Development and sensory evaluation of rabbit meat marinade formulations with additive reduction: physicochemical and textural properties

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ABSTRACT

Objective: The study evaluated the effect of different levels of liquid marination and phosphate on several physicochemical and textural parameters, product preference, and sensory characteristics of rabbit meat during storage.

Methodology: Six rabbit meat formulations stored at 4 °C for periods of 1, 8, and 15 days were analyzed. Physicochemical parameters evaluated included pH, acidity and texture. In addition, a sensory evaluation was performed to examine characteristics of the roasted rabbit meat, such as color, texture, among other attributes.

Results: The physicochemical parameters included pH (6.0-6.6), acidity (0.35-0.65%), and texture (hardness, 1.85-3.23 N). Sensory evaluation was conducted to assess characteristics of roasted rabbit meat, such as white appearance and raw texture, among other attributes.

The results revealed significant differences ($p<0.05$) among formulations in physicochemical properties, particularly in texture and acidity. Sensory characteristics were generally similar, except for white appearance ($p<0.01$) and raw texture ($p<0.05$).

Limitations: The study was limited to assessing only three periods of storage (1, 8 and 15 days), which may not reflect the long-term effects of marinated rabbit meat. On the other side, although this study contributes with descriptors to the lexicon for the characterization of rabbit meat, additional studies with trained panels for developing a more comprehensive lexicon are recommended.

Conclusions: This study demonstrates the feasibility of producing marinated rabbit meat with reduced additive content, effectively lowering production costs while maintaining quality and sensory attributes.

Keywords: rabbit meat; marination; physicochemical properties; sensory quality.

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INTRODUCTION

Rabbit meat is highly nutritious due to its high oleic acid, protein, and essential amino acid content, as well as its low fat and cholesterol levels (Raniska *et al.*, 2018; Hernandez and Gondret, 2006). Traditionally, rabbit meat has had little acceptance among consumers worldwide. However, in recent years, consumers have paid greater attention to their health,

and consequently, one of the main trends in food consumption is the search for foods with greater nutritional value (Dalle Zotte *et al.*, 2020). Compared to other domestic animal meats, rabbit meat is high in protein and low in fat, sodium, and cholesterol. It is easily digestible and recommended for people with high protein needs or a sensitive digestive system (Cury *et al.*, 2011; Dalle Zotte, 2014). The consumption of rabbit meat can be enhanced by using traditional preservation methods that offer greater flavor and consumer appeal, such as marinating. This process refers to a mixture of ingredients in dry or liquid form that are applied to uncooked foods to enrich their flavor and textural properties (Petrescu and Petrescu-Mag, 2018).

Meat can be marinated in a tumbler operating in a static, vacuum, or high-pressure environment to improve marinade absorption and uniformity (Gao *et al.*, 2015). These products can be sold directly to the consumer as pre-marinated, ready-to-cook meat or frozen for distribution to canteens or restaurants (Fletcher, 2004). Rabbit meat is usually lean and therefore has low juiciness and marked stringiness, which are the main sensory defects of rabbit meat (Dalle Zotte, 2002). Marinating at the industrial level involves adding or injecting an aqueous solution, which may contain different ingredients and additives (salt, phosphates, aromas, etc.), into the meat. The injection can be adapted to various product sizes and shapes, leaving the bone intact. It is ideal for whole carcasses, halves, as well as large and small pieces.

Sensory evaluation performed by consumers to identify and describe food attributes has been proposed as a fast and reliable alternative to Quantitative Descriptive Analysis (Qannari, 2017). This approach is still considered reliable and highly accurate, although the considerable time and cost needed to train sensory judges are disadvantages. The main argument against sensory descriptions performed by consumers is that they do not usually have a sufficient glossary for describing products. However, it has been reported that consumers have some capacity for expressing the sensory characteristics related to liking or rejecting food (Sharma *et al.*, 2019). Therefore, using sensory evaluation techniques for describing products among consumers can provide similar results to Quantitative Descriptive Analysis (Moussaoui and Varela, 2010; Valentin *et al.*, 2012), especially when the techniques are fast and easy to understand for inexperienced judges.

Alternatives are being explored to improve the quality of rabbit meat and include it in the population's diet as a substitute for more common meats. Rabbit farming has a lower ecological impact compared to other forms of animal husbandry. Its carbon and water footprint are smaller, making it a more sustainable option. For example, rabbit farming consumes less water and land than cattle, pig, or poultry farming (Raniska *et al.*, 2018; Hernandez and Gondret, 2006). From a microbiological point of view, rabbit meat is less prone to certain pathogens that affect other types of meat, making it a safer option for consumers (Cury *et al.*, 2011). However, the disadvantage of this type of meat is its flavor. One way to improve the physicochemical and sensory properties of rabbit meat is through marinating. This process can enhance the taste, texture, and overall consumer appeal of the meat. Therefore, this study aims to investigate the impact of marinating on the sensory and physicochemical characteristics of grilled rabbit meat, highlighting its potential as a healthy and sustainable alternative to commonly consumed meats.

MATERIALS AND METHODS

Raw material

The rabbit meat used in this study was provided by PROLECON SC de RL de CV, an enterprise located in Guanajuato, Mexico. Thirty carcasses (*Oryctolagus cuniculus*, New Zealand rabbits) from healthy animals 2.5 to 3.0 months old, with a carcass weight average 1.2 kg were used. Liquid marinade (NutriFoods, Celaya, Mexico) and mixing marinated spices were purchased from a local market in Pénjamo, Guanajuato, Mexico.

Marination of rabbit meat

A total of 15 *Longissimus dorsi* meat samples were prepared for the different formulations based on the weight of the rabbit meat, following the method described by Latif (2010) with some modifications. First, parts of the rabbit loin and hind leg were weighed for each formulation. Table 1 presents the formulations and the injection marination method used. The meat was then left for 24 hours in a refrigeration chamber at 4 °C.

pH and titratable acidity

The pH was measured following the standardized methodology described by the AOAC (2005), method 981.12. Briefly, 10 g meat sample was homogenized in 100 mL of distilled water, filtered, and measured with a pH meter (HI9810, Hanna Instruments, Italy). As for titratable acidity, the samples were titrated with 0.1 N NaOH, and the mEq of NaOH was converted to and expressed as a percentage of lactic acid (Manalo and Gabriel, 2020). The means of three successive measurements were recorded.

Color

The color evaluation was performed using a CR-410 colorimeter (Konica Minolta, Sensing, Inc., Osaka, Japan). The CIE L* a* b* color specification system was used to express the color coordinates: lightness (L*), redness (a*), and yellowness (b*). Each sample was cut into 2 cm^2 pieces and kept at room temperature for 15 minutes before analysis. These determinations were carried out on days 1, 8, and 15. Triplicate measurements were made, and the resulting values were reported as the mean (American Meat Science Association, 2023).

Table 1. Formulations of marinating for rabbit meat*.

Ingredient (g/kg)	C0	FB	FBP	FA1	FA2	FA3
Water	-	89.3	71.28	75.75	82.5	89.25
Liquid marinated	-	-	20.72	17.25	11.5	5.75
Phosphate	-	1.5	3.0	2	1	0
Salt	-	7.3	5.0	5	5	5
Spices mix	-	5	0	0	0	0

* Treatments: C0: raw meat; FB: formulation base; FBP: formulation base product. FA1: Formulation 1 (17.25 g/kg liquid marinated+2 g/kg phosphate); FA2: Formulation 2 (11.5 g/kg liquid marinated+1 g/kg phosphate); FA3: Formulation 3 (5.75 g/kg liquid marinated+0 g/kg phosphate).

Determination of texture

The texture analysis was performed using a CT3 Brookfield Texture Analyzer. A compression test with a measuring 10 mm in width and 20 mm in length target value was selected, the probe test speed being set to 1.0 mm/s, the trigger load at 25 kg, and the probe compressed the sample to 60% of its original height. Readings were taken at six points on the meat (Gómez-Salazar *et al.*, 2018). To improve the ease of core preparation, the analysis was performed at a uniform temperature of 20-21 °C and carried out in triplicate.

Sensory acceptance and characterization

Marination process and sample preparation

Rabbit meat was marinated by injecting solutions prepared with mixtures of marinated liquid and phosphate (Table 1). A batch of rabbit meat was injected with purified water, which served as the control. After 24 hours of marinating, salt was added to the meat (3 g salt per 700 g of meat) and the meat was wrapped in aluminum foil. The wrapped pieces were placed on a grill and cooked over low heat, turning the pieces four times for a total of 24 minutes (6 min on each side), then the meat was grilled for 5 min (2.5 min on each side), and 5 g pieces of each of the formulations were cut for sensory testing. The meat was roasted and cut into cubes of approximately 3 cm^2 (American Meat Science Association, 2016).

Obtention of sensory attributes

The sensory descriptors for the rabbit meat were obtained from 20 subjects (13 men and 7 women aged between 19 and 57 years), each receiving a 5.0 g sample of roasted rabbit meat from each treatment served on white plates. Participants were given a white sheet of paper and instructed to write the perceived attributes unrelated to liking that could contribute to differentiation between treatments in terms of appearance, smell, taste, and texture. The subjects were free to rinse their mouths with water between samples. The responses from the participants were analyzed, synonyms were identified, and the most frequently mentioned characteristics were selected to be part of the consumer sensory characterization test.

Acceptance and sensory characterization

Sensory evaluation of acceptance and characterization of the roasted rabbit meat was conducted with 119 subjects (students and staff) at the Universidad Politécnica de Penjamo (78 men and 41 women aged between 18 and 57 years). Participants received a 5.0 g sample from each treatment of roasted rabbit meat and, after tasting, indicated their degree of liking for each sample using a 15-point scale printed on cardboard (numbers only), with 1 representing the lowest level of liking and 15 the highest. After the acceptance test, the subjects received an answer sheet containing the sensory descriptors obtained in the previous test. Participants were instructed to mark the attributes perceived in each sample of roasted rabbit meat using a Check-All-That-Apply (CATA) procedure. The order of presentation for the attributes shown in the CATA questions was randomized to avoid bias in selecting characteristics (Ares and Jaeger, 2013).

Statistical analysis

All samples were analyzed after preparation on days 1, 8, and 15 of storage, expressing the data as the mean ± standard deviation (SD) of three independent experiments. Using the statistical software Minitab software (v.16, Minitab Inc, State College, PA, USA)., an analysis of variance (ANOVA) with means comparison by Tukey's test ($p<0.05$) was performed. The acceptance tests were analyzed with Kruskal-Wallis tests for means comparison. The frequency of mention for the attributes in the CATA test was analyzed with Cochran's Q. Furthermore, a Correspondence Analysis was performed on the contingency table to generate a sensory map showing the relationships between the sensory attributes and the rabbit meat samples generated after the application of the different marinade formulations. Finally, statistical analysis of the sensory data was carried out using the XLSTAT system (Addinsoft, France) with a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Physicochemical attributes of marinated rabbit meat

Table 2 shows physicochemical characteristics of marinated rabbit meat during storage and monitored on days 1, 8, and 15. System C0 starts with a value of 6.0, which increased significantly by day 15 ($p<0.05$). For the other formulations, the opposite behavior was observed as the pH values remained in the range of 6.0-6.6, while the addition of salts and phosphates provided meat stability (Vlahova-Vangelova and Dragoev, 2014). The pH is one of the most important quality parameters for meat, because it contributes to juiciness and texture (Deogade *et al.*, 2011) in treatment C0 was lower on day 1 than on day 15 ($p<0.05$). Moreover, the pH of the meat (0) during the 15-day period was similar to that reported by Gonzales and Ordoñez (2010), with a pH of 6.03±0.01 for thawed rabbit meat. For fresh rabbit meat, the pH according to studies by Cury *et al.* (2011) and Gómez-Salazar *et al.* (2018) was 6.22 and 6.01, respectively.

In this study, acidity behaved differently from pH. In the FB formulation, acidity decreased significantly after 8 days ($p<0.05$) and returned to its initial value after 15 days. Furthermore, meat (C0) and FBP showed no difference during the 15 days of storage ($p<0.05$). Titratable acidity indicates the content of organic acids in the meat. This information is useful for marinated rabbit meat, as it helps to understand how different marinating treatments can affect both sensory perception and shelf life of the product. The acidity values obtained for meat (C0) were similar to those reported by García *et al.* (2012), with a value of 0.57±0.07. The FA3 formulation presented the lowest values due to the small number of components in the marinade formulation. This contrasted with FA1 and FA2, which contained higher values of tenderizer and phosphates on day 1; these values increased significantly on day 8, and on day 15 there was a decrease in acidity ($p<0.05$). FA3 and FB showed similar behavior, as their acidity increased during storage due to the low content of phosphates and tenderizer, yet their acidity was lower than the control meat as they contained other ingredients, such as water, which prevented the acidity from increasing.

Table 2. Physicochemical characteristics of marinated rabbit meat during storage.

Formulations	Days	pH	Acidity (% lactic acid)	Hardness (N)
C0	1	6.0 ± 0.05^{Bef}	0.53 ± 0.04^{ABabc}	3.33 ± 0.95^{Aab}
	8	6.1 ± 0.10^{Bdef}	0.53 ± 0.04^{ABabc}	2.85 ± 0.51^{Aabcd}
	15	6.4 ± 0.05^{Babc}	0.51 ± 0.02^{ABabc}	2.25 ± 0.61^{Abcd}
FB	1	6.5 ± 0.10^{Bab}	0.43 ± 0.12^{BCabc}	2.78 ± 0.51^{ABabcd}
	8	6.0 ± 0.00^{Bf}	0.37 ± 0.02^{BCc}	2.15 ± 0.55^{ABcd}
	15	6.4 ± 0.05^{Babc}	0.50 ± 0.02^{BCabc}	2.05 ± 0.67^{ABd}
FBP	1	6.6 ± 0.01^{Aa}	0.57 ± 0.09^{Aabc}	2.85 ± 0.88^{ABabcd}
	8	6.3 ± 0.00^{Abcde}	0.51 ± 0.14^{Aabc}	2.25 ± 0.61^{ABbcd}
	15	6.6 ± 0.05^{Aa}	0.53 ± 0.04^{Aabc}	2.05 ± 0.47^{ABd}
FA1	1	6.3 ± 0.11^{Bbcd}	0.43 ± 0.04^{ABabc}	2.87 ± 1.60^{Babcd}
	8	6.0 ± 0.05^{Bf}	0.65 ± 0.09^{Aba}	1.82 ± 0.64^{Bd}
	15	6.4 ± 0.05^{Bab}	0.52 ± 0.02^{ABabc}	1.96 ± 0.66^{Bd}
FA2	1	6.2 ± 0.10^{Bcdef}	0.48 ± 0.04^{ABabc}	3.47 ± 2.76^{Aba}
	8	5.9 ± 0.05^{Bf}	0.61 ± 0.14^{ABab}	2.08 ± 0.83^{ABd}
	15	6.4 ± 0.05^{Babc}	0.48 ± 0.04^{ABabc}	1.85 ± 0.48^{ABd}
FA3	1	6.3 ± 0.15^{Bbcd}	0.35 ± 0.02^{Cc}	3.23 ± 0.85^{ABabc}
	8	6.1 ± 0.10^{Bdef}	0.41 ± 0.02^{Cbc}	2.22 ± 0.50^{ABbcd}
	15	6.4 ± 0.05^{Babc}	0.43 ± 0.04^{Cabc}	2.13 ± 0.63^{ABcd}

Values represent mean±standard deviation. Capital letters represent statistical differences ($p<0.05$) among treatments. Lowercase letters represent statistical differences between time. C0: Control; FB: formulation base; FBP; producer's formulation; FA1: Formulation 1 (17.25 g/kg liquid marinated+2 g/kg phosphate); FA2: Formulation 2 (11.50 g/kg liquid marinated+1 g/kg phosphate); FA3: Formulation 3 (5.75 g/ kg liquid marinated+0 g/kg phosphate).

Texture

Table 2 shows the texture of the marinated rabbit meat expressed as hardness. Regardless of the marinating formulation and the initial pH, meat texture decreased as the days of storage elapsed ($p<0.05$). According to Warner (2017), tissue softens and breaks down due to the pH, causing the meat to become softer over time. This softening is attributed to the activity of proteolytic enzymes that degrade myofibrillar proteins, reducing shear resistance. This parameter showed a significant difference between treatments ($p<0.05$). The values of the FA1 formulation indicate that less effort is required to penetrate the meat, meaning that it is soft due to the presence of tenderizer and phosphates. According to Alarcón-Rojo *et al.* (2019), an increased pH brings a higher water-holding capacity. As expected, FA3 presented a similar texture to the control during storage. This is attributed to the incorporation of chemicals that lead to modifications in protein solubility and improving the water-holding capacity, thereby softening the meat texture (Bhat *et al.*, 2018; Scanga *et al.*, 2000). The meat (C0) presented a texture of 3.33 N, which is a higher value than that reported by Gómez-Salazar *et al.* (2018), who reported a value of 1.69 N for rabbit meat without marination. This difference in texture

could be associated with the storage conditions, contributing to higher firmness and, consequently, a higher texture value. Additionally, variations in diet and management of the rabbit prior to slaughter can also affect the muscle composition and, thus, the texture of the meat.

Color

Table 3 shows the color parameters for marinated rabbit meat during storage. No significant differences were observed in the L* parameter (lightness) during storage nor between treatments (P=NS), indicating that the components of the formulations do not affect the lightness of the marinated meat. As for the a* parameter (redness), a decrease in color was observed during storage ($p<0.05$), although no difference was observed between treatments ($p<0.05$). Differences in the b* parameter (yellowness) were found during storage ($p<0.05$), as there was a decrease in the marinated meats with yellowish tones. Furthermore, meat (C0) showed a difference on day 15 of storage ($p<0.05$). These results are lower than the values reported by Gómez-Salazar *et al.* (2018) for the b* parameter, with their investigation reporting a value of b*=10.56 for fresh meat. Meat color parameters remained stable during the period evaluated, indicating a potential increase in shelf life. Additionally, the selection of marinated rabbit meat will not be affected by storage time.

Table 3. Color parameters for marinated rabbit meat during storage.

Formulation	Days	Parameters		
		L*	a*	b*
C0	1	54.25 ± 1.92^{Aa}	19.88 ± 1.65^{Aab}	4.25 ± 1.29^{Bd}
	8	58.86 ± 6.89^{Aa}	20.64 ± 1.19^{Aab}	5.33 ± 0.85^{Babcd}
	15	55.00 ± 3.91^{Aa}	16.67 ± 0.42^{Ab}	4.64 ± 0.99^{Bbcd}
FB	1	51.29 ± 2.21^{Aa}	20.32 ± 3.45^{Aab}	8.20 ± 1.05^{Aa}
	8	54.11 ± 2.77^{Aa}	22.27 ± 0.93^{Aa}	5.53 ± 0.56^{Aabcd}
	15	52.20 ± 1.12^{Aa}	18.42 ± 0.67^{Aab}	5.47 ± 0.43^{Aabcd}
FBP	1	53.90 ± 0.18^{Aa}	18.96 ± 0.58^{Aab}	5.57 ± 1.94^{ABabcd}
	8	53.14 ± 2.78^{Aa}	22.56 ± 1.11^{Aa}	5.86 ± 0.11^{ABabcd}
	15	52.81 ± 1.68^{Aa}	18.59 ± 0.51^{Aab}	4.40 ± 0.75^{ABcd}
FA1	1	55.43 ± 3.52^{Aa}	19.12 ± 0.67^{Aab}	7.29 ± 1.74^{Aabc}
	8	52.95 ± 2.34^{Aa}	20.26 ± 3.12^{Aab}	7.02 ± 0.45^{Aabcd}
	15	57.71 ± 4.50^{Aa}	20.22 ± 0.21^{Aab}	5.00 ± 0.69^{Abcd}
FA2	1	57.39 ± 2.23^{Aa}	21.85 ± 1.94^{Aab}	7.41 ± 0.85^{Abab}
	8	57.07 ± 1.08^{Aa}	20.07 ± 2.43^{Aab}	4.63 ± 0.42^{ABbcd}
	15	55.82 ± 1.47^{Aa}	18.68 ± 1.67^{Aab}	5.67 ± 0.55^{ABabcd}
FA3	1	54.07 ± 1.67^{Aa}	19.68 ± 1.86^{Aab}	6.74 ± 1.17^{ABabcd}
	8	58.92 ± 7.05^{Aa}	21.52 ± 2.95^{Aab}	4.82 ± 0.86^{ABbcd}
	15	55.87 ± 1.36^{Aa}	16.43 ± 1.95^{Ab}	4.21 ± 0.12^{ABd}

Values represent mean standard deviation. Capital letters represent statistical differences ($p<0.05$) among treatments. Lowercase letters represent statistical differences among storage day. C0: Control; FB: formulation base; FBP; producer's formulation; FA1: Formulation 1 (17.25 g/kg liquid marinated+2 g/kg phosphate); FA2: Formulation 2 (11.50 g/kg liquid marinated+1 g/kg phosphate); FA3: Formulation 3 (5.75 g/ kg liquid marinated+0 g/kg phosphate). L*: lightness; a*: redness b*: yellowness.

Sensory attributes

From the analysis of the responses from 20 participants, only twelve sensory descriptors were selected for sensory characterization since they were mentioned by more than 15% of respondents. The limited glossary of consumers to describe foods is common since they are not used to explain the sensory characteristics of products (Santos *et al.*, 2013). However, for sensory characterization of products by consumers, it is important to provide a list of attributes easy to understand, to identify, and enough in quantity to allow them to describe the food samples. In this experiment, the obtained descriptors were classified into the following categories: texture, appearance, smell, and taste (Table 4). The most frequently mentioned attributes for texture were soft, hard, dry, doughy, and raw. Meanwhile, the attributes mentioned for appearance were white, appetizing, and juicy. Regarding smell, the descriptors 'intense' and 'smoky' were mentioned, while for taste, 'intense' and 'chicken' were noted. Textural attributes were more frequently mentioned as differential descriptors for the analyzed samples and could be related to the effect of the formulations used to make the brine solutions.

Sensory characterization and acceptance of marinated rabbit meat

All the attributes used in the CATA questionnaire were important for describing the samples. The textural characteristics of raw, hard, doughy, and white appearance (mentioned by 27%, 32%, and 33% of participants, respectively) were related to undesirable characteristics. In contrast, soft texture and juicy appearance were the most desirable attributes, mentioned by 83% and 93% of the participants, respectively.

The sensory characteristics of the roasted rabbit meat samples were similar, except for the attributes of white appearance ($p<0.01$) and raw texture ($p<0.05$). A tendency towards a differentiation between the samples for the attributes of intense smell, doughy texture, and taste intensity ($p<0.05$) was also observed.

Research on the development of sensory lexicons for marinated rabbit meat is scarce. Identifying sensory characteristics related to acceptance and dislike during the prototyping stage is crucial for product developers since it could help identify the effects of adding ingredients on sensory attributes. It is helpful to compare the sensory characteristics of prototypes with commercial products (Suwonsichon, 2019; Martinez-Alvarado, 2018). The main characteristics related to consumer liking in this study were soft texture along with a juicy and appetizing appearance. This is because the marinating formula employed

Table 4. Selected sensory attributes in marinated, cooked and roasted rabbit meat samples.

Flavour		Odor		Texture		Appearance	
Intense	8	Intense	6	Soft	11	White	7
Chicken	4	Smoked	6	Hard	10	Appetizing	6
				Dry	5	Juicy	3
				Doughy	4		
				Raw	4		

The selected attributes are presented. Numbers indicate the frequency of mentions made by participants in the quick profile test.

is one of the processing techniques that helps to improve the quality of meat products by increasing juiciness by increasing water-holding capacity (Samant *et al.*, 2016; Gault, 1991; Rao, 1989).

It is noteworthy that rabbit meat marinated with FBP is a commercially available product in the region where this experiment was conducted. The similarity of sensory characteristics found in rabbit meat marinated with the base formulation of the manufacturer, which includes a high content of tenderizer, and the meat prepared with the lowest level of this ingredient, suggests a possibility of changing the formulation used to tenderize the rabbit meat.

Rabbit meat was evaluated by a group of participants, 20% of whom had never previously consumed rabbit meat. Despite this, the overall level of liking observed (9.6±0.3) was good, with differences in liking levels between samples ($p<0.01$). The results of the liking level test are shown in Figure 2.

Meat obtained by marinating with the alternative formulation 1 recorded the highest level of liking, followed by meat marinated with formulation 3. Meat produced with the control treatment recorded the lowest levels of liking, second only to meat marinated with formulation 2.

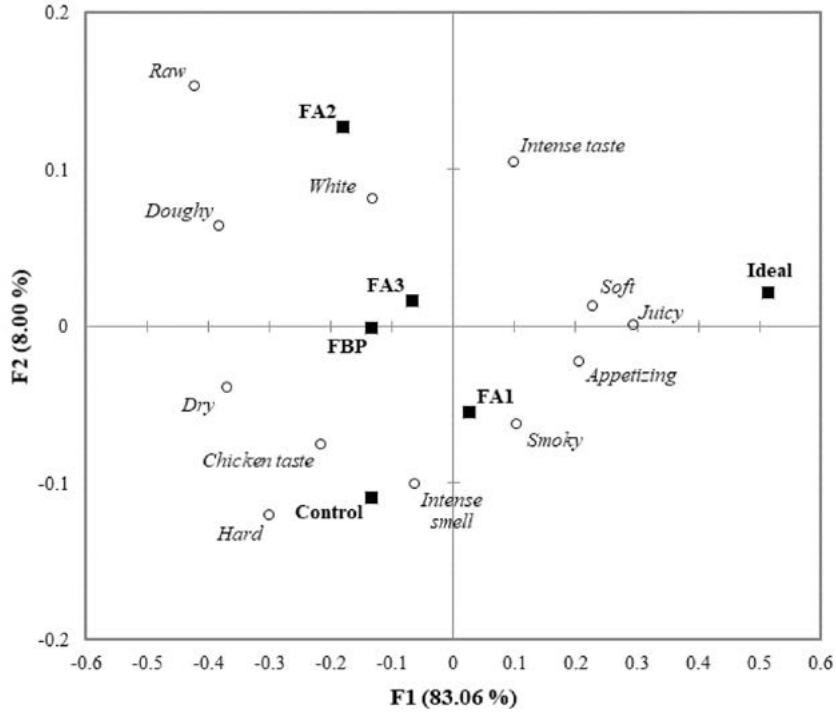

Figure 1. Map of sensory characteristics and marinated roast rabbit meat samples using different formulations. FBP: Supplier's Base Formulation; FA1: Formulation 1 (20.72 g/kg liquid marinated+2 g/kg phosphate); FA2: Formulation 2 (17.25 g/kg liquid marinated+1 g/kg phosphate); FA3: Formulation 3 (5.75 g/ kg liquid marinated+0 g/kg phosphate).

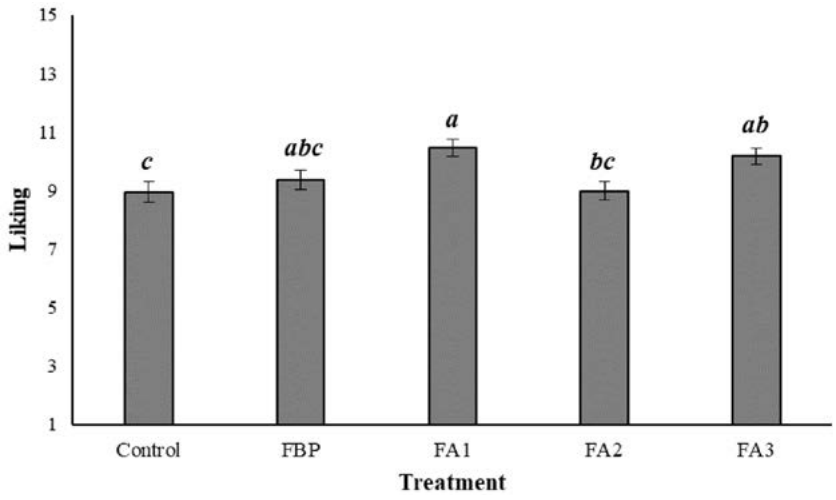

Figure 2. Level of liking for rabbit meat marinated with different formulations. FBP: Base Formulation of the Supplier; FA1: Formulation (20.72 g/kg liquid marinated+2 g/kg phosphate); FA2: Formulation 2 (17.25 g/kg liquid marinated+1 g/kg phosphate); FA3: Formulation 3 (5.75 g/ kg liquid marinated+0 g/kg phosphate). Bars of the same indicator but with different superscript letters (a, b, or c) different significantly ($p<0.05$). SEM, standard error of the means.

CONCLUSIONS

Rabbit meat marinated with different concentrations of liquid marinated and phosphates showed no significant differences compared to the base formulation (FB). The results indicated that there were no notable differences between the formulation with phosphates (FBP) and the treatments with different levels of tenderizer (FA1, FA2, and FA3), which were perceived as favorable in the sensory tests. This finding is particularly important from a competitive perspective, as it allows offering a product with fewer additives, which is a key advantage in today's market that values more natural and healthier products.

The ability to reduce the addition of additives in the marinating process, while maintaining the textural and sensory characteristics appreciated by consumers, positions marinated rabbit meat as an attractive alternative to other commercial products that rely more on these ingredients. This not only improves product perception among health-conscious consumers but also highlights sustainability and naturalness as competitive advantages in a market increasingly conscious of food quality and composition.

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