Elkhatim et al. (2018) e Abd El-ghfar et al. (2016) orange peels contain large amounts of flavonoids and vitamin C. Such compounds can impact the ruminal microbiota, consequently affecting the composition of the meat of ruminant animals.

In this context, this research aimed to evaluate the fatty acid profile of the meat of lambs finished with diets containing orange peel silage as corn replacement.

Material and Methods

Location and ethical considerations

The experiment was carried out at the Animal Nutrition Laboratory of the Animal Science Department of the Federal University of Sergipe (UFS), São Cristóvão, Sergipe, and the analysis of fatty acids in animal meat at the Laboratory of Analysis of Food and Animal Nutrition (LANA) of the State University of Maringá (UEM), Maringá, Paraná, both in Brazil. The experiment followed the guidelines set by the Ethics Committee on Animal Use (approval no. 04/12) of Federal University of Sergipe.

Animals, experimental design and diets

Twenty Santa Inês lambs, with approximately five months of age and initial average body weight of 25.37 ± 1.94 kg were used, distributed in a completely randomized design with four treatments, (five replicates per tratament), being these, four levels (0, 33, 66 and 100%) of replacement of ground corn by orange pell silage (OPS). The animals were housed in individual pens with a 2 m2 dirt floor, covered with a solarium and provided with drinking and feeding troughs with unrestricted access to water and experimental diets. At the beginning of the experiment, the animals were identified, subjected to endo and ectoparasite control, immunized against clostridia and randomly distributed among treatments.

The experimental period lasted an average of 60 days, preceded by 10 days for the animals to adapt to the environment, pens, management and diets. The roughage:concentrate ratio was 50:50, consisting of Tifton-85 hay (Cynodon spp.) as roughage, previously ground, and concentrate composed of soybean meal, ground corn grain and OPS replacements (Table 1). Sheep-specific mineral supplementation was offered ad libitum. The diets were provided in two meals, 50% at 7:00 am and the other 50% at 5:00 pm, in order to allow between 10 and 15% of leftovers. The diets were following the recommendations of the National Research Council [NRC] (2007), allowing a daily average weight gain of 200 grams.

Table 1
Commercial product, active ingredient, class of products and doses used in soybean seed treatments

Composition	Orange Peel Silage (%)			
	0	33	66	100
Ingredient proportions (%DM)				
Orange Peel Silage	0.00	11.66	23.33	35.00
Ground corn	35.00	23.33	11.67	0.00
Soybean meal	15.00	15.01	15.01	15.00
Tifton-85 hay	50.00	50.00	50.00	50.00
Chemical composition (%DM)				
Dry matter (% as fed)	84.37	77.10	69.82	66.76
Organic matter	95.16	94.73	94.29	93.86
Crude protein	11.90	11.98	12.05	12.11
Mineral matter	4.83	5.27	5.71	6.14
Neutral detergent fiber	46.33	47.14	47.95	48.76
Acid detergent fiber	19.44	21.63	23.82	26.01
Metabolizable energy (Mcal/kg DM)	2.78	2.86	2.71	1.71

The orange peel was donated by the company Maratá Sucos do Nordeste Ltda, located in Estância, Sergipe, Brazil. Before ensiling, the orange bagasse was placed on a plastic sheet in a 10 cm high layer, where it remained in the sun for six hours, at an average temperature of 28 ºC, being turned every two hours. The silage was made in plastic drums with a capacity of 200 liters, sand was placed in each drum (a layer of five centimeters) to allow the absorption of the slurry generated in the silage and right after a layer of hay to avoid contact of the silage with the sand. After 80 days of ensiling, the silos were opened and silage was offered to the animals, in the established treatments, in the form of a total mixture of the feed.

Chemical analysis

During the feedlot period, samples of ingredients, diets and leftovers were collected and stored in a freezer at -20 ºC and subsequently, before analysis, pre-dried in an oven with forced air circulation at 55 ºC for 72 hours. Then, the samples were ground in a knife mill (Wiley, AH Thomas, Philadelphia, PA, USA) with a sieve of one mm sieves to determine the dry matter (DM), mineral matter (MM), and crude protein (CP) contents (Association of Official Analytical Chemists [AOAC], 2005). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were estimated according to Van Soest (1994).

When they reached slaughter weight, 32 kg of body weight, the animals were submitted to a 16-hour fasting period. At the time of slaughter, the animals were stunned by electronarcosis, which was followed by the bleeding, skinning, and evisceration steps, in accordance with the current procedures provided by the guidelines for human handling, transport and slaughter of livestock (Ministério da Agricultura, Pecuária e Abastecimento [MAPA], 2000). Subsequently, portions of the loins of each animal were lyophilized for 72 hours and then ground in a ball mill to obtain samples for determining the fatty acid profile.

Before reading the fatty acids, the extraction of total lipids from the meat from the Longissimus lumborum muscle was performed using the cold technique described by Bligh and Dyer (1959), which removes the lipid phase from the sample. Then, the transesterification of triacylglycerols was carried out using the method 5509 of International Organization for Standardization [ISO] (1978), in a solution of n-heptane and KOH/methanol. The fatty acid esters were isolated and analyzed in a Shimadzu 14B gas chromatograph, equipped with a flame ionization detector and fused silica capillary column (30 m long, 0.25 mm internal diameter and 0.25 μm Omegawax 250). The gas flows were 1.2 Ml/min for the carrier gas (H2); 30 Ml/min for auxiliary gas (N2) and 30 and 300 Ml/min for H2 and synthetic air, respectively. The initial temperature for the column flame was established at 50°C, maintained for 2 minutes, being then raised to 220°C at a rate of 4°C/minute, remaining for another 25 minutes. The sample split ratio was 1:100. The peak areas were determined by Integrator-Processor CG-300, and the identification by comparison of the retention times with the standards of methyl esters obtained from sigma. Fatty acids were identified by comparing their retention times with the methylated fatty acid standard described previously.

The concentration of desirable fatty acids (DFA) was estimated according to Rhee (1992). The activities of Δ9 desaturases and elongase enzymes was estimated according to Malau-Aduli et al. (1997) and Kazala et al. (1999). Atherogenicity (AI) and thrombogenicity (TI) indices was estimated according to Ulbricht and Southgate (1991). The hypocholesterolemic:hypercholesterolemic index (h:H), as well as the concentrations of hypercholesterolemic, hypocholesterolemic and neutral fatty acids were conducted according to Santos-Silva et al. (2002).

Statistical analysis

A randomized complete design with four treatments and five replicates was adopted. Results were evaluated by variance and regression analyses, in which the degrees of freedom were decomposed into linear or quadratic effects, according to the percentages of OPS. The significance of regressions was obtained by the t test at the 5% probability levels, using SISVAR statistical software (Ferreira, 2011). The following statistical model was used:

$$y_{ij} = \mu + t_i + e_{ij},$$

in which y_{ij} = observed value of the variable that received OPS replacements levels I; μ = overall mean; t_i = effect of substitution level I, being I = 0, 33, 66 e 100%; and e_{ij} = random error associated with each observation.

Results and Discussion

The replacement of ground corn grain by OPS improved ($P < 0.05$) the fatty acid profile of the meat of confined lambs (Table 2). There was a linear increase in capric fatty acid (C10:0; P = 0.026) and a quadratic effect for palmitic (C16:0; P<0.01), stearic (C18:0; P = 0.004), palmitoleic (C16: 1; P = 0.043), oleic (C18:1 n-9; P<0.01), linoleic (C18:2 n-6; P = 0.040), α-linolenic (C18:3 n-3; P = 0.024) and conjugated linoleic (CLA, C18:2 cis-9 trans-11; P = 0.030), in which the highest levels of these fatty acids in meat were observed in diets with 66% OPS.

Table 2
Fatty acid profile (mg/100 g meat) of lamb meat fed levels of orange peel silage in replacement corn

Fatty acid	Orange Peel Silage (%)				SEM[1]	*p-value*[2]	
	0	33	66	100		L	Q
Capric (C10:0)[3]	2.4	3.2	4.8	3.6	0.29	0.026	0.054
Lauric (C12:0)	3.0	5.6	6.3	4.6	0.89	0.542	0.259
Myristic (C14:0)	56.7	80.8	103.0	79.4	7.40	0.168	0.102
Palmitic (C16:0)[4]	570.1	704.8	918.1	733.5	30.20	<0.01	<0.01
Stearic (C18:0)[5]	587.1	698.7	920.3	709.9	35.73	0.017	0.004
Palmitoleico (C16:1 n-7)[6]	46.3	55.4	73.8	59.2	3.39	0.034	0.043
Oleic (C18:1 n-9)[7]	904.2	1158.5	1407.4	1197.8	46.13	<0.01	<0.01
Linoleic (C18:2 n-6)[8]	82.1	106.6	124.8	95.9	6.59	0.291	0.040
CLA (C18:2 cis-9 trans-11)[9]	14.6	25.8	36.1	24.0	2.88	0.105	0.030
α-linolênico (C18:3 n-3)[10]	12.3	16.4	30.2	17.7	2.18	0.067	0.024
Araquidônico (C20:4 n-6)[11]	42.5	42.2	78.1	54.9	4.85	0.050	0.144

[1] SEM = Standard error of the mean; [2]L = Linear e Q = Quadratic; CLA = conjugated linoleic acid; [3]$Y = 2,774 + 0,015x$, $r^2 = 0,46$; [4]$Y = 546,251 + 9,362x - 0,072x^2$, $r^2 = 0,81$; [5]$Y = 559,968 + 9,080x - 0,073x^2$, $r^2 = 0,75$; [6]$Y = 44,182 + 0,711x - 0,005x^2$, $r^2 = 0,77$; [7]$Y = 881,640 + 13,912x - 0,105x^2$, $r^2 = 0,92$; [8]$Y = 80,132 + 1,383x - 0,012x^2$, $r^2 = 0,91$; [9]$Y = 13,529 + 0,645x - 0,005x^2$, $r^2 = 0,90$; [10]$Y = 10,540 + 0,466x - 0,003x^2$, $r^2 = 0,64$; e [11]$Y = 37,691 + 0,745x - 0,005x^2$, $r^2 = 0,47$.

The increase in saturated fatty acids C10:0, C16:0 and C18:0 was due to their high concentration in the by-products of the orange crop used in ruminant feed, which is higher compared to corn grain (Lanza et al., 2015). The fatty acid C10:0, despite being saturated, reduces the energy deficit of the brain, which maintains its proper functioning and cognitive performance. This is because this fatty acid increases the formation of ketone bodies, which allow the transport of energy to peripheral tissues (neurons and gliocytes) (Courchesne-Loyer et al., 2013; Cunnane et al., 2016; Vandenberghe et al., 2017).

Although C16:0 in foods is often considered to have adverse effects on chronic disease in adults (Gilmore et al., 2011), it can be elongated to C18:0, considered neutral. Furthermore, the increased of C16:0 in 61% in the treatment with 66% replacement of corn by OPS; the CLA, C18:3 and C20:4 increased by 147, 146 and 84% respectively for this treatment, these fatty acids being considered beneficial to human health.

The fatty acid C16:1 n-7, the last of the omegas discovered, was recently described as a lipid hormone called lipokine, which is synthesized and secreted by adipocytes and acts on distant target organs by modulating important metabolic and inflammatory processes in body tissues such as muscle, liver and pancreas (Frigolet & Gutiérrez-Aguilar, 2017). In addition, it plays an important role in metabolic and mitochondrial function, increasing cellular energy metabolism and, thus, adipocyte energy expenditure, thus acting in the treatment or prevention of obesity (Cruz et al., 2018).

The increase in unsaturated fatty acids in the meat of the lambs in this research are considered hypocholesterolemic and, therefore, desirable because they contribute to improving the health of human beings (Lage et al., 2020). C18:1 n-9 was the most representative in meat, which is responsible for reducing the content of cholesterol and LDL (low density lipoproteins) and, consequently, in the LDL:HDL ratio (high density lipoproteins) (Negele et al., 2015).

A concentrate-based diet with a high presence of rapidly degradable carbohydrates (such as orange peel) contributes to a shorter food retention time in the rumen and, therefore, a shorter period of action of the bacteria responsible for the biohydrogenation process on fatty acids unsaturated. In addition, diets rich in C18:2, such as corn grain and citrus pulp (Evan et al., 2020), cause a reduction in biohydrogenation due to its inhibitory activity on lipolytic bacteria (Lanza et al., 2015), and this may have contributed to the greater deposition of C18:1 n-9 in animal meat.

According to Salami et al. (2020), diets rich in C18:3, such as the one formulated with citrus pulp, promote an increase in the concentration of CLA in ruminant meat. The accumulation of these intermediates is associated with the concentration of CLA in the milk or tissues of ruminants via absorption of C18:2 cis-9 trans-11 produced in the rumen or by endogenous synthesis carried out in tissues, having C18:1 trans-11 as a precursor (vaccenic acid) by Δ^9 desaturase enzyme activity (Oliveira et al., 2017). Furthermore, when 66% of corn was replaced by citrus pulp, there was possibly an improvement in the ruminal environment, and combined with a greater supply of C18:2 from corn, it contributed to the increase in the CLA content in the meat of the lambs (Lashkari et al., 2017), with a maximum value of 34.33 mg/100g of meat for the level of substitution of ground corn grain by OPS of 64.50%. CLA is recognized for its potential health benefits, acting in the prevention of cancer, diabetes, and coronary artery disease (Chen & Liu, 2020).

The elevation of C18:2 n-6, of the omega 6 family (n-6), which is also a precursor of CLA via ruminal biohydrogenation (Buccioni et al., 2012), also occurred due to vaccenic desaturation (Lanza et al., 2015), which was observed by Solomon et al. (2000) when detecting a higher concentration of vaccinia in the milk of cows where the pulp replaced corn. Furthermore, the C18:2 n-6 probably provided the increase in the C18:3 n-3 (Buccioni et al., 2012).

There was a quadratic effect for the concentrations of fatty acids in meat (P<0.01) (Table 3), showing that the increase in saturated fatty acids (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) were sufficient to change its concentrations. Likewise, there was a quadratic increase (P<0.05) for the desirable fatty acids (DFA), with a maximum value of 2592.9 mg/100g of meat; for the concentrations of fatty acids of the n-3 families (maximum value of 30.20 mg/100g of meat) and n-6 (maximum value 202.9 mg/100g of meat), both for the replacement level of 66 %. Although the concentrations of SFA, MUFA and PUFA and of the Σn-6 and Σn-3 families have increased due to the replacement of corn by OPS in animal feed, their relationships were not compromised, this fact being attributed to the subtle differences between the sum, which were not high enough to differ statistically.

Table 3
Sums and ratios from fatty acids of lamb longissimus muscle fed with levels of orange peel silage in replacement corn

Fatty acid (mg/100g of meat)	Orange Peel Silage (%)				SEM[1]	*p-value*[2]	
	0	33	66	100		L	Q
Saturated (SFA)[3]	1262.1	1535.5	2030.8	1586.1	65.85	<0.01	<0.01
Unsaturated (UFA)[4]	1059.7	1362.9	1672.6	1394.8	52.09	<0.01	<0.01
Monounsaturated (MUFA)[5]	950.6	1214.0	1481.3	1257.1	48.03	<0.01	<0.01
Polyunsaturated (PUFA)[6]	109.1	148.9	191.3	137.8	10.52	0.126	0.016
UFA:SFA	0.8	0.9	0.8	0.9	0.02	0.768	0.988
MUFA:SFA	0.8	0.8	0.7	0.8	0.02	0.755	0.875
PUFA:SFA	0.1	0.1	0.1	0.1	0.01	0.730	0.351
(C18:0 + C18:1):C16:0	2.6	2.6	2.5	2.6	0.06	0.752	0.841
Desirables[7]	1646.8	2061.7	2592.9	2104.8	80.07	<0.01	<0.01
Σn-3[8]	12.4	16.4	30.2	17.7	1.68	0.067	0.024
Σn-6[9]	124.6	148.8	202.9	150.8	9.24	0.132	0.053
Σn-6: Σn-3	11.1	9.0	7.3	8.9	0.39	0.097	0.091

[1] SEM = Standard error of the mean; [2]L = Linear e Q = Quadratic; [3]$Y = 1203,8 + 20,712x - 0,163x^2$, $r^2 = 0,78$; [4]$Y= 1030,0 + 17,119x - 0,131x^2$, $r^2 = 0,90$; [5]$Y = 925,822 + 14,623x - 0,110x^2$, $r^2 = 0,91$; [6]$Y = 104,202 + 2,495x - 0,021x^2$, $r^2 = 0,86$; [7]$Y = 1589,9 + 26,199x - 0,205x^2$, $r^2 = 0,86$; [8]$Y = 10,540 + 0,466x - 0,003x^2$, $r^2 = 0,64$; e [9]$Y = 117,82 + 2,129x - 0,017x^2$, $r^2 = 0,72$.

The DFA are formed by the MUFA, PUFA and the C18:0. Among the MUFA, oleic is the most representative and, therefore, important in the prevention of diseases in humans (Sales-Campos et al., 2013), in which, in the meat of lambs fed with 66% of OPS it reached 95.01 % of MUFA (Table 2). The PUFA, for the most part, also play considerable roles in preventing various diseases (Zárate et al., 2017). C18:0, despite being an DFA, helps prevent cardiovascular disease and cancer (Senyilmaz-Tiebe et al., 2018). Thus, meat from lambs that were fed with OPS-containing diets and had the highest DFA values becomes beneficial and desirable in a healthy diet.

The increase in linoleic fatty acid (C18:2 n-6), from the series of omega 6 (n-6), which is also a precursor of CLA via ruminal biohydrogenation (Lanza et al., 2015; Salami et al., 2020), probably occurred by the desaturation of vaccenic acid by the enzyme Δ^9 desaturase in lamb tissues (Lanza et al., 2015). Fatty acids from the n-3 and n-6 families are considered essential due to the inability of ruminants to synthesize them (Scollan et al., 2006), in addition, they are important because they are essential to human health (Delgado-Pertíñez et al., 2021; Russell & Bürgin-Maunder, 2012).

There was a reduction (quadratic effect, P = 0.012) in the activity of the enzyme Δ^9 desaturase 16 and an increase (quadratic effect, P<0.01) in the concentration of hypocholesterolemic (h) and hypercholesterolemic fatty acids (Table 4). Despite the reduction in the activity of the enzyme Δ^9 desaturase 16, which is responsible for the transformation of C16:0 into C16:1 (Lopes et al., 2012), its lower activity in the meat of animals in this research was not able to reduce the content of C16:1 (Table 2).

Table 4
Enzymatic active and nutraceutical compounds indices (%) from fatty acids of lamb longissimus muscle fed with levels of orange peel silage in replacement corn

Item	Orange Peel Silage (%)				SEM	*p-value*	
	0	33	66	100		L	Q
Δ^9 desaturase 16[1]	17.1	14.8	11.0	14.1	0.47	0.010	0.012
Δ^9 desaturase 18	60.5	62.6	60.4	62.7	0.92	0.613	0.942
Elongase	70.7	70.9	70.0	70.6	0.55	0.805	0.843
Hypocholesterolemic (Σh)[2,3]	1013.3	1307.4	1598.7	1335.6	50.07	<0.01	<0.01
Hypercholesterolemic (ΣH)[2,4]	626.9	785.6	1021.2	813.0	35.41	<0.01	<0.01
h:H ratio	1.6	1.6	1.5	1.6	0.03	0.907	0.835
Atherogenicity index	0.7	0.7	0.8	0.7	0.02	0.895	0.710
Thrombogenicity index	2.2	2.1	2.2	2.1	0.04	0.527	0.977

SEM = Standard error of the mean; L = Linear e Q = Quadratic; [1]$Y = 17,545 - 0,159x + 0,001x^2$, $r^2 = 0,81$; [2]mg/100g of meat; [3]$Y = 985,842 + 16,407x - 0,126x^2$, $r^2 = 0,91$; [4]$Y = 600,811 + 10,713x - 0,083x^2$, $r^2 = 0,83$.

The increase in the concentration of h and H acids did not compromise the h:H ratio. The h:H ratio in lamb meat up to 2.0 is considered acceptable (Costa et al., 2018) and does not represent a risk to human health (Carneiro et al., 2016; Nudda et al., 2019). The relationship between h and H fatty acids is an index related to the functionality of fatty acids in the metabolism of cholesterol transporting lipoproteins in the blood, in which the type and amount is associated with the onset or prevention of cardiovascular disease (Ulbricht & Southgate, 1991).

Conclusion

The inclusion of 66% of orange peel silage as a replacement for corn on finisher lambs improves fatty acid profile of the meat due to the increased concentration of conjugated linoleic acid and desirable fatty acids, beneficial to human health.

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