

Article

Sensorial Analysis of Lamb Meat Fed a Mixture of Protected Fatty Acids Using a Trained Panel

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Simple Summary

The authors of this research wanted to find out whether adding extra healthy fats to lamb feed would improve the taste of the meat. They raised three groups of lambs and gave one group no extra fat, a second group 50 g of a special fat blend (85% of palmitic acid) each day during the finishing stage, and a third group 100 g. After processing the animals, trained taste testers compared samples from the three groups. Using methods similar to those employed by restaurants and food companies, the panel scored the meat for flavor, aftertaste, tenderness, and the pleasant “juiciness” that comes from fat. Computer analysis revealed clear differences: meat from lambs that consumed the highest fat level consistently received the highest scores. The testers said that this meat had a richer flavor, a nicer lingering taste, and was softer to chew without being too greasy. In general, this study suggests that adding an extra 50 or 100 g of fat supplement to a lamb’s diet towards the end of its growth can significantly improve the enjoyment consumers get from eating the meat. However, it should be noted that excessive intake of saturated fats can impact consumer health, so consumption should be discretionary.



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Abstract

The present study aimed to determine whether enriching the finishing ration of lambs with incremental doses of a protected fatty acid (FA) blend would result in noticeable differences in the eating experience of the resulting meat. Three isonitrogenous diets containing 0, 50, or 100 g day^{−1} of the FA mixture were formulated, and the lambs were fed these diets until slaughter under otherwise identical management conditions. After postmortem aging, boneless loin samples from each treatment were submitted to a descriptive sensory evaluation by a rigorously trained panel that followed international guidelines. Multivariate techniques—principal component analysis combined with hierarchical clustering—were applied to integrate the panel’s quantitative scores and visualize how the treatments segregated in sensory space. The lamb meat presented a level of acceptance dependent on the proportion of fatty acids. In general, this study suggests that adding an extra 50 or 100 g of fat supplement to a lamb’s diet towards the end of its growth can significantly improve the enjoyment consumers get from eating the meat. Sensory analysis of lamb meat enriched with fatty acids indicated that the most important attributes determining

the acceptance of lamb meat were color, flavor, odor, and toughness. Consequently, it can be recommended that dietary fatty acids be strategically increased during the finishing phase as a practical approach to enhancing the sensory appeal of sheep meat without compromising panel consensus.

Keywords: feeding innovations; livestock sector; multivariate techniques; sensorial preference

1. Introduction

Lamb meat is a valuable but relatively small component of the global meat supply ($\approx 5\%$ of consumption), with production reaching ~ 17 million metric tons in 2023 [1]. Major producers include China, Australia, New Zealand, and Middle Eastern countries [2]. In Mexico, sheep farming is traditional yet niche; per capita consumption has hovered around 0.5–0.95 kg/year over the last 25 years, tied largely to regional dishes (e.g., barbacoa) [3]. Domestic production is supplemented by imports [4], and lamb's premium positioning heightens the need for production efficiency.

From the consumer standpoint, tenderness, juiciness, and flavor drive meat choice across species [5]. In lamb, flavor—shaped by age and diet—is often decisive once tenderness is acceptable [6]. As Zhang et al. [7] emphasized, fatty acid composition strongly influences acceptance; species-specific aromas have been linked to branched-chain fatty acids in lamb fat. Beyond intrinsic traits, extrinsic cues matter: Mexican consumers regard lamb as traditional and wholesome and will pay more when assured of naturalness and safety [3]. Appearance (color, marbling) and price further guide purchasing. Overall, the market prizes eating quality—taste/aroma, tenderness, juiciness—alongside assurances of healthfulness and authenticity [8].

Producers must reconcile economics with quality. Feed typically represents 65–70% of total costs, making feed efficiency critical. Small-scale operations and commodity pricing constrain margins, so nutrition strategies that raise growth rate and carcass yield without undue cost are attractive. High-energy finishing diets can shorten time to market [9], but changes must safeguard rumen health and meat quality [10], as excessive energy can affect carcass fattiness [11] and sensory traits [12]. The overarching challenge is to improve efficiency cost-effectively while protecting consumer-relevant quality.

Dietary fat supplementation is one route to increase dietary energy density [11]. Saturated fatty acids—notably palmitic acid (C16:0)—are appealing due to energy density and lower oxidative susceptibility than polyunsaturated fats [13]. Moderate palmitic inclusion has improved average daily gain and feed conversion; for example, $\sim 3\%$ palmitic increased daily gain and nearly doubled the gain per unit of intake versus controls, and elevated dressing percentage by $\sim 7\%$. Comparable protected fat studies report $\sim 5\%$ increases in carcass yield [10]. Because palmitic is saturated and partly rumen bypass, moderate levels can supply energy with minimal disruption to fiber digestion [14].

Supplementation also alters meat composition. Palmitic inclusion (3–6%) increases the proportion of palmitic and stearic acids in intramuscular fat yet has not consistently changed pH, color (L^* , a^* , b^*), drip loss, cooking yield, or Warner–Bratzler shear force versus controls, indicating no detrimental effects on basic physical quality at moderate doses [10]. Some evidence suggests greater oxidative stability with more saturated intramuscular fat [13]. However, most work emphasizes carcass and instrumental traits; sensory outcomes and consumer perception remain underexplored.

Key gaps concern how diet-induced shifts in fatty acid profiles translate to sensory attributes. Fatty acids drive flavor through thermal degradation to volatiles; more unsatu-

rated fat can improve nutritional profile but raises oxidative potential and off-flavor risk, whereas more saturated fat may stabilize oxidation yet subtly change flavor and mouth feel. Few studies directly link saturated fat supplementation to sensory descriptors (lamb flavor intensity, juiciness, and overall palatability). Thus, we ask the following questions: How do different inclusion levels of palmitic acid affect lamb meat sensory characteristics? Can targeted supplementation optimize the consumer-pleasing sensory outcomes?

Our hypothesis in this regard is that increasing palmitic acid will improve carcass performance but may modify sensory attributes. Consumer acceptance will depend on the dose and will be linked to specific changes in the fatty acid profile. By integrating production and sensory science, this study addresses the question of whether palmitic acid supplementation can improve efficiency and food quality. The objective was therefore to evaluate the sensory acceptability of meat from sheep fed increasing levels of fatty acids during the fattening process.

2. Materials and Methods

2.1. Field Experiment

The experiment was carried out in an experimental field at the Unidad Regional Universitaria de Zonas Áridas—Universidad Autónoma Chapingo in Bermejillo, Mapimí, Durango, Mexico. It is located at 25° 52'28" LN y 103° 37'07" LO at 1119 masl with an average rainfall of 200 mm and an average temperature of 21 °C [15].

The animals were handled according to the Norma Oficial Mexicana NOM-062-ZOO-1999. This official standard refers to the technical specifications for the production, care, and use of laboratory animals in order to maintain the well-being of the animals in the experiment development. Also, they were handled according to the federal animal health law that governs the Estados Unidos Mexicanos (Mexico) [16].

Twenty-one six-week-old Dorper lambs with an average body weight of 14 ± 2.85 kg were used as experimental units. The lambs were assigned to one of three treatment groups via simple randomization. T100 = 100 g rumen protected fat, $n = 7$, BW = 14.2 ± 4.1 kg; T50 = 50 g rumen protected fat, $n = 7$, BW = 13.9 ± 2.3 kg; control = no inclusion of rumen protected fat, $n = 7$, BW = 13.8 ± 2.2 kg.

2.2. Feeding and Health Management

Dietary feed was developed in accordance with NRC (2007) guidelines [17] to meet the nutrient needs of sheep gaining 300 g per day. The diet's components and chemical composition are listed in Table 1.

The animals were fed with a total mixed ration (TMR) for 13 weeks. The lambs were permitted a two-week period in which to acclimatize to the new diet. They had ad libitum access to clean and fresh drinking water. The animals were subjected to deworming (Endectoplex L.A + ADE[®], 1ml 50⁻¹ kg, Mediker, Gómez Palacio, Durango, Mexico), vaccination (Clostridium and Anthrax), and vitamin application at the beginning of this study (A-5 Mineralizer with Vit. D[®], 1–5 mL animal⁻¹ and Sel + Vit. E[®], 0.25 mL animal⁻¹; Interprode; Zapopan, Jalisco, Mexico). The animals were housed in individual metal mesh pens (2 × 2.5 m) with a 3 m high metal sheet shade. In each pen there was a feeder and drinker with a capacity of 20 L. Feed and water were provided in two offerings per day (8:00 a.m. and 4:00 p.m.). In the mornings, before offering feed and water, the rejection of both was measured to determine consumption. The BW was measured on a weekly basis and was measured during fasting before offering feed and water. The amount of feed offered was weekly adjusted at 5% of the BW on a dry basis of feed. At week 6 of the experiment, commercial rumen protected fat (82% palmitic acid, 9.6% calcium, and 5.95 Mcal/kg Net Energy for Lactation; LactoMil[®], Oleofinos, Monterrey, Nuevo

León, Mexico) was added gradually until 7 weeks to reach the amount established in the experiment (50 and 100 g).

Table 1. Ingredients and chemical composition of the total mixed ratio offered to fattening Dorper lambs.

Ingredients	% MS	
Rolled corn	17.1	
Ground corn	17.1	
Wheat bran	9.0	
Soybean paste	9.0	
Urea	1.0	
Molasses	4.8	
Ground triticale hay	8.0	
Ground alfalfa hay	32.0	
Mineral premix—Bovi-8-ways *	2.0	
Nutrient	Content % MS	
	TMR	Rumen protected fat
Dry matter (DM)	93.34	46.38
Crude protein (CP)	14.2	0.19
Neutral detergent fiber (NDF)	34.58	7.13
Acid detergent fiber (ADF)	19.06	8.21
Net energy of maintenance (NEm MJ kg ^{−1})	7.85	12.8

* Bovi-8-ways (compound of 8 microminerals in yeast (organic minerals): Se, Cr, Cu, Zn, Co, Mn, I, and Fe, *Saccharomyces cerevisiae*-type yeast enriched with vitamin E; Biotecap Group, Tepatitlán de Morelos, Mexico).

2.3. Meat Sampling for Sensory Analysis

At the completion of 13 weeks of fattening, the animals were slaughtered according to NOM-033-Z00-1995 (humane slaughter of domestic and wild animals). The lambs were slaughtered at a 35.65 ± 7.21 kg mean live weight. The left longissimus thoracis et lumborum muscle was removed from the tenth rib in a caudal direction in each carcass 24 h postmortem and cut at 2 cm thickness. Table 2 shows the chemical composition of the meat in each treatment.

Table 2. Chemical composition of the meat in each treatment.

Variables	Control	T50	T100	<i>p</i>
Protein (%)	20.90	20.98	20.43	0.58
Fat (%)	5.53 ^b	7.87 ^a	7.58 ^a	0.01
Collagen (%)	1.67	1.71	1.72	0.26
Humidity (%)	72.38 ^a	69.17 ^b	70.64 ^b	0.03

^{a,b} Significant coefficients ($p < 0.05$).

Samples were vacuum-packed, matured at 2 ± 2 °C for seven days, frozen at -18 ± 2 °C and transported to the sensory analysis laboratory of the Instituto Nacional de Investigaciones Forestales, Agícolas y Pecuarias—experimental field Zacatecas (INIFAP Zacatecas) at a temperature of 1 °C for sensory evaluation. Prior to the sensory study, the samples (1.0 kg) were thawed overnight (24 h) at 4.0 °C, cooked only with salt and pepper in a pressure cooker for 50 min at 120 ± 2 °C. The unopened pressure cooker was then left to stand for 15 min to allow the pressure to release naturally. Samples of each treatment were divided into portions of approximately 20 g and were individually wrapped in coded aluminum foil and kept at a constant temperature using a steamer filled with hot water at 70 ± 2 °C. The time elapsed between cooking and serving (consumption) was approximately 85 min.

2.4. Sensory Analysis

This study was conducted at the Sensory Analysis Laboratory of INIFAP-C.E. Zacatecas (22° 54' N, 102° 39' W; altitude 2197 m above sea level). The facilities have 12 tasting booths that comply with the ISO-22000 protocol. This provided an environment that allowed for a functional and objective analysis of this study.

The experiment was conducted on a trained panel. The panel was formed in three stages:

1. **Preselection:** In this stage, 30 people with the ability to detect certain sensory properties were selected. In different sessions, they were trained in the discipline of sensory analysis, periodically evaluating various products to identify organoleptic and sensory characteristics. To this end, the methodology suggested in Regulation (EU) No. 1169/2011 of the European Parliament was followed.
2. **Selection of panelists:** The selected individuals underwent training on the main senses and terms of reference used in sensory analysis. Subsequently, various tests were carried out with the aid of a blindfold to heighten the senses. First, basic flavors (sweetness, acidity, bitterness, and saltiness) were identified through different sensory mixtures with sucrose, citric acid, sodium chloride, and caffeine. Additionally, training was provided on complex flavors in meat (meaty flavor, umami). Subsequently, the identification of odors was carried out using aromas of fresh, rancid, and cooked meat, as well as specific odors of certain cuts and origins. Similarly, the individuals were trained on the different textures in food. Samples with different textures were presented (raw carrot, peanut, soft gelatin (5%), celery string, soft tofu, orange slice, toasted white bread, chewy caramel, soft fresh cheese, chewing gum, chopped walnut shell) so that each individual could try to describe the type of texture if they did not know how to associate it with a specific word. In each test, individuals who obtained 80% correct answers were considered to have passed.
3. **Specific training:** Only 25 people were recruited for their olfactory and gustatory sensitivities and their ability to identify subtle differences between samples objectively. The panelists completed a total of 110 h of training in sensory methodology, including scaling, and became familiar with the specific sensory attributes of the product (lamb meat enriched with fatty acids).

The role of the expert tasting panel is fundamental in analyzing which products are most accepted in the market and, therefore, most chosen by consumers [18]. An expert tasting panel is a crucial tool for guiding companies' decision-making quickly and efficiently.

Once the trained panel had been calibrated, the 25 tasters (aged 22 to 65; 13 women and 12 men) evaluated three treatments in two separate sessions. The evaluation was carried out in two phases: (i) visual attributes (appearance, color, and smell) and (ii) taste attributes (flavor, texture, tenderness, firmness, juiciness, fat, and aftertaste). Each session constituted a complete balanced block, so that each panelist evaluated the three samples in each session, avoiding bias due to order of presentation [19].

The samples were presented monadically and coded with random three-digit numbers. The order of presentation was randomized using a restricted randomization procedure, ensuring that each treatment appeared in first, second, and third position with equal frequency among the panelists. The balancing allowed for control of carryover and position effects. Between samples, the tasters rinsed their mouths with mineral water and consumed unsalted bread to neutralize their palates.

The panelists rated overall acceptability using a nine-point Likert scale (1 = extremely poor, 9 = extremely good), applied to the attributes of appearance, color, smell, texture, and juiciness. In a second step, the five-point Just-About-Right (JAR) scale was used for

taste, tenderness, fattiness, and aftertaste (1 = much less than expected; 3 = just as expected; 5 = much more than expected) [20].

The JAR responses were recoded into three categories: “less than expected” (1–2), “just as expected” (3), and “more than expected” (4–5). Based on this recoding, a penalty analysis was performed, which consisted of calculating the proportion of panelists who considered an attribute to be outside the “just right” level and the difference in acceptability compared to the group that rated it as optimal. In this way, the attributes that significantly penalized overall acceptability were identified.

In the statistical analysis, treatments were considered fixed effects, while panelists were modeled as random effects in a mixed linear model, with the aim of capturing individual variability and avoiding biases in the comparison between treatments.

The validity of the panel was evaluated using linear models per attribute, considering the effect of Product and Session as fixed, and the differences between Tasters as the main factor of variability. The panel showed acceptable discriminatory capacity, since in most attributes no significant differences were detected between panelists ($p > 0.05$), indicating homogeneity in the evaluations.

Intra-taster repeatability was adequate, reflected in the low individual standard deviation and the stability of the evaluations between sessions. Inter-panelist reproducibility was also satisfactory, given that the variability between judges was lower than that associated with the products evaluated, and the effects of Session were not significant.

Agreement among tasters was moderate to high, in line with expectations for trained panels, and the overall reliability of the panel can be considered good to excellent, supporting the validity of the group of judges. At the individual level, most tasters showed high discrimination (significant product effect ($p < 0.05$)), low error in replicates, and consistent use of the scale.

The questionnaire was validated and approved by an ethical committee of social sciences. It was conducted according to the principles established in the Declaration of Helsinki, with special care on protecting personal information required by Mexican standards. The panelists signed a consent form which was read aloud.

2.5. Statistical Analysis

Before analyzing the data, the panelists' hedonic scores were standardized to normalize the data. The data were analyzed with a Completely Randomized Model and Internal Preference Map (CRPM). Internal preference maps report which products are preferred by panelists and allow identifying panelists with similar preferences [21].

Subsequently, the multivariate technique of correspondence analysis (CA) was applied to determine the possible simultaneous association between the treatments and the attributes evaluated [22]. The information was analyzed in the SPSS 27.0 statistical system for Windows and in the statistical analysis system SAS ver. 9.4 2002-2010 (Cary, NC, USA) [23].

The effect of the sensory attributes evaluated on the average acceptability was determined by a penalty analysis. The effect of the proportion of fatty acids on the acceptability of lamb meat was studied through the response surface model generated in the statistical package STATGRAPHICS Centurion XVI.

3. Results

3.1. Sensory Analysis Without Information on Fatty Acid-Enriched Lamb Meat

In the sensory experience, for the trained panel, the most important attributes were color, flavor, odor, and toughness, whose mean values on the hedonic scale were 3.7. Attributes such as juiciness (3.5), tenderness (3.4), appearance (3.4), and texture (3.4) were

moderately liked. In contrast, the mean values of residual grade (3.1) and fattiness (2.9) tended to be slightly palatable (Figure 1).

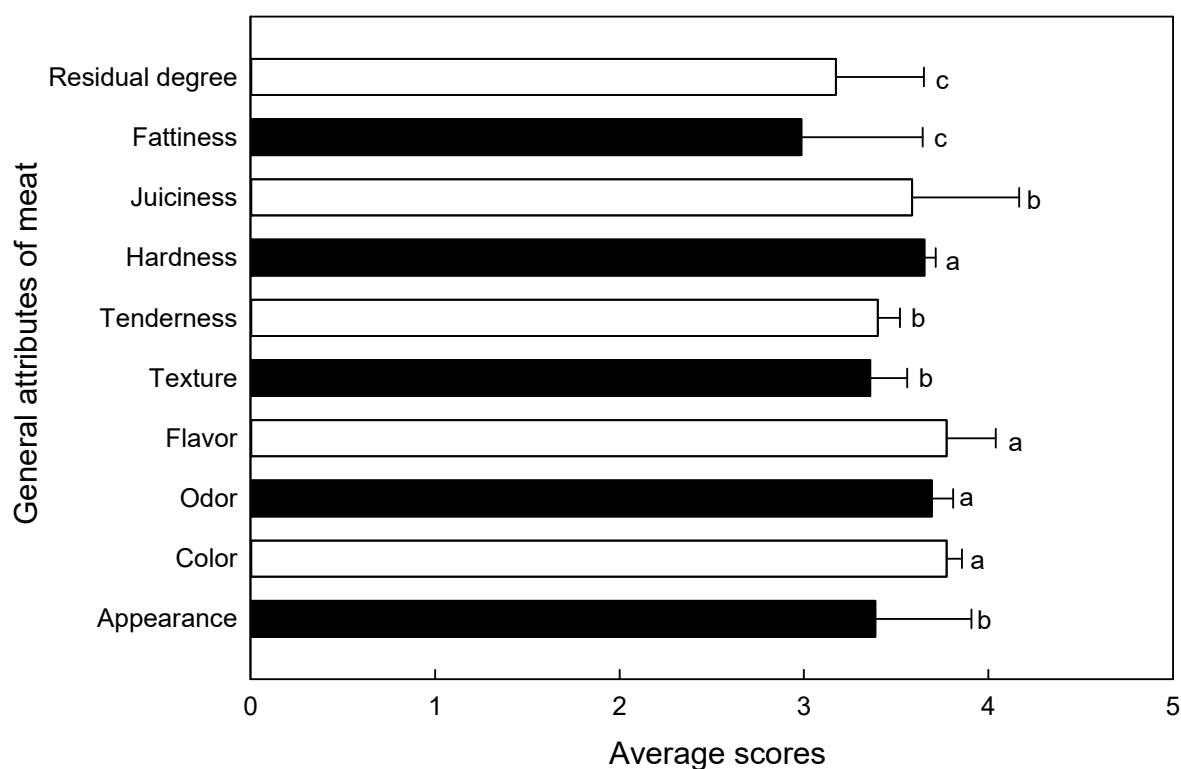


Figure 1. Average hedonic scores for fatty acid-enriched meat attributes. 1 = do not like at all, 2 = do not like, 3 = neither like nor dislike, 4 = like, 5 = like very much. a,b,c Statistical differences between attributes at 95% (Tukey).

3.2. Acceptance of the Fatty Acid-Enriched Lamb Meat

The treatment with the best acceptance by the panelists was, on average, the lamb meat that passed T100. This was followed by the meat of the control group (T0) and T50 (Table 3).

Table 3. Panelists' acceptance towards fatty acid-enriched meat treatments.

Treatments	n *	Preference	Acceptance of the Consumer (%)		
			Like	Neither Like nor Dislike	Does Not Like
Control	25	7.56 ^{ab}	8.8	24.0	67.2
T ₅₀	25	6.68 ^b	36.3	28.3	35.4
T ₁₀₀	25	8.00 ^a	56.0	29.6	14.4

* Size of the sample; 1 = I extremely dislike it, 2 = I dislike it a lot, 3 = I moderately dislike, 4 = I barely dislike, 5 = Neither like nor dislike, 6 = I like it a little, 7 = I moderately like it, 8 = I like it a lot, 9 = I extremely like it; a,b Statistical differences between the panelists at 95% (Tukey).

In Figure 2, each panelist is represented on the map by a red dot. This corresponds to the end of the vector. The vector can be obtained by drawing a straight line to join the end of the vector with the origin of the coordinates. The length of the vector depends on the R² of the model and indicates the precision with which the individual's preference is explained by the dimensions represented graphically [24]. The vector indicates the direction of increasing preference of a given consumer on the map.

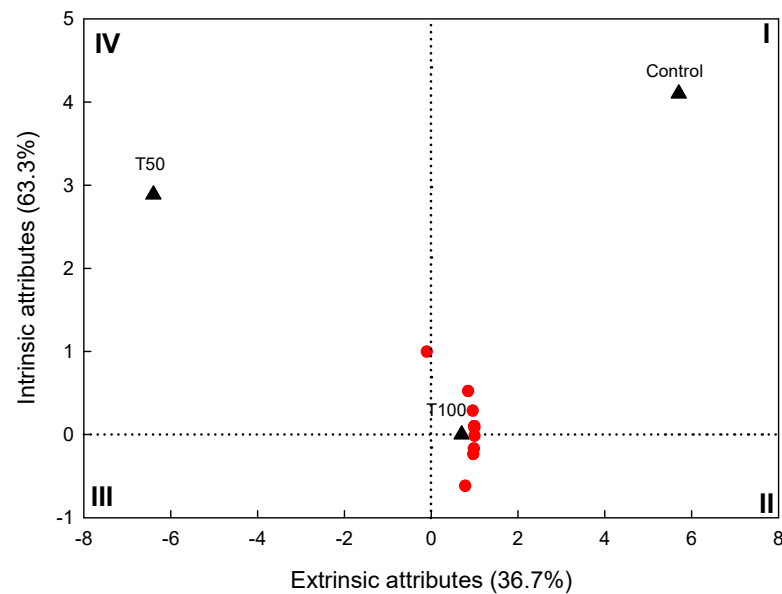


Figure 2. Map of internal preferences based on the treatments of lamb meat enriched with fatty acids.

Figure 2 shows the internal preference map of the treatments, control group, and panelists. The first two factors accounted for 100% of the variance explained (63.3%, 36.7% on the first and second axes, respectively).

Multivariate correspondence analysis indicated dependence ($\chi^2 = 3681$; $p < 0.0001$) between treated meat and the intrinsic and extrinsic attributes evaluated. The analysis indicated that the first two dimensions accounted for 89.9% of the total inertia (Figure 3). Attributes such as color, hardness, tenderness, and texture appeared not to be associated with any treatment (Quadrant I, Figure 3). The attributes odor and flavor were associated with the T50 treatment (Quadrant II, Figure 3). In contrast, appearance and juiciness tended to be associated with the control (Quadrant III, Figure 3). Fattiness and residual taste tended to be better associated with meat from sheep exposed to the T100 treatment (Quadrant IV, Figure 3).

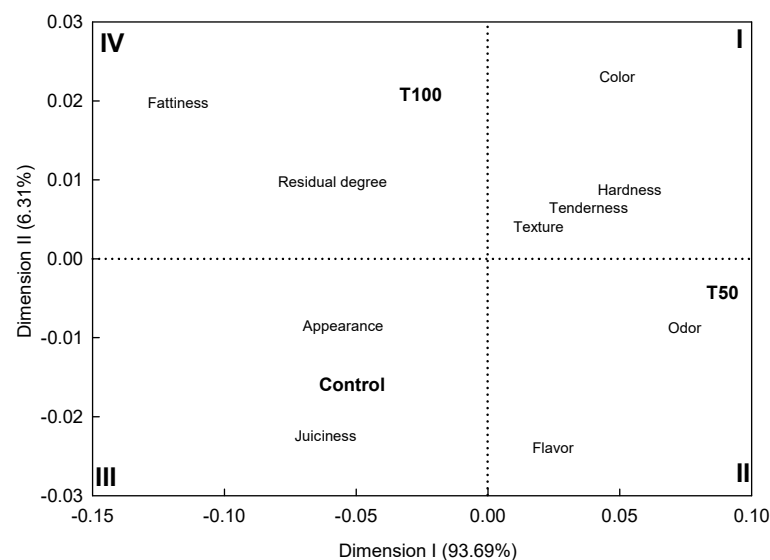


Figure 3. Bidimensional average positioning of attributes and treatments rated by the panelists.

It was observed that this model adequately explained the experimental data ($p < 0.05$). The model allowed predicting the acceptability of lamb meat as a function of fatty acid ratio, including non-experimental regions but within the limits of the design:

$$\text{Acceptability} = 85.8205 - 0.157778 \times \text{Fat} - 7.38916 \times \text{Protein} + 0.000962233 \times \text{Fat}^2 + 0.00378585 \times \text{Fat} \times \text{Protein} + 0.172372 \times \text{Protein}^2.$$

Figure 4 shows the response surface of the quadratic polynomial model obtained for the acceptability of lamb meat as a function of the type and proportion of fatty acids. The optimum value for acceptability was nine and the fatty acid treatment was T100 with 22.2% protein.

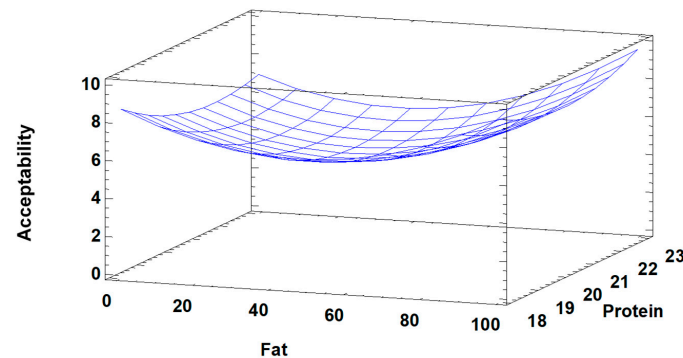


Figure 4. Response surface of the effect of fatty acid concentration on the acceptability of lamb meat.

The results of the JAR test used to evaluate the influence of the attributes flavor, tenderness, fattiness, and residual taste on the acceptability of the different levels of fatty acids are shown in Figure 5. The control had a greater effect on residual taste and tenderness, while T50 reflected its effect on residual taste, flavor, tenderness, and less fattiness. On the other hand, in the T100 treatment, qualities with a greater effect on acceptability were observed in residual taste, flavor, tenderness, and fattiness, a pattern reflected by its location in the graphs on the upper right and attributable to the greater presence of fatty acids.

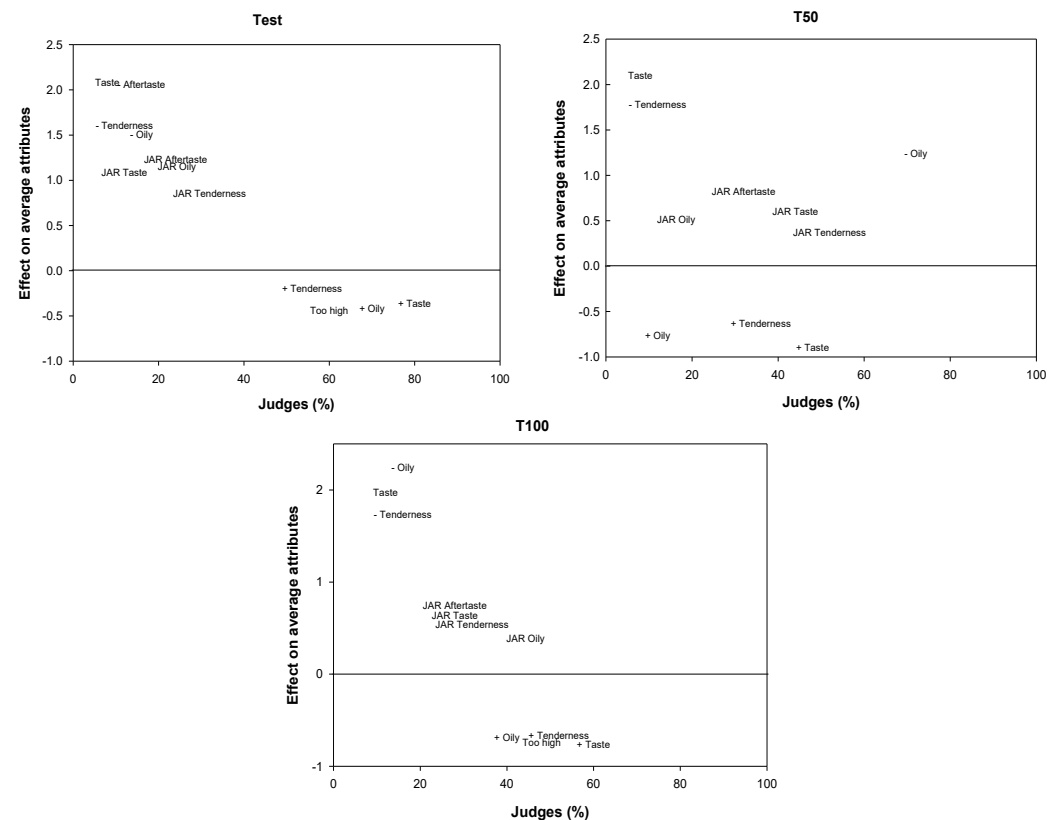


Figure 5. Effect of sensory attributes on fatty acid acceptability, measured with JAR (Just-About-Right) scale for each fatty acid level, reducing the scale from 5 to 3 points.

4. Discussion

The sensory analysis conducted by the trained panel revealed that the most highly valued attributes were color, flavor, odor, and firmness, each with an average score of 3.7 on the hedonic scale. In this regard, color represents a key attribute in meat commercialization, as it is the first quality characteristic perceived by consumers and serves as an indicator of freshness and wholesomeness [25,26]. This attribute is mainly determined by the content of myoglobin and hemoglobin, as well as by the oxidation state of these pigments within muscle fibers [27].

On the other hand, the attributes of juiciness, tenderness, appearance, and texture received moderate ratings, with average scores ranging from 3.4 to 3.5. Tenderness, defined as the ability of meat to be cut and chewed, is considered one of the main determinants of product quality and consumer acceptance [28]. Juiciness, in turn, plays a fundamental role in the sensory experience, since the juices released during mastication provide both softness and flavor. These juices originate primarily from intramuscular lipids and water, which act as an aqueous substrate. In this regard, Miller et al. [29] reported that the lack of juiciness considerably limits consumer acceptance.

In general, the sensory quality of meat results from the appropriate combination of tenderness, juiciness, flavor, and color [30]. This quality is influenced by several factors, including species, breed, age of the animal, antemortem handling, postmortem storage conditions, intrinsic characteristics of the muscle and connective tissue, the intensity of postmortem proteolysis, and cooking temperature [31].

In contrast, residual taste and fattiness were the least appreciated attributes, with average scores of 3.1 and 2.9, respectively. The multivariate analysis showed that the most valued attributes, such as odor and flavor, were associated with the T50 treatment, whereas moderately accepted attributes, such as appearance and juiciness, were linked to the control treatment. In turn, fattiness and residual taste were primarily associated with the T100 treatment. This behavior aligns with previous studies that have shown a decrease in the perception of pork's meat flavor, juiciness, and tenderness when it is enriched with fatty acids [32].

Surprisingly, despite residual taste and fattiness being perceived as less desirable qualities, the T100 treatment, which is associated with these characteristics, received the highest overall acceptance from the panelists. This result suggests that a higher proportion of intramuscular fat may enhance sensory preference, as it directly influences the perception of juiciness and flavor [33].

The sensory improvement observed in lamb meat enriched with fatty acids can be explained by different mechanisms. Among them are an increase in intramuscular fat, which promotes juiciness and aroma release during cooking, as well as the presence of a lipid profile enriched in monounsaturated fatty acids, capable of generating desirable volatile compounds such as aldehydes and lactones [34,35].

However, this same enrichment also carries certain risks. A higher proportion of fatty acids increases the susceptibility to lipid oxidation, favoring the formation of aldehydes and ketones responsible for rancid odors and flavors [36,37].

Beyond the effects observed with lipid supplementation, it is also important to consider that other compounds present in the diets of small ruminants significantly influence the quality of both meat and milk. For instance, the inclusion of alternative grains such as sorghum and legumes such as bitter vetch has been shown to affect productive performance [26].

Similarly, dietary tannins, naturally present in various forage resources, exert a dual function: on the one hand, they modulate ruminal fermentation and reduce biohydrogena-

tion, and on the other, they enhance antioxidant capacity, which may help improve lipid stability and, consequently, the shelf life of meat [38].

In the case of dairy products, microalgae supplementation has proven to be an effective strategy to enrich milk with functional compounds such as n-3 fatty acids and conjugated linoleic acid, resulting in significant improvements in composition and nutritional value [39]. Altogether, these findings show that the inclusion of alternative dietary ingredients in small ruminant feeding represents a promising tool for product differentiation in the market.

Therefore, lamb meat enriched with fatty acids may provide differential advantages in the marketplace, enabling producers to generate added value through targeted dietary strategies.

In this study, it should be considered that panelists were not provided with information regarding the potential health benefits derived from the consumption of fatty acid-enriched meat. Thus, their evaluation was based exclusively on hedonic criteria. This aligns with what was previously mentioned by Boukrouh et al. [26] and Annett et al. [40], who reported that although consumers tend to prefer healthier and more nutritious foods, purchasing decisions are primarily driven by flavor and other sensory characteristics.

Similarly, Vermeir and Verbeke [41] emphasize that food choice is a complex process that integrates subjective and environmental factors, as well as individual, automatic, and subconscious motivations. Among these are sensory attributes, nutritional properties, price, and the socioeconomic characteristics of consumers [42].

Finally, it is crucial to emphasize that the expert panel was exclusively composed of individuals from the state of Zacatecas, Mexico. While this trained panel ensured a precise evaluation of specific sensory attributes, it is important to acknowledge that general consumer preferences may vary. Consequently, the extrapolation of these results is limited. Future studies should include a larger and more diverse sample of participants from different regions of Mexico, including untrained consumers to obtain more representative and broadly applicable conclusions. Looking ahead, it would also be relevant to assess economic feasibility, health perception, and market acceptance, considering factors such as cost, labeling, and regulations, to guide differentiated production strategies.

5. Conclusions

The lamb meat presented a level of acceptance dependent on the proportion of fatty acids. In general, this study suggests that adding an extra 50 or 100 g of fat supplement to a lamb's diet towards the end of its growth can significantly improve the enjoyment consumers get from eating the meat.

Sensory analysis of lamb meat enriched with fatty acids indicated that the most important attributes determining the acceptance of lamb meat were color, flavor, odor, and toughness. The attributes were modified by the effect of feeding, and the treatment with the highest amount of fatty acids in the diet was the one that stood out.

The results of this study provide a first insight into the effects of dietary fatty acid enrichment on lamb meat quality. Although the consumers evaluated were exclusively from the state of Zacatecas, Mexico, these findings offer valuable information to guide future research with more representative samples across different geographic regions, contributing to the optimization of feeding strategies to improve both the sensory and nutritional profile of the meat.

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