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Comparison of Vegetarian Sausages: Proximal Composition, Instrumental Texture, Descriptive Sensory Profile and Overall Liking with Consumers

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Abstract: The aims of this research were to know the physicochemical parameters, texture properties and sensory profile of vegetarian sausages through the flash profile, overall liking and purchase intention. Additionally, protein, fat and carbohydrate contents, pH, water activity, color, instrumental texture and descriptive profile were quantified with the overall liking and purchase intention of four sausages: ovo-vegetarian (SO), classic vegan (SC), fine herb vegan (SH) and vegan quinoa (SQ). Regarding the physicochemical properties, significant differences ($p < 0.05$) were obtained. Using the flash profile, consumers described SO with attributes of elasticity, tamale smell, strange smell, characteristic flavor, pastiness, softness, pastel color. SC described as soft, pale color, characteristic odor, characteristic flavor, porous and flexible; SH and SQ characterized by the presence of ingredients, stew flavor, spices, pale and soft color. The SO sample presented greater overall liking and purchase intention compared to the other samples, and had a better texture and higher protein content. Through the HMFA analysis, a positive correlation was obtained between the texture and descriptive sensory of the flash profile, and on the other hand, a correlation between the physicochemical characteristics pH, a_w, color, overall liking and purchase intention.

Keywords: overall liking; texture profile analysis; purchase intention; flash profile; vegan; descriptors

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1. Introduction

Healthy eating and concern for caring for the environment are generating more and more awareness among consumers. For this reason, the food industry shows greater interest in the development of analogues from vegetable proteins that allow the quality characteristics of conventional meat products to be achieved, reducing environmental impact, such as greenhouse gas emissions, acidification, land and consumers' risk of suffering from cardiovascular diseases [1,2].

The use of vegetable proteins in the preparation of meat analogues improves cooking performance, increases protein content and allows obtaining a texture close to a conventional meat product due to its techno-functional properties such as water retention capacity, emulsion formation and properties. gelling agents [3]. However, the total replacement of meat proteins with vegetable proteins can generate sensory changes that affect the acceptability of the product, hence the importance of a sensory analysis [4]. Additionally, among vegetarian products there are ovo-vegetarian products, which contain, in addition to vegetable proteins, ovalbumin in their

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composition, which has been reported to generate a positive effect on the texture of similar sausages [5].

Sensory analysis is carried out with the purpose of obtaining a response from the consumer regarding whether or not they like the appearance or characteristics of the product and if they would be willing to buy it and how often [6]. Although beyond appearance, consumers also condition their purchase intention with the benefits that a certain product can provide, such as its effect on health or whether the product is environmentally friendly [7]. Techniques for describing foods include flavor and texture profile, quantitative descriptive analysis, free profile, flash profile, check all that apply, etc. The flash profile is a methodology used in the field of sensory analysis to have quick access to the sensory positioning of the evaluated products, since it does not require the training of the panelists because they can use their own vocabulary to describe the products and rank them for each attribute previously indicated [8,9].

Hierarchical multiple factor analysis (HMFA) belongs to the group of statistical tools used for multivariate analysis and is applied in the food industry to correlate descriptive sensory profile data with other quality characteristics of products and allows highlighting their sensory and instrumental characteristics. through configurations in the factor map [10]. It has been noted that it is generally used in the study of foods to correlate texture and color data obtained instrumentally and sensorially in products such as cheeses, yogurts, among others [11]. Therefore, the objective of the present study was mainly to evaluate the sensory profile of sausages: ovo-vegetarian (SO), classic vegan (SC), fine herb vegan (SH) and vegan quinoa (SQ) by testing overall liking, intention to purchase and flash profile.

2. Materials and Methods

2.1. Preparation of Sausage Samples

Table 1 shows the characteristics and ingredients of the sausage samples evaluated. The preparation of the ovo-vegetarian sausage consisted of the hydration of the vegetable proteins, mixing with the rest of the ingredients, formation of the emulsion with the addition of the vegetable oil, stuffing (synthetic casings 20 mm in diameter and 12 cm long), cooking (up to internal temperature of 72°C), immediate cooling and storage until analysis. The vegan sausages SH, SC and SQ were purchased at a shopping center in Lima, Peru, and were stored at 4°C until analysis.

Table 1. Proximate composition of ovo-vegetarian (SO), classic vegan (SC), quinoa vegan (SQ) and fine herb vegan (SH) sausage.

Sample	Ingredients	Protein (%)	Fat (%)	Carbohydrates (%)
SO	Egg albumin, soy protein concentrate, chickpea flour, soy protein isolate, wheat gluten, vegetable oil, salt, seasonings, flavoring and colorings.	16.3^{a}	2.57^{c}	6.68^{b}
SC	Soy, soy protein, vegetable oil, potato starch, garlic, onion, flavoring, annatto, smoke essence, natural gum and salt.	14.7^{c}	6.00^{b}	7.80^{a}

SQ	Soy, isolated soy protein, vegetable oil, potato starch, garlic, onion, flavoring, smoke essence, annatto, aromatic herbs, red quinoa, black quinoa, natural gum and salt.	15.6[b]	6.30[a]	4.20[c]
SH	Soy, isolated soy protein, vegetable oil, potato starch, garlic, onion, flavorings, smoke essence, annatto, aromatic herbs, fine herbs, thyme, rosemary, natural gum and salt.	4.00[d]	2.30[d]	2.30[d]

Different letters indicate that data in the same column have significant differences ($p < 0.05$).

2.2. Proximal Composition and Colorimetric Parameters

The protein (AOAC.984.13) and fat (AOAC.2003.05) content was determined, in triplicate, of the SO sample with the methodology established by AOAC [12]. The carbohydrate content was determined by difference [13]. For commercial samples SH, SQ and SC, this information was obtained from the commercial packaging of each product.

The water activity of 2 g of sausage sample was determined using the previously calibrated AquaLab Water Activity Meter (Decagon Devices Inc ®) [14]. The pH of homogenized sample (10 g) was determined in 100 mL of distilled water for 5 min with the use of a potentiometer (Hanna Instruments Co., USA) [15]. The color was determined with the Konica Minolta CR400 colorimeter, the results were reported on the CIELab scale. Also, results were presented for the cylindrical coordinates Hue°, expressed in degrees, and Chroma [16].

2.3. Texture Profile Analysis (TPA)

The texture profile of the four sausage samples was determined according to the methodology proposed by Xiong et al. [17], with some modifications. Samples of 15 mm thickness were cut and conditioned at room temperature for analysis. We worked with the Brookfield Ametek® texturometer with the following configurations: a 5 kg load cell cylindrical probe plate, deformation of 50% of the original height of the sample, pre-test speed of 2 mm/s, speed constant pressure of 1 mm/s and induction force of 5 g. The attributes of hardness, cohesiveness, elasticity and chewiness were reported.

2.4. Sensory Analysis

2.4.1. Consumers

Sensory analysis was worked with people aged 18 - 30 years. The sample was obtained through non-probabilistic convenience sampling. For the flash profile, there were 15 untrained panelists (gender: 40% male and 60% female) and for acceptability and purchase intention, a total of 60 participants were gathered (gender: 52% male and 48% female).

2.4.2. Flash Profile

The flash profile technique was used to generate a sensory profile for each of the sausage samples, which consisted of two stages. In the first, the panelists tested the samples (conditioned at room temperature, with a three-digit code assigned randomly and used table water as a draft) and listed all the attributes (using their own vocabulary) that best describe them. The second stage consisted of updating the personal lists of each of the panelists, where a consensus was generated on

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some terms, and subsequently the samples were ordered in an increasing manner, according to the attributes they indicated in the first section [18].

2.4.3. Overall Liking and Purchase Intention

Overall liking and purchase intention were evaluated with the methodology proposed by Morais et al. [19]. A 9-point hedonic scale (1: dislike it extremely, 9: like it extremely) was used for the overall liking test and a 5-point scale (1: would not buy it, 5: would buy it) for the of purchase intention. Each participant was assigned samples of the four sausages that were 1 cm thick, conditioned at room temperature, and with a different random code for each sample.

2.5. Statistical Analysis

The average and standard deviation of the physicochemical characteristics, texture profile, general acceptability and purchase intention of the sausage samples were quantified and a completely randomized design was applied. An analysis of variance was performed and, if significance ($p < 0.05$) was found, the Tukey mean comparison test was performed. The flash profile was worked through a generalized procruster analysis, determining the ANOVA and the sensory maps of the samples and attributes. In addition, hierarchical multiple factor analysis (HMFA) was applied to all quantified determinations to identify correlations between the sensory profile (results of general acceptability, purchase intention and flash profile analysis) with the physicochemical characteristics and texture profile of the samples. To process the statistical data, RStudio 3.5.0 and XLSTAT 2023 programs, were used.

3. Results and Discussion

3.1. Proximal Composition

Table 1 shows the protein, fat, and carbohydrate content of the four sausage samples. The SH sample presented a lower protein content (4.00%), while SO presented a higher protein content (16.3%), with a $p < 0.05$, due to the protein content of egg albumin [20], soy protein [3] and chickpea flour [21], while in the other formulations the main protein source was soy protein isolate. The difference in the protein content of the SH, SC and SQ samples can be explained by the difference in the dose of soy protein isolate that they presented. The SQ sample was the second to present a high protein content (15.6%), with a $p < 0.05$, and can be explained by its quinoa content in addition to the soy protein isolate. On the other hand, the SO and SH samples presented lower fat content ($p < 0.05$) than the SC and SQ samples; and the SC sample had a high carbohydrate content ($p < 0.05$), while in the SH sample it was lower ($p < 0.05$). The values obtained were different from those reported by Keerthana et al. [22], who developed a vegetarian sausage with a protein content of 18.5% and fat of 3.45%.

In Figure 1, the different ovo-vegetarian sausages studied are shown. In general, sausages have an elongated cylindrical shape and a shiny surface. The SO and SC sausages have similar structure and pale pink color. Samples SQ and SH have a brownish yellow color with the presence of particles (fine herbs) inside.

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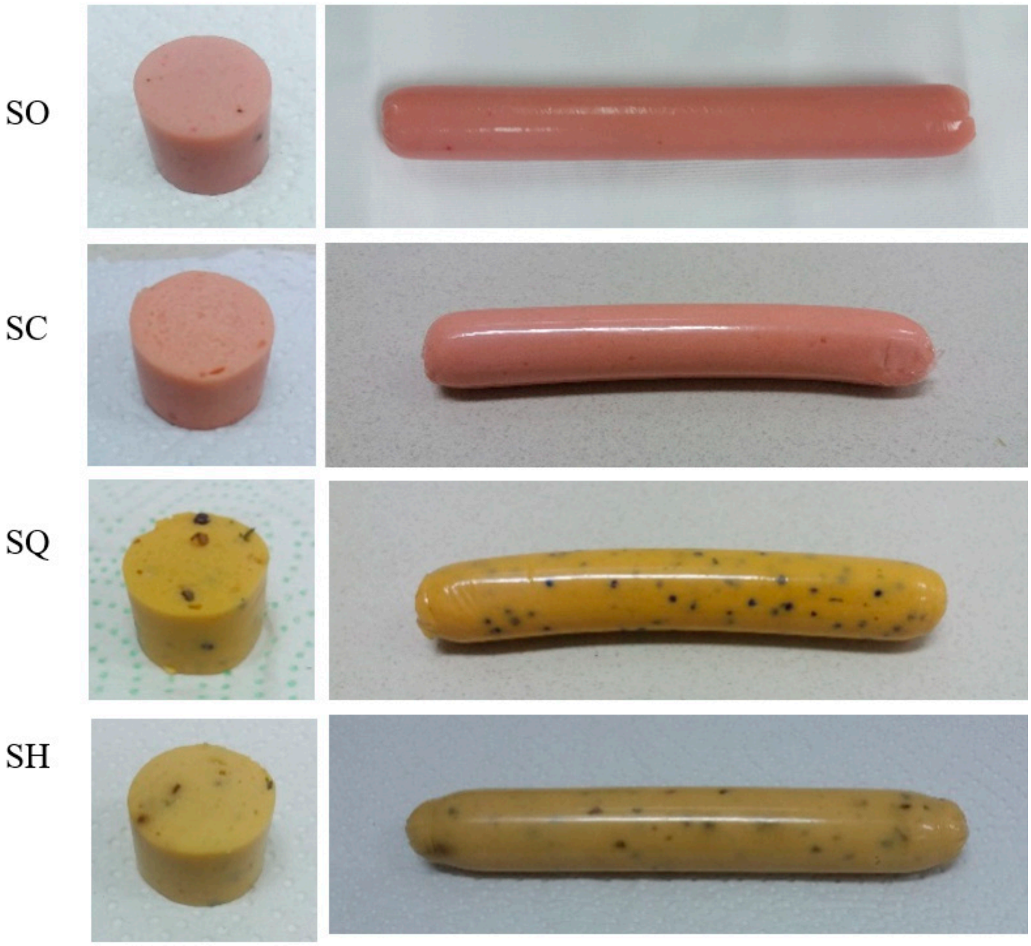

Figure 1. Ovo-vegetarian (SO), classic vegan (SC), quinoa vegan (SQ), and fine herb vegan (SH) sausage samples.

Table 2 shows the physicochemical characteristics of the sausage samples. The SO sample presented a lower pH than the other samples ($p < 0.05$), while the SC and SQ samples presented a higher and similar pH ($p > 0.05$), which is related to the pH of the ingredients that compose them and can be corroborated with what was reported by. Kamani et al. [13] and Keerthana et al. [22], who obtained different pH values in vegetarian sausages developed with different sources of vegetable protein and at different proportions. On the other hand, the SO sample presented greater a_w ($p < 0.05$) than the other samples. The results obtained are within the water activity range of conventional sausages [23].

Table 2. Mean and deviation of the physicochemical characteristics and texture profile of the ovo-vegetarian (SO), classic vegan (SC), quinoa vegan (SQ) and fine herb vegan (SH) sausage.

Sample	pH	a_w	L*	a*	b*	Hue°	Chroma	Hardness	Cohesiveness	Elasticity	Adhesiveness (N-mm)	Chewiness (N)
SO	7.34 ± 0.01^{a}	0.990 ± 0.001^{c}	65.5± 0.17^{a}	17.9 ± 0.05^{d}	7.27 ± 0.08^{a}	22.2 ± 0.28^{a}	19.3 ± 0.02^{a}	19.5 ± 0.90^{c}	0.63 ± 0.06^{b}	0.83 ± 0.06^{a}	0.32 ± 0.00^{a}	10.3 ± 0.86^{c}
SC	7.52 ± 0.01^{c}	0.986 ± 0.001^{b}	66.6 ± 0.02^{c}	17.3 ± 0.03^{c}	16.6 ± 0.04^{b}	43.9 ± 0.05^{b}	24.0 ± 0.05^{b}	13.4 ± 0.21^{a}	0.40 ± 0.00^{a}	0.80 ± 0.00^{a}	0.40 ± 0.03^{b}	4.29 ± 0.07^{a}
SQ	7.51 ± 0.01^{c}	0.986 ± 0.001^{b}	66.9 ± 0.03^{d}	7.87 ± 0.11^{b}	42.8 ± 0.17^{d}	79.6 ± 0.12^{c}	43.5 ± 0.18^{d}	17.9 ± 0.81^{b}	0.57 ± 0.06^{b}	0.80 ± 0.00^{a}	0.40 ± 0.00^{b}	8.07 ± 0.48^{b}
SH	7.38 ± 0.01^{b}	0.984 ± 0.001^{a}	66.1 ± 0.06^{b}	4.09 ± 0.07^{a}	26.8 ± 0.03^{c}	81.3 ± 0.15^{d}	27.2 ± 0.02^{c}	19.7 ± 0.10^{c}	0.60 ± 0.00^{b}	0.83 ± 0.06^{a}	0.37 ± 0.03^{ab}	9.86 ± 0.63^{c}

Different letters indicate that data in the same column have significant differences ($p < 0.05$).

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3.2. Colorimetric Parameters

Table 2 shows that the SO sample presented lower luminosity (L*), a greater tendency towards red (+a*) and a lower tendency towards yellow color (-b*), compared to the other sausages ($p < 0.05$); SC presented an a* value close to SO; SQ presented greater L* and SH less a* ($p < 0.05$). In other investigations, L* values of 68.68 – 70.46 [24] and 59.36 – 68.48 [25] for conventional sausages were reported, which allow corroboration of the results obtained.

The SO and SC samples presented a greater red hue than that reported by Keerthana et al. [22] for a vegetarian sausage. The SQ sample presented a yellow hue greater than the values of 15.00 – 23.40 [26] and 7.32 – 8.32 [27] of conventional sausages obtained in other investigations; while SO, SC and SH presented a yellow tone close to these.

There were significant differences ($p < 0.05$) between the Hue° and Chroma values of the four sausage samples. According to the results, the SO sample presented a pale pink color; the SC sample has a pinkish tone that is closer to red and less pale; the SQ sample a yellow and brighter tone; and sample SH an even yellower shade than SQ but was pale like SC. These values were different from the Hue° (66.6°) and Chroma (13.7) of a chicken sausage [25]. The differences in the color of the sausage samples are related to the different ingredients used in their production and at different doses [9].

3.3. Texture Profile Analysis (TPA)

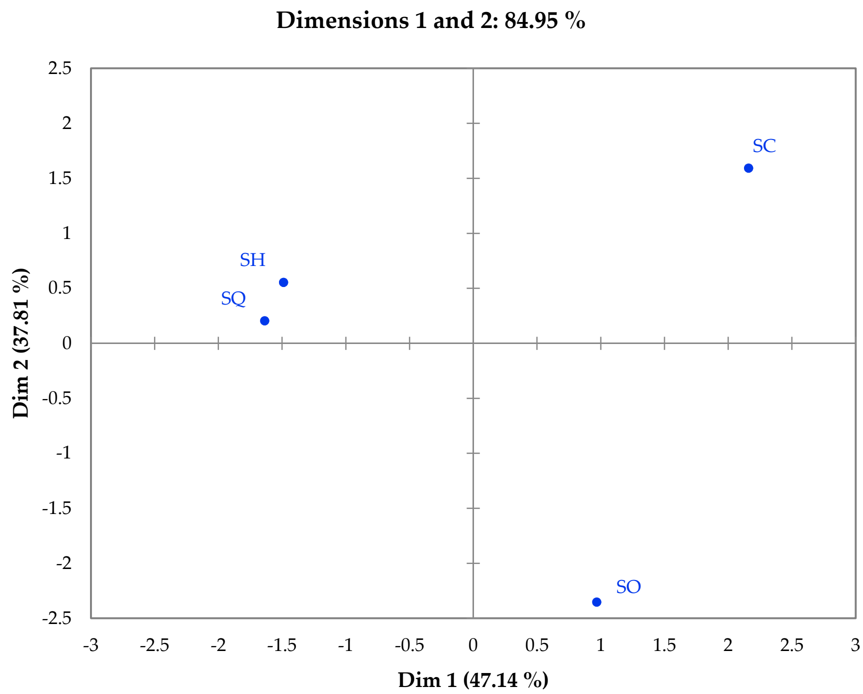
Table 2 shows the results of the texture profile analysis of the sausage samples. There were no significant differences ($p > 0.05$) in the hardness of the SH (19.74 N) and SO (19.51 N) samples, and it was higher than in the other samples due to the gelation capacity of soy protein [3] and egg albumin [5]. Chickpea flour also influenced the hardness of the SO sample, due to its relatively high gelation capacity and its high fiber content that allows water absorption and contributes to hardness [28], in addition the starch content of chickpea flour generated an increase in hardness and chewiness due to the swelling of the starch granules embedded in the protein matrix [29]. The SC sample presented a hardness similar to that of a vegetarian sausage (13.4 N) reported by Kamani et al. [15]. The SO and SH samples also presented greater chewiness ($p > 0.05$) and SC presented less chewiness than the other samples ($p < 0.05$). However, the SO, SQ and SH samples presented greater hardness and chewiness than a chicken sausage with values of 16.7 N and 6.7 N, respectively [30]. Samples SO, SQ and SH presented similar ($p > 0.05$) and greater cohesiveness than sample C, indicating that these samples better preserved their integrity during cooking due to the forces of molecular bonds within the product [31]. Zhao et al. [5] reported the positive effect of egg albumin on the cohesiveness of vegetarian sausages, which allows corroborating the result obtained. There were no significant differences between the elasticity values of the four samples ($p > 0.05$). The results were higher than the elasticity of a chicken sausage with 30% hemp flour (0.79) but lower than that of a conventional chicken sausage, with a value of 0.91 [30]. The SC and SQ samples presented a similar value of adhesiveness ($p > 0.05$) and higher than the other samples, which may be related to the moisture content of the product or to a greater presence of dietary fiber in its composition that improves retention. of water and consequently increases adhesiveness [30].

3.4. Sensory Analysis

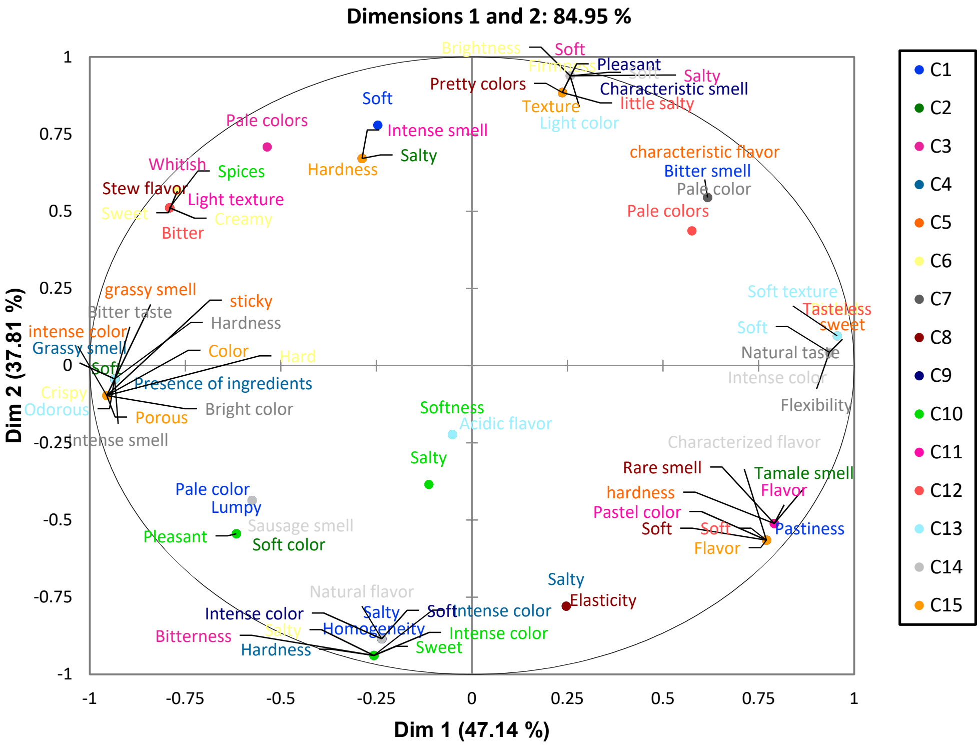
3.4.1. Flash Profile

Figure 2 presents the two-dimensional consensus space, where the four evaluated samples are located. According to Rodríguez-Noriega et al. [32] and Lozano et al. [33], it is necessary to work with two dimensions if they explain more than 80% of the variance of the data. For this reason, it was considered sufficient to analyze the flash profile data of the sausages with the first and second dimensions. In Figure 2 it can also be seen that consumers considered three groups of samples: the first group the SH and SQ samples, and the second and third groups the SC and SO samples, respectively. According to the descriptors seen in Figure 3, the SC sample was characterized as soft, pale in color, characteristic odor, characteristic flavor, porous and flexible; Samples SH and SQ were described as having a bean flavor, spices, pale and soft color.

The SO sample was characterized by being elastic, smelling like a tamale, strange smell, characteristic flavor, pasty, soft, pastel color. The attributes of characteristic flavor and smell, salty, soft texture and pale color have been used as descriptors in a Bologna sausage, where it is mentioned that they are terms frequently used in this type of meat products [34, 14]. Cruz-López et al. [35] also reported descriptors of grassy smell, porous, pasty, grassy taste, plastic, stretchy in their powdered cricket-based sausages.



(a)



(b)

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Figure 2. Two-dimensional graph using the flash profile: Samples (a) and attributes (b). SO: ovo-vegetarian sausage; SH: vegan fine herb sausage; SQ: vegan quinoa sausage; SC: classic vegan sausage.

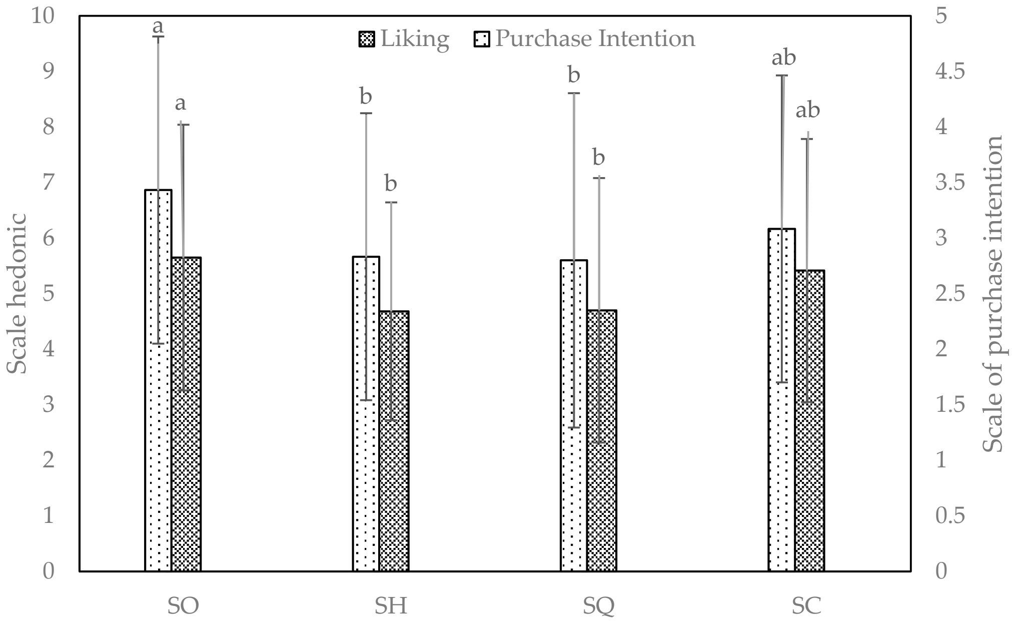

Figure 3. Evaluation results of overall liking and purchase intention of the ovo-vegetarian sausage (SO) and three commercial vegan sausages (SC, SQ and SH).

3.4.2. Overall Liking and Purchase Intention

In Figure 3, no significant differences ($p > 0.05$) are observed in overall liking and purchase intention between the SH and SQ samples. The SO sample presented higher overall liking (5.65/9.00) and purchase intention (3.43/5.00) than the other samples. The acceptability of the product by the consumer is conditioned by aspects such as its appearance, texture, color and flavor [6], which were better in SO, according to consumer preference in the present study. In the case of meat products, consumers prefer a color that gives the sensation of meat; this explains that the SO and SC samples presented greater acceptability and purchase intention due to their more red-pink hue than the SH and SQ samples, which presented a yellow hue [19]. The use of a high dose of vegetable protein and fiber can affect the acceptability of the product by giving it a more pasty or floury consistency [6,19], so the low acceptability may be related with the ingredients used in the preparation and the proportions. Morais et al. [19] developed a collared peccary sausage that presented an overall liking of 7.84 and a purchase intention of 4.19, values higher than what was obtained. Mazumder et al. [36] reported a general acceptability of 5.70 for a vegetarian sausage based on oyster mushroom, chickpea flour, gluten and pea protein isolate, which is also higher than the value obtained.

3.5. Hierarchical Multiple Factor Analysis (HMFA)

The results of the hierarchical multiple factor analysis (HMFA) are shown in Figure 4. The results of the analysis were presented in two dimensions because they explained 86.86% of the variance of the data. Sensory attributes from flash profile analysis (descriptive sensory) were positively correlated with texture; Likewise, there was a correlation between the physicochemical characteristics (pH and a_w), color and the results of overall liking and purchase intention (hedonic); however, there was no correlation between the sensory descriptive and texture with the other variables, as shown in Figure 4a. It has been reported that descriptive sensory data correlates with texture because it is one of the attributes that consumers define most in tasting; However, it is also linked to the overall liking of the product, since in the case of sausages, descriptors such as hardness, chewiness, saltiness are those that lead to greater overall liking and purchase intention [6].

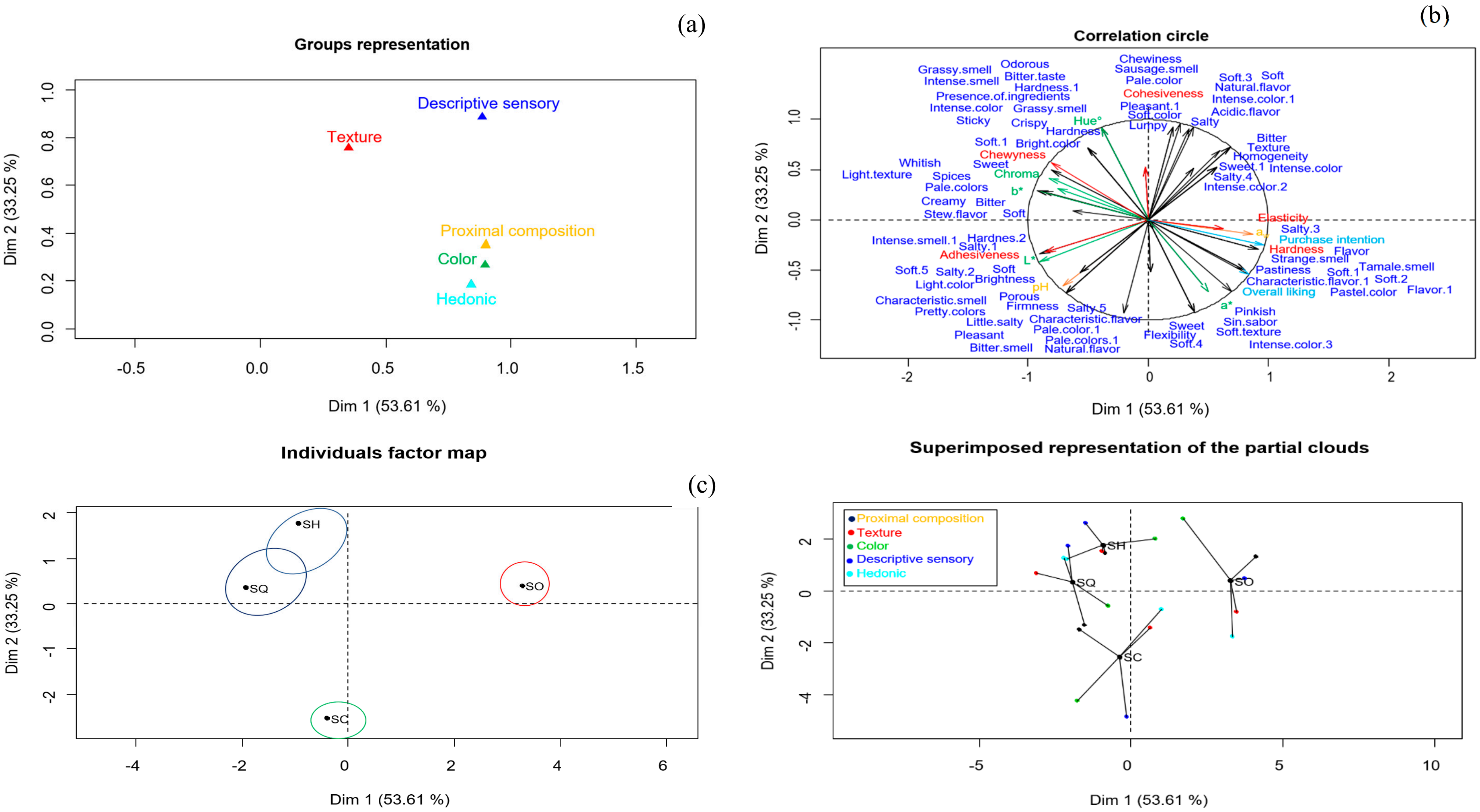

Figure 4. Hierarchical multiple factor analysis (HMFA) generated with the sensory profile and the physicochemical characteristics and texture profile of the sausage samples: (a) two-dimensional graphic representation of the response variables evaluated in the sausage samples, (b) correlation of the sensory profile with the physicochemical characteristics and texture profile, (c) confidence ellipses of the sausage samples with a confidence level of 95%, (d) comparison and statistical approximation of the sausage samples.

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The lack of correlation between descriptive and hedonic sensory data can be explained by the discrepancy between consumers from the flash profile analysis that made it difficult to define consumer preferences towards a product. Valli et al. [37] also obtained a positive correlation between sensory analysis data and the texture of a salami. On the other hand, there is a correlation between color and overall liking and purchase intention, since color is part of the appearance and the consumer generally expects a product to present the same color as the raw material from which it comes [19]. The correlation between pH and water activity with hedonic can be explained by the high overall liking that the SO sample had with a lower pH and higher a_w than the other samples, and how the acceptability decreased with the increase in pH and the decrease in water activity. No information has been found in sausages, but it has been reported that pH significantly influences ($p < 0.05$) the acceptability of drinks with red cabbage and hibiscus extracts due to the acidity that can increase or decrease with different doses of the ingredients. in the formulation [38].

There was dispersion in the color results for the SO sample (Figure 4b), unlike the physicochemical, texture, hedonic and descriptive sensory results where everyone responded similarly. In the SC sample there was greater dispersion in all response variables; In the SH sample, greater consensus was obtained for all response variables, especially in the physicochemical and texture results; and in the SQ sample a small difference was obtained between the response variables but a homogeneous consensus, unlike SC and SO where a greater difference was obtained. The dispersion of the results of the physicochemical properties, color and texture can be explained by factors that affect the evaluation, the margin of error of the equipment or variations in the different sample points; and the variations in the descriptive and hedonic sensory results due to the different vocabulary used by the consumer and the difference in preference, respectively [35,38].

The map of individual factors (Figure 4c) shows the confidence ellipses to determine the existence of significant differences ($p < 0.05$) between the sausage samples. The SQ and SH samples presented similar characteristics ($p > 0.05$) due to the descriptors correlated with dimensions 1 and 2; However, the SO and SC samples are opposite regarding dimensions 1 and 2 ($p < 0.05$). Samples SQ and SH are similar with SC with respect to dimension 1 but are opposite with respect to dimension 2; while SQ and SH are similar with SO in dimension 2, but different with respect to dimension 1. According to Figure 4d, the SO sample presented greater general acceptability and purchase intention, and greater hardness, elasticity, a_w and a* value than the other samples. The SH and SQ samples presented greater hardness, cohesiveness, and chewiness, after SO, and high values of Hue°, Chroma and b*; and SC presented higher luminosity and pH than the other samples. The SH, SQ and SC samples presented greater adhesiveness than SO.

4. Conclusion

The classic vegan and quinoa vegan sausage presented similar pH and a_w values, and there were no significant differences ($p > 0.05$) in the instrumental color of the four samples. The ovo-vegetarian and fine herb vegan sausage presented similar values ($p > 0.05$) of hardness and chewiness. The classic vegan sausage presented lower cohesiveness ($p < 0.05$), there were significant differences ($p < 0.05$) in the elasticity of the four samples; and the classic vegan and quinoa vegan sausage presented similar adhesiveness ($p > 0.05$).

As a result of the flash profile analysis, the ovo-vegetarian sausage was characterized by having a tamale or strange smell, with a pasty, soft and elastic texture, and a pastel color; the classic vegan sausage with descriptors of soft, porous, pale color, with characteristic odor and flavor; and the fine herb vegan and quinoa vegan sausage descriptors such as stew flavor, spices, soft texture and pale color. The ovo-vegetarian sausage presented higher overall liking and purchase intention than the other samples, with values of 5.65 on a nine-point scale and 3.45 on a five-point scale, respectively. The results of the hierarchical multiple factor analysis (HMFA) showed a positive correlation between texture and descriptive sensory, but presented a low correlation with the physicochemical, color and hedonic characteristic variables.

As future research, further studies will be performed to produce emulsified meat products by adding coloring-antioxidant compounds, obtained by ultrasound technology from agro-industrial waste such as fruit peel, and evaluating their effect on sensory features.

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Data Availability Statement: The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to privacy.

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Conflicts of Interest: The authors declare that they have no conflict of interest.

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