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Safflower seed supplementation in lamb feed: effects upon fatty acid profile and quality of meat patty formulations

MITALLY RAYANA C. DE OLIVEIRA, LARISSA ECHEVERRIA, ANTONIO C. MARTINEZ, RAFAEL HENRIQUE T.B. DE GOES, JULIANA SCANAVACCA & BEATRIZ C.B. BARROS

Abstract: The aims of this study were to determine the fatty acid profile of meat from lambs fed with different levels of safflower seed (0%, 7.5%, and 15%) and, also, to compare the characteristics of the meat patties prepared from this lamb meat (LMP) with beef meat patties (BMP). The safflower seed-supplemented diet did not change the contents of polyunsaturated and unsaturated fatty acids, except for C22:1. All meat patty formulations were considered safe for consumption. The values of cooking yield, shrinkage, water absorption index, luminosity (L^*), and redness (a^*) were similar for the LMP and BMP tested. While the safflower seed-supplemented diet did not alter the moisture, ash, and protein levels of LMP, the lipid content was lower than that in BMP. The incorporation of 15% safflower seed into lamb feed contributed to promoting better sensory attributes of the meat patties. Most of the physicochemical properties evaluated were similar among LMP and BMP. However, to improve the sensory properties of the product, dietary supplementation with 15% safflower seed is recommended.

Key words: unsaturated fatty acids, hamburger, cooking properties, composition, sensory attributes.

INTRODUCTION

Meat is an important component of the human diet, providing high-quality nutrients (such as proteins and lipids) and essential micronutrients, including iron, zinc and B vitamins (Boada et al. 2016). Consumers are becoming increasingly aware of the correlation between diet, health, and overall well-being, leading to an increased search for foods with health-promoting properties (De Smet & Vossen 2016). Thus, there is an increasing demand for meat products with low lipid contents and a “healthy” fatty acids (FA) profile. Ruminant meat is a good source of omega (w)-3 polyunsaturated fatty acids (PUFA) and PUFA-biohydrogenation intermediates, including conjugated linoleic acid and *trans*-monounsaturated fatty acids (MUFA), which display potential human health benefits (Chikwanha et al. 2018, Dilzer & Park 2012). Also, FA can enhance the sensory attributes of meat, such as the texture, flavor, and aroma and thereby the overall acceptance of the product (Chikwanha et al. 2018, Watkins et al. 2014).

An animal feed diet can affect the FA composition of the meat and its overall quality (Raes et al. 2004). Among the studies aimed to improve the diet of lambs (Cobellis et al. 2015, Abreu et al. 2019), Kott et al. (2003) verified that feeding of lambs with a supplemented diet containing 6% oil from safflower (*Carthamus tinctorius* L.) seeds positively impacted on the FA profile of meat, resulting in a healthier product. Safflower is considered an oilseed crop. The oil content is variable (27–60%), and it is typically used for cooking and frying, but it is attracting increasing interest as a feedstock for biodiesel. Although safflower oil composition varies greatly, about 90% of the oil is made up of oleic and linoleic acids (Hall 2016).

The rapid expansion of the fast-food market in recent years has caused a considerable increase in the production and consumption of meat products, particularly meat patties (Oliveira et al., 2016). This class of product is of great industrial and economic importance (Angor & Al-Abdullah 2010), and the quality and nutritional value depend on meat type, lean meat content, meat particle size, and the presence of other ingredients (Al-Mrazeeq et al. 2010; Guedes-Oliveira et al. 2016). This study aimed to develop and characterize meat patties produced with meat from lambs fed a diet with different levels of safflower seed (0, 7.5, and 15%) and, also, to investigate the effects of these diets on the FA profile of the lamb meat.

MATERIALS AND METHODS

Management of animals and diets

The lambs used in the present study were obtained from the Animal Breeding Laboratory of Maringa State University, located at the Maringa State University Experimental Farm (Umuarama, Paraná, Brazil). Lambs with an average age of 7 months and a mean body score of 1.5 were housed in sheltered bays. Feeding was given individually (Table I), at three different times throughout the day (08:00, 12:00, and 16:00 h), and at 3.5% of dry matter with respect to the animals' body weight, following the recommendations of the National Research Council (2007). The FA profile of the safflower seed used in the lamb feed at different concentrations (0, 7.5, and 15%) is compiled

Table I. **Proportion of ingredients and chemical composition of lambs fed diet in the confinement period.**

Ingredients	Levels of inclusion of safflower in lamb fed diet [%DM]		
	0	7.5	15
Safflower seed	0.00	7.50	15.00
Corn grain	58.93	54.28	49.63
Soybean meal	16.07	13.22	10.37
Grass hay[1]	20.00	20.00	20.00
Mineral[2]	5.00	5.00	5.00
Chemical composition [$g \cdot kg^{-1}$ DM]			
Dry matter	838.1	871.5	845.1
Crude protein	159.6	155.5	151.8
Fat	24.7	39.7	54.7
Neutral detergent fiber	286.5	310.2	334.5
Acid detergent fiber	114.3	138.8	163.3
Mineral matter	34.3	35.6	36.7

[1]*Cynnodon dactylon* cv. Tifton 85, [2]Guaranteed levels (kg/product): calcium: 120.00 g; phosphorus: 88.00 g; iodine: 75.00 mg; manganese: 1300.00 mg; sodium: 126.00 g; selenium:15.00 mg; sulfur: 12.00 mg; zinc:3630.00 mg; cobalt: 55.50 mg; copper:1530.00 mg; iron: 1800.00 mg.

in Table II. After 60 days of feeding, the lambs were slaughtered in accordance with animal welfare protocols under official inspection by responsible authorities. The carcasses were cooled at 4 °C for 24 h and then boned and frozen.

The ingredients used in the meat patties formulations were obtained from a local market in Umuarama/PR/Brazil. All reagents used in the analyses were analytical grade.

Fatty acid profile of lamb meat

The fatty acid profile of lamb meat was determined according to the recommendations of Hwang & Joo (2017). The lipids were extracted from lamb meat samples using a mixture of chloroform–methanol (2:1, v/v) Transesterification of triglyceride acids was achieved using a solution of n-heptane and KOH/methanol. The grease material (200 mg) was transferred to a 10 mL test tube with a screw lid, to which 2.0 mL of n-heptane were added. The material was agitated until complete solubilization of the fatty matter; then, 2.0 mL of 2 mol/L KOH in methanol were added and the solution was mixed vigorously for 5 min.

The fatty acid analyses were carried out in a gas chromatograph 14-A (Shimadzu Corp., Nakagyoku, Kyoto, Japan) equipped with a flame ionization detector and fused silica capillary column with 100-m length, 0.25-mm inner diameter and 0.20 mm in polisiloquixanocyanoalkyl, CP-Sil 88 (Chrompack, Santa Clara, CA, USA). For recording of the concentrations of fatty acids, the device was coupled to a GC-300 Processor Integrator (CG Scientific Instruments, Woburn, MA, USA). The conditions adopted in the chromatographic separation process were: injector temperature: 250 ºC; column temperature: 165 ºC held for 8 min, increase in intervals of 4 °C until 185 ºC and held for 4 min, and an increase from 185 ºC to 220 ºC, at a rate of 5 ºC/min, which was held for 17 min; detector temperature: 235 ºC; gas flow rate: 30 mL/min (N2); hydrogen: 35 mL/min; synthetic air: 350 mL/min; volume injected: 1.0 mL of each sample. Chromatograph peaks of fatty acids were identified by comparison with retention time using a mixture of Sigma (St Louis, MO, USA) standards, and the nonadecanoic acid (19:0) was

Table II. Fatty acid profile of safflower seed used in the lambs fed diet.

Saturated Fatty acid	[g·kg^{-1} of seed DM]	Unsaturated Fatty acid	[g·kg^{-1} of seed DM]
C 14:0	1.11	C 16:1	0.81
C 15:0	0.52	C 17:1	0.32
C 16:0	54.13	C 18:1	129.31
C 17:0	0.40	C 20:1	2.81
C 18:0	23.91	C 22:1	3.02
C 20:0	4.61	C 24:1	1.51
C 22:0	9.10	C 18:2	764.52
C 24:0	1.71	C 18:3	2.21

DM – Dry matter.

used as internal standard. Quantification of fatty acids was performed using correction factors for peak areas and internal standard based calculations, and the results were expressed in mg/g of tissue.

Meat patties production and characterization

Meat patties were prepared using meat from lambs which received feed containing 0% (control), 7.5% and 15% of safflower seed and other components (Table I), which were named L0, L7.5 and L15, respectively. To compare the results, a formulation was produced with beef meat (BMP). The production followed the normative instruction n° 20, 31/07/2000 of the Ministry of Agriculture Livestock and Food Supply – MAPA (2000). The meat for each formulation was separated, cut and ground into an 8 mm disc. After this step, the ground meat was weighed (65 g) and mixed to the other ingredients – pork fat (6 g), textured soy protein (3 g), ice-cold water (4.8 g), salt (0.82 g), ground white pepper (0.052 g), garlic powder (0.06 g), monosodium glutamate (0.25 g) and dried chives (0.052 g). Then, the meat patties were molded with approximately 80 g of meat each, packaged and frozen at -14 ºC until the moment of analyses. Three batches were produced, totaling 45 meat patties of each formulation.

In order to determine the cooking characteristics of the prepared formulations, their weight and diameter were verified before and after frying. The meat patties were fried in skillet and greased with soybean oil for 8 min. Cooking yield, moisture retention and shrinkage were calculated using the Eq. 1, 2 and 3 (Seabra et al. 2002).

$$\%\ yield = \frac{cooked\ sample}{crude\ sample} \quad \text{(Eq.1)}$$

$$\%\ shrinkage = \frac{crude\ diameter - cooked\ diameter}{crude\ diameter} \quad \text{(Eq.2)}$$

$$\%\ moisture\ retention = \frac{\%\ yield\ x\ \%\ sample\ moisture}{100} \quad \text{(Eq.3)}$$

The water absorption index (WAI) was determined according to Sharma et al. (2011) The pH values of the formulations were measured by immersing a common pH-electrode (Testo 205) into a sample diluted in distilled water. The color characteristics of the sample were defined by the parameters of CIE-Lab, L^* (lightness), $+a^*$ (red) $-a^*$ (green), and $+b^*$ (yellow) $-b^*$ (blue) using the colorimeter Color Reader CR-10, Konica Minolta, with an aperture size of 8 mm and D65 illuminate. This colorimeter was calibrated with a white tile (Y = 93.5, x = 0.3159, y = 0.3324) and three replicate measurements were taken at different positions on measured surface.

The composition of formulations was determined according to AOAC methods: moisture (method 925.09), ashes (method 923.03), proteins (method 920.87) and lipids (method 920.85) (Horwitz & Latimer 2005).

The microbiological parameters required by Brazilian legislation (thermotolerant coliforms, coagulase positive Staphiloccocus and *Salmonella* spp.) were assessed in the formulations following the methodology recommended by the American Public Health Association (2001).

In order to evaluate the sensory acceptance of the meat patty formulations, an acceptance test was applied to a panel of untrained testers (n=100) composed of individuals of both sexes and aged from 16 to 60 years. The meat patty formulations were grilled for about 8 min using 1 mL of vegetable oil. The samples (20 g) were provided in encoded disposable cups to testers in a randomized manner. A structured nine-point hedonic scale was used (9 = like extremely; 8 = like very much; 7 = like moderately; 6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly; 3 = dislike moderately; 2 = dislike very much; 1 = dislike extremely). For purchase intention, a structured five-point scale was used, ranging from 1, which corresponds to “would not buy”, up to 5, which corresponds to “would certainly buy” (Meilgaard et al., 1999). This analysis was approved by the Ethics Committee - COPEP-UEM/CAAE: 66525917.8.0000.0104.

Statistical analysis

All assays were performed in triplicate. Variance analysis (ANOVA) for all results obtained was conducted in a completely randomized design with four treatments to meat patties (L0, L7.5, L15, and BMP) and six animals per treatment. A one-way ANOVA was used to test the effect of diet on fatty acid profile and to obtain standard mean error and *P* value. The one-way ANOVA was followed by Tukey test to the results of characterization of meat patties, being evaluate just the panelists’ scores in the sensory analysis (one session). It was used the level of 5% of significance and Statistica® 8.0 software.

RESULTS AND DISCUSSION

Fatty acid profile of lamb meat

According to the FA composition of the lamb meat (Table III), among the saturated fatty acids (SFA), C14:0 and C17:0 was affected by the addition of safflower seed to the diet of lambs. However, these alterations did not alter the total amount of SFA, as also observed by Kott et al. (2003) who reported a lower value for total SFA (400 mg/g) in meat from lambs fed a diet containing 15% safflower seed than that found in the present work (473.51–475.51 mg/g). Such discrepancies can be due to the composition and proportions of other ingredients used in the diet fed to the lambs. Goes et al. (2017) noted that the addition of sunflower cake to lamb feed influenced the C15:0, C20:0, and C20:3w-6 contents in lamb muscle. According to those authors odd-chain FA, such as C15:0 and C17:0, are unusual lipids in most mammals, but in ruminants, they are synthesized from propionic acid during the fermentation process.

The MUFA data showed that only the content of C22:1 was different ($P<0.05$) among the tested groups, such that the values were 10.4 and 29.7% higher when 7.5 and 15% safflower seed were incorporated into the lamb diet, respectively. These results can be explained by the isomerization and bio hydrogenation of dietary PUFA by microbial enzymes in the rumen (Turner et al. 2015a). Nonetheless, the total MUFA content was similar among all samples (462.81–463.71 mg/g), and oleic acid (C18:1) was the most abundant (435.30–437.30 mg/g), as also reported by Smeti et al. (2018). According to Abreu et al. (2019), the high content of MUFA in lamb meat can promote a hypocholesterolemic effect.

Despite safflower seed presenting high levels of PUFA (Table II), especially linoleic acid (764.80 mg/g), there were no differences ($P>0.05$) in the individual contents of the PUFA, total PUFA, w-3, and w-6, among the groups evaluated. These results are contrary to those obtained by Kott et al. (2003) and Smeti et al. (2018). Hence, it can be inferred that the combination of the ingredients used in lamb feed in this study did not affect the ruminal biohydrogenation, resulting in a similar FA profile irrespective of the amount of included safflower seed. However, Chikwanha et al. (2018) affirmed that in comparison to beef, lamb meat generally has higher amounts of linoleic and linolenic FA, whose consumption is associated with health benefits. As expected, the w-6/w-3 and PUFA/SFA ratios were similar among the treatments ($P>0.05$).

Physicochemical characterization of meat patties

Regarding the cooking properties (Table IV), the tested formulations had similar values ($P>0.05$) for cooking yield, shrinkage, and water

Table III. Fatty acid profile of lamb meat extracts with and without safflower seed-supplemented diet.

Fatty Acids Composition	Safflower seed level (% DM)			SME	*P* value
	0	7.5	15		
Saturated Fatty Acids	**[g·kg^{-1} of tissue]**				
C 10:0	1.08	1.08	1.06	0.13	0.678
C 12:0	1.16	1.21	1.25	0.22	0.122
C 14:0	26.50	27.04	28.00	0.10	0.033*
C 15:0	2.13	2.11	2.23	0.10	0.468
C 16:0	242.64	242.40	243.01	0.11	0.835
C 17:0	14.30	14.70	15.02	0.19	0.039*
C 18:0	186.80	183.90	183.91	0.12	0.257
C 20:0	1.08	1.10	1.10	0.11	0.618
Total[a]	475.69	473.54	475.58	1.20	0.966
Monounsaturated Fatty Acids	**[g·kg^{-1} of tissue]**				
C 14:1	1.05	1.08	1.06	0.100	0.645
C 16:1	15.71	16.33	15.80	0.10	0.429
C 18:1	437.30	437.43	435.30	0.22	0.481
C 20:1	1.03	1.03	1.01	0.11	0.559
C 22:1	7.68	8.48	9.96	0.30	0.010*
Total[a]	462.77	464.02	463.13	0.12	0.885
Polyunsaturated Fatty Acids (%)	**[g·kg^{-1} of tissue]**				
C 18:2 (n-6)	35.30	35.70	35.20	0.10	0.949
C 18:2 (CLA)	4.58	4.61	4.16	0.11	0.168
C 18:3 (n-3)	1.68	1.76	1.76	0.10	0.120
C 20:2	1.05	1.06	1.01	0.10	0.261
C 20:3 (n-3)	14.93	15.30	15.06	0.22	0.704
C 20:3 (n-6)	1.05	1.01	1.05	0.10	0.481
C 20:4	1.95	1.90	1.95	0.11	0.618
C 20:5 (n-3)	1.00	1.10	1.10	0.10	0.369
Total[a]	61.54	62.44	61.29	0.30	0.538
n-3 PUFA	17.60	18.11	17.54	0.20	0.859
n-6 PUFA	38.31	38.60	38.25	0.20	0.950
n-6/n-3	21.70	21.20	21.81	0.21	0.888
PUFA/SFA	1.33	1.34	1.30	0.12	0.581

DM – Dry Matter, SME - Standard Mean Error, PUFA – polyunsaturated fatty acids, SFA – saturated fatty acids, $^*P<0.05$, [a] Based only on fatty acids identified.

absorption index. Seabra et al. (2002) analyzed meat patties prepared from sheep meat containing 2% cassava starch or 2% oat meal and found higher values for cooking yield (727.7 and 759.2g·kg^{-1}, respectively), and lower values for shrinkage (154.7 and 154.5 g·kg^{-1}, respectively) and water absorption (547.4 and 737.8 g·kg^{-1}, respectively) when compared with the present study, which can probably be attributed to the flour addition. The water absorption index denotes the ability of a meat product to retain the water contained in its structure. It is a common technological parameter used in the meat industry, as it is related to the post-slaughter weight loss, as well as the quality and yield of meat and meat products (Hautrive et al. 2008). This index is directly linked to the sensory quality of the meat because the loss of water during the cooking process can reduce the juiciness and tenderness of the meat (Hautrive et al. 2008).

The moisture retention data revealed a lower value (222.8 g·kg^{-1}) for BMP than that found in patties prepared from the meat of lambs fed a diet containing safflower seed at 7.5 and 15%. A similar value was found in beef patty formulations (299.8–431.3 g·kg^{-1}) by Velioglu et al. (2010) who highlighted the importance of high moisture retention during cooking, because meat proteins denature, causing a decrease in water holding capacity, leading to shrinkage of the protein network. This shrinkage exerts a mechanical force between the water and the fibers, and these pressure gradients cause the excess water to be expelled to the surface of the meat (Velioglu et al. 2010). In order to avoid this outcome, the addition of textured soy protein is generally recommended (Velioglu et al. 2010). All the formulations developed in this work contained equal proportions of textured soy protein.

The meat patties had pH values (Table IV) considered acceptable for consumption

Table IV. **Cooking properties, pH, color parameters and composition of meat patty formulations.**

Variable	BMP	L0	L7.5	L15
Cooking yield [g·kg^{-1}]	664.8^{a} ±18.4	629.2^{a}±25.4	598.2^{a}±31.4	595.6^{a}±18.1
Shrinkage [g·kg^{-1}]	190.4^{a}±14.1	193.1^{a}±19.2	200.0^{a}±20.2	215.9^{a}±15.0
WAI [g·kg^{-1}]	972.2^{a}±1.0	971.4^{a}±1.9	973.7^{a}±1.4	974.2^{a}±1.7
Moisture retention [g·kg^{-1}]	222.8^{a}±6.5	233.2^{ab}±5.2	240.3^{b}±6.6	240.8^{b}±3.9
pH	6.05^{b}±0.03	5.88^{d}±0.01	6.17^{c}±0.01	6.32^{a}±0.01
L*	52.49^{a}±1.82	53.58^{a}±1.81	53.55^{a}±1.00	52.72^{a}±1.21
a*	10.69^{a}±1.11	10.57^{a}±1.80	8.89^{a}±0.23	9.26^{a}±0.40
b*	7.91^{b}±1.45	11.38^{ab}±1.43	10.65^{a}±1.14	9.33^{ab}±1.00
Moisture [g·kg^{-1}]	675.7^{a}±2.3	680.0^{a}±1.60	691.8^{a}±12.1	699.1^{a}±7.4
Ashes [g·kg^{-1}]	19.8^{a}±1.6	21.7^{a}±0.2	18.5^{a}±1.4	20.0^{a}±1.2
Proteins [g·kg^{-1}]	152.3^{a}±3.9	155.1^{a}±9.8	146.5^{a}±5.5	155.4^{a}±12.9
Lipids [g·kg^{-1}]	151.9^{a}±2.5	97.7^{b}±6.4	93.6^{b}±1.7	103.3^{b}±9.3

BMP – beef meat patties, L0 – lamb meat patties produced from lambs without safflower seed-supplemented diet, L7.5 – lamb meat patties produced from lambs with 7.5% of safflower seed-supplemented diet, L15 - lamb meat patties produced from lambs with 15% of safflower seed-supplemented diet, WAI – water absorption index. Means followed by same letters (same line) did not differ statistically (*P*>0.05) by Tukey test.

of processed meat products (pH 5.80–6.30), according to Florek et al. (2004), Barros et al. (2012) affirmed that many factors could alter the pH of food products, such as the type and quantity of raw materials used in the formulation. It could also be observed that the safflower seed-added lamb diet increased the pH values of the meat patties.

Color, appearance, and presentation of the product are very important for consumers and greatly influence purchasing decisions (Nassu et al. 2012). There was no *L** and *a** color differences (*P*>0.05) among the meat patty formulations (Table IV). Only the formulation L7.5 had a higher value of *b** (yellowness) in comparison to the control formulation (*P*<0.05). These results were interesting because it is desirable that novel functional meat products have similar color characteristics as the conventional alternative. Consistent with the present study, and in line with the consumer preference for bright red beef than purple or brown, Baugreet et al. (2016) found 47.66–51.96 *L** and 111.84–15.35 *a** in fortified beef patties. Similarly, Turner et al. (2015b) observed that the color parameters of meat patties did not change with the steer diet.

From the composition results (Table IV), it was evidenced that all formulations tested had similar values for moisture, ash, and protein (*P*>0.05). Moreover, these values were comparable to those recorded in chicken meat patties by Guedes-Oliveira et al. (2016) of 653.4–656.8 $g \cdot kg^{-1}$ moisture, 30.9–31.9 $g \cdot kg^{-1}$ ash, and 167.3-172.4 $g \cdot kg^{-1}$ protein. The lipid content was higher (*P*<0.05) in BMP (151.9 $g \cdot kg^{-1}$) than in lamb meat patties (93.6–103.3 $g \cdot kg^{-1}$), which amounts to a lipid reduction of roughly 50%. This result is interesting, as consumers tend to demand products with lower lipid content, which consequently have lower energetic values.

Microbiological and sensorial results

All the formulations produced shared similar microbial results, with values of >3 most probable numberg^{-1}, 0 colony forming units$\cdot g^{-1}$, and absence$\cdot$25g^{-1}, for thermotolerant coliforms, coagulase-positive *Staphylococcus* and *Salmonella* spp., respectively. Moreover, these data complied with the limits recognized by Brazilian legislation (ANVISA 2001). Thus, the hygienic-sanitary conditions of the raw materials and processing steps applied in this study contributed to the achievement of safe microbial parameters required for the consumption of food products. The fact that the ingredients used did not negatively affect the microbial parameters is important not only for the food industry but also minimizes microbiological risks to elderly consumers, which tend to be vulnerable due to their usually frail health (Baugreet et al. 2016).

The average scores obtained in the sensory analysis (Table V) ranged from 6 to 8 (approximately) on the 9-point hedonic scale, corresponding to “slightly like” to “like very much”. Similar findings were observed by Guedes-Oliveira et al. (2016) in their sensory analysis of chicken meat patties.

The BMP, L7.5, and L15 formulations had similar scores to each other for overall appearance and aroma (*P*>0.05), which were higher than the values found for L0 (*P*<0.05). PUFA oxidation during meat cooking can cause the development of a rancid flavor (Abreu et al. 2019), but such an effect was not observed by the evaluators in the present study, even for the L15 formulation, which received an average score of 8.02, similar to that assigned to the BMP (8.05). In comparison, however, formulations L0 and L7.5 had lower scores for flavor (6.05–6.07), indicating that the formulation containing meat from lambs fed a diet with 15% safflower seed was more likely to be viable to improving the sensory attributes when the meat was processed

Table V. Sensory results of meat patty formulations.

Variables	BMP	L0	L7.5	L15
Overall appearance	7.12^{a}±1.69	6.50^{b}±1.70	7.10^{ab}±1.57	7.00^{ab}±1.54
Aroma	8.01^{a}±1.37	6.11^{b}±1.64	7.02^{ab}±1.50	7.08^{ab}±1.34
Flavor	8.05^{a}±1.32	6.07^{b}±2.09	6.05^{b}±1.81	8.02^{a}±1.73
Texture	8.05^{a}±1.36	7.14^{b}±1.66	7.09^{b}±1.53	7.21^{b}±1.61
Purchase intention	4.11^{a}±0.93	3.01^{b}±1.28	3.20^{b}±1.07	4.03^{a}±1.02

BMP – beef meat patties, L0 – lamb meat patties produced from lambs without safflower seed-supplemented diet, L7.5 – lamb meat patties produced from lambs with 7.5% of safflower seed-supplemented diet, L15 - lamb meat patties produced from lambs with 15% of safflower seed-supplemented diet. Means followed by same letters (same line) did not differ statistically (*P*>0.05) by Tukey test.

as meat patties. For texture, BMP showed the best result (8.05) compared with the lamb meat patties (L0, L7.5, and L15), which received scores for this sensory attribute in the range 7.09–7.21. Abreu et al. (2019) showed that different levels of spineless cactus used in sheep diet did not alter the sensory parameters of meat.

The values for purchase intention agreed with the sensory analysis findings; the values for the BMP (4.11) and L15 (4.07) formulations, corresponding to “probably buy” (4) and “maybe buy/maybe not buy” (3) on the 5-point hedonic scale used, were higher than those found for the L0 (3.01) and L7.5 (3.21) formulations. In previous work, the inclusion of safflower seed in sheep diet improved the sensorial acceptance of sausage (Catussi et al. 2017).

CONCLUSIONS

The use of 7.5 and 15% safflower seed to supplement the diet of lambs did not increase the FA content of the meat, except for C22:1 ($P<0.05$). Moreover, the high content of MUFA and PUFA found in lamb meat is associated with consumer health benefits. Meat patties prepared from the meat of lambs fed diets containing 0, 7.5, and 15% safflower seed had similar cooking and color properties when compared with BMP. No significant differences in the composition were found among the tested formulations, except for lipid content. The addition of 15% safflower seed to the diet of lambs improved the sensory properties of the meat patties and can, therefore, be considered as an alternative production procedure to improve the commercialization of this type of meat.

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MITALLY RAYANA C. DE OLIVEIRA[1]
https://orcid.org/0000-0002-9627-7455

LARISSA ECHEVERRIA[1]
https://orcid.org/0000-0002-2056-8985

ANTONIO C. MARTINEZ[2]
https://orcid.org/0000-0002-9002-5388

RAFAEL HENRIQUE T.B. DE GOES[3]
https://orcid.org/0000-0002-4744-0367

JULIANA SCANAVACCA[1]
https://orcid.org/0000-0002-2007-968X

BEATRIZ C.B. BARROS[1]
https://orcid.org/0000-0003-1191-4740

[1]Maringá State University, Departament of Technology, Avenida Ângelo Moreira da Fonseca, 1800, Parque Danielle, 87506-370 Umuarama, PR, Brazil

[2]Maringá State University, Departament of Veterinary Medicine, Estrada da Paca s/n, São Cristóvão, 87502-970 Umuarama, PR, Brazil

[3]Federal University of Grande Dourados (UFGD), Department of Animal Science, Rod. Dourados-Itahum, Km 12, 79804-970 Dourados, MS, Brazil

Correspondence to: **Beatriz Cervejeira Bolanho**
E-mail: beatrizbolanho@yahoo.com.br

Author contributions

Mitally Rayana Cardoso de Oliveira and Larissa Echeverria realized the meat patties formulations and characterization; Antonio Campanha Martinez was responsible for animal treatments, Rafael Henrique de Tonissi e Buschinelli de Goes performed the fatty acid analysis, Juliana Scanavacca and Beatriz Cervejeira Bolanho Barros supervised the findings of this work. All authors discussed the results, wrote the manuscript and contributed to the final manuscript.