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QUALITATIVE DIFFERENCES CAUSED BY THE ADDITION OF LIQUID SMOKE IN MEAT PRODUCTS WITH DIFFERENT STRUCTURES COMPARED TO TRADITIONAL SMOKING

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Abstract

The aim of this study was to compare the qualitative and sensory disparities between conventionally smoked meat products and those treated with liquid smoke. Conducted at the University of Life Sciences' meat micro-production workshop (IULS), the experiment yielded three batches of meat samples: compact, heterogeneous, and emulsion. While batches 2 and 3 received treatments of 0.1% and 0.2% liquid smoke, respectively, across all three product categories, the control batch was subjected to conventional smoking. Twenty semi-trained evaluators conducted both sensory and physicochemical analyses. Liquid smoke significantly altered the texture, flavour, and appearance of emulsion-type goods, favouring samples that had been traditionally smoked. The variations were less pronounced in the products with heterogeneous structures, where there was a slight preference for the control batch and a considerable appreciation for the 0.2% liquid smoke batch.

Key words: *liquid smoke, meat products, sensory preferences, smoking methods.*

INTRODUCTION

The food industry is extensively researching and developing new products to meet the growing consumer demand for healthier options. Through reformulating food preparations, the aim is to enhance the physiological activity of natural nutrients or incorporate bioactive components to satisfy this continually expanding demand from consumers (Anchidin et al., 2023).

For decades, traditional smoking has been employed to preserve food, particularly meat. Smoke derived from wood burning not only aids in maintaining food quality through its antioxidant and antibacterial properties but also imparts appealing sensory characteristics to smoked preparations (Lingbeck et al., 2014).

The antimicrobial and antioxidant properties of smoke have been extensively researched by scientists from various countries over the years (Gucianu et al., 2023). Formaldehyde and phenols are emitted when wood is burned, imparting preservative characteristics to the resulting smoke. These chemical compounds hinder the growth of various microorganisms and limit oxidative reactions during the smoking process (Abou-Taleb et al., 2011).

Utilizing liquid smoke presents a quicker alternative to traditional smoking practices, offering environmental benefits and preserving the sensory attributes characteristic of traditional smoke, while simultaneously reducing the presence of potentially harmful compounds. Employing liquid smoke is a safer alternative to traditional smoking techniques due to the ability to eliminate residue molecules of polycyclic aromatic hydrocarbons (PAH) through re-distillation purification (Saloko et al., 2014).

Furthermore, the accumulation of tar residues and harmful air pollutant (HAP) chemicals, such as benzopyrene, in products can adversely affect consumer health. Thus, the use of the liquid smoke technique allows for a more convenient application of smoke flavor in food, as it can be simply immersed or introduced into food (Indiarto et al., 2020).

The purpose of this paper is to underscore the qualitative differences in meat preparations with various structures (compact, heterogeneous, and emulsified) processed by the addition of liquid smoke compared to the conventional smoking method. The research objectives are focused on analyzing the sensory and chemical parameters of the obtained batches.

MATERIALS AND METHODS

To achieve the set objectives, three distinct categories of meat products were developed, each with a specific structure: emulsified sausages, sausages with a heterogeneous structure, and smoked loin, with a compact structure.
The experimental materials were purchased from a local hypermarket and subsequently processed in the meat micro-production workshop of the "Ion Ionescu de la Brad" Iași University of Life Sciences, undergoing selection and processing operations resulting in pork products.
For each type of preparation, three different batches were formulated: one control batch smoked by the traditional method (L1), and two batches processed using liquid smoke flavoring (L2 and L3). The liquid smoke was purchased from ROCAS FDS SRL and composed of natural smoke extract and acetic acid. Concentrations of 0.1% and 0.2% were used for this study, as recommended by the manufacturer.
The formulation of control and experimental batches was based on a technological flow, utilizing raw materials, spices, and flavors as listed in Table 1. For preparations with a compact structure, after selection and preparation, the pork was brined with a 10% salt solution and liquid smoke, then immersed in the brine for 24 hours.
The technological process for obtaining preparations with a heterogeneous structure (sausages) followed the stages outlined in the study by Ciobanu et al. (2023), with optimal adjustments for the desired preparation. For preparations with an emulsified structure, the process followed the method outlined in the study by Manoliu et al. (2023), with specific modifications for this type of product. Initially, raw meat was coarse-ground using a WP-105 grinder with a 3 mm diameter sieve, then finely ground using a meat grinder (Cutter Titane V 45L) commonly used in the food industry for grinding cold or frozen meat. The mixture was homogenized until a fine and homogeneous meat paste was obtained. In the case of minced meat preparations, the liquid smoke was integrated into the paste during mixing.

Table 1. Formulation of experimental batches

	Ingredients	UM	Batch 1	Batch 2	Batch 3
Sausages	Pork meat	kg	2,4		
	Garlic	g/kg	15		
	Pepper		5		
	Coriander		3		
	Emulsifier		2		
	Liquid smoke		-	1	2
Emulsified sausages	Pork meat	kg	2,4		
	Garlic	g/kg	2		
	Pepper		2		
	Coriander		0,5		
	Emulsifier		4		
	Liquid smoke		-	1	2
Smoked loin	Pork loin	kg	2		
	Salt (in brine)	%	10		
	Liquid smoke	g/kg	-	1	2

UM - unit of measurement

The thermal treatment was adapted according to each type of preparation and each batch separately, so batch 1 represents the control batch for the resulting preparations, batch 2 and 3 are represented by the batches in which flavours of liquid smoke were used. Table 2 shows the times and temperatures used for preparation.

Table 2. Heat treatment applied to obtain formulations with different structures

Formulation	Batch	Air drying		Smoking		Hot air cooking	
		Time	*°C*	*Time*	*°C*	*Time*	*°C*
Sausages	SHL1	20	45	30	50	30	76
	SHL2			-	-		
	SHL3						
Emulsified sausages	SEL1	30	60	20	70	60	78
	SEL2			-	-		
	SEL3						
Smoked loin	SCL1	30	65	30	72	50	86
	SCL2			-	-		
	SCL3						

SHL1 - heterogeneous structure - control batch, SEL2 - emulsified structure - batch 0.1% liquid smoke, SCL3 - compact structure - batch 0.2% liquid smoke.

After obtaining the experimental batches, they underwent chemical and sensory analyses. The determination of the chemical composition of the experimental batches involved measuring the main components, including moisture, protein, collagen, fats, and salt. These determinations were conducted using the Food-Check automatic meat analyzer, which utilizes near-infrared (NIR) spectroscopy, referring to the region of the electromagnetic spectrum located near the infrared spectrum, with

wavelengths between approximately 700 and 2500 nm.
The sensory analysis was conducted in the University's sensory analysis laboratory with a group of 20 semi-trained students, aged 20-23 years, without health problems, and with a diet that frequently includes meat products. At the beginning of the session, the evaluators were trained on the contents of the questionnaire and the terms used, to familiarize them with the descriptive terms. The samples were sliced using a professional slicer to ensure sample uniformity and presented to the evaluators in random batch order, coded with 3 randomly chosen digits to maintain sample anonymity.
For the sensory analysis, descriptive tests were conducted to asses the flavor and texture profiles, along with affective tests (hedonic test). The flavor profile followed the ISO 6564:1985 standard, considering sensory characteristics of smell (pork aroma, fat aroma, spice aroma, and smoke aroma) and taste (mouthfeel and aftertaste). For the texture profile, characteristics such as hardness, elasticity, juiciness, and masticability perception were analyzed, following the ISO 11036:2020 standard. The hedonic test employed a 9-point scale, following the method outlined by Manoliu et al. (2023).
Data interpretation utilized the Principal Component Analysis (PCA) method, a statistical technique used to reduce the number of dependent variables in a dataset by identifying underlying variables, known as factors, through analysis of correlation patterns between the original variables (Lawless, 2010).
The results obtained from the chemical and sensory determinations of the evaluated batches were compared using analysis of variance (ANOVA), followed by the Tukey test at a significance level of 5% ($p < 0.05$) using XLStat V.24.

RESULTS AND DISCUSSIONS

The data obtained for the three types of preparations with different structures are presented in Table 3. No significant differences were identified between batches of preparations with a heterogeneous structure (sausages) in terms of moisture, lipid, protein, and collagen content ($p > 0.05$). However, a significant difference in salt content ($p < 0.05$) was observed between batches in this product category. The salt content of the control sample (SHL1) was significantly higher than that of the SHL2 and SHL3 samples. Thus, the introduction of liquid smoke at different concentrations appears to have a significant effect on the salt content in pork sausages.
Regarding emulsified preparations, there were no significant differences between batches in terms of moisture, lipid, protein, collagen and salt content ($p > 0.05$).

Table 3. Chemical analysis results

Category	Moisture (%)	Lipid (%)	Protein (%)	Collagen (%)	Salt (%)
SHL1	$62.62^{a} \pm 1.68$	$15.14^{a} \pm 3.25$	$18.70^{a} \pm 0.04$	$16.80^{a} \pm 0.04$	$2.58^{a} \pm 0.16$
SHL2	$61.96^{a} \pm 0.36$	$17.20^{a} \pm 0.45$	$19.66^{a} \pm 1.77$	$18.12^{a} \pm 2.08$	$2.14^{b} \pm 0.09$
SHL3	$63.24^{a} \pm 1.14$	$14.60^{a} \pm 2.79$	$19.86^{a} \pm 1.59$	$18.24^{a} \pm 1.97$	$2.30^{b} \pm 0.12$
Pr > F(sig.)	***0.273***	***0.257***	***0.390***	***0.345***	***0.001***
SEL1	$61.96^{a} \pm 0.53$	$17.48^{a} \pm 0.18$	$18.28^{a} \pm 0.27$	$16.40^{a} \pm 0.28$	$2.28^{a} \pm 0.24$
SEL2	$62.70^{a} \pm 0.04$	$16.30^{a} \pm 0.09$	$18.60^{a} \pm 0.07$	$16.60^{a} \pm 0.04$	$2.40^{a} \pm 0.09$
SEL3	$62.80^{a} \pm 0.96$	$15.64^{a} \pm 2.30$	$19.28^{a} \pm 1.30$	$17.52^{a} \pm 1.61$	$2.28^{a} \pm 0.11$
Pr > F(sig.)	***0.112***	***0.128***	***0.15***	***0.178***	***0.382***
SCL1	$62.92^{a} \pm 0.81$	$14.46^{a} \pm 2.68$	$20.16^{a} \pm 1.98$	$16.86^{b} \pm 0.39$	$2.06^{b} \pm 0.09$
SCL2	$63.32^{a} \pm 1.54$	$14.00^{a} \pm 3.29$	$20.25^{a} \pm 1.84$	$18.80^{ab} \pm 2.20$	$2.42^{a} \pm 0.18$
SCL3	$64.10^{a} \pm 0.35$	$11.60^{a} \pm 0.52$	$21.92^{a} \pm 0.18$	$19.80^{a} \pm 1.51$	$2.38^{a} \pm 0.22$
Pr > F(sig.)	***0.221***	***0.187***	***0.242***	***0.032***	***0.011***

Values are expressed as means ± SE from triplicate determinations; letters a-b in each column represent statistically significant differences ($p < 0.05$) determined by Tukey's test. SH - heterogeneous structure, SE - emulsified structure, SC - compact structure.

The moisture, lipid, and protein content did not show significant differences between batches of preparations with a compact structure, SCL1, SCL2, and SCL3 ($p > 0.05$). However, there was a significant difference in collagen content between batches. The values for SCL1 were significantly lower than those of SCL2 and SCL3, and the value for SCL2 was significantly

lower than that of SCL3. This could be related to the conventional smoking procedures applied. Khalid W. et al. (2023) confirm in their study that major meat proteins are denaturated by heat; denaturation of actin and myosin has been connected to harder meat; denaturation of collagen has been linked to a loss in firmness. Additionally, there was a significant difference in salt content ($p < 0.05$) between the control batch (SCL1) and the experimental batches (SCL2 and SCL3). Thus, the SCL2 and SCL3 samples appeared to have higher collagen and salt content compared to the control sample, SCL1.
Following the sensory analysis of the three types of preparations with different structures, the results were grouped according to the tests applied: descriptive tests (flavor and texture profile) and acceptance test (hedonic test).

Flavor profile

For the experimental batches of meat products with a heterogeneous structure, the sensory attributes followed in the flavor profile were represented by olfactory characteristics: pork smell (MCP), fat smell (MG), smoky aroma (MA); taste features: salty taste (GS), pork taste (GCP), fat taste (GG), spice taste (GC), and smoke taste (GA), along with mouthfeel (the general sensation of the product in the oral cavity). The sensory attributes pursued were chosen according to the specifics of each category of preparations.
Principal Component Analysis (PCA) revealed the direction and intensity of descriptive sensory attributes for batches of preparations with a heterogeneous structure with different percentages of added liquid smoke and allowed comparison of sensory profiling data with the conventional smoked control batch. In the first dimension (F1, 55.62%) of the variation, the aroma of smoke, fat taste, and fat odor were associated. The second dimension (F2, 44.38%) was mainly associated with the aroma of spices, pork, smoke, meat, salt, and a pleasant mouthfeel.
Figure 1 illustrates a distinct variation between batches of preparations with a heterogeneous structure, although the boundary between SHL2 (947) and SHL3 (503) is less defined, with this variation attributed to the technological processes used.

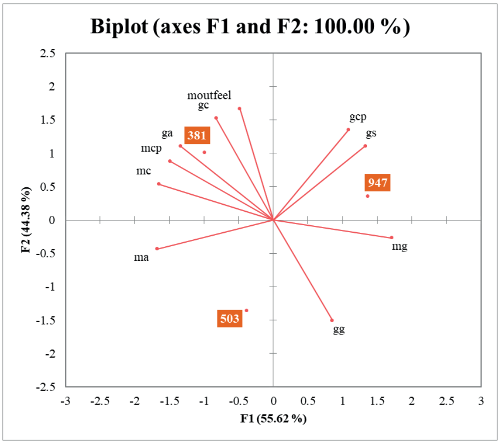

Figure 1. Principal Component Analysis (PCA) for consumer preference and sensory profile of 3 batches of heterogeneously structured products. Sample codes 381, 942 and 503 represent SHL1, SHL2 and SHL3 respectively

In the second dimension, the SHL3 batch (503), with 0.2% added liquid smoke, exhibited the most intense smoking aroma, while the SHL1 (381) and SHL2 (947) batches showed lower perception of this feature. Regarding taste, both the meat and salt were more pronounced in the batch with 0.1% liquid smoke (947).
For batches of products with an emulsified structure (Figure 2), the positioning of the batch with 0.1% liquid smoke (725) in the upper right quadrant of the biplot indicates high levels of olfactory characteristics (MCP, MG, MA) and moderate levels of taste characteristics (GS, GCP, GA). This suggests that 0.1% smoked emulsified sausages have a more intense taste and a moderate flavor.
Batch 492 (emulsified sausages with 0.2% liquid smoke) is located in the lower right quadrant of the biplot, indicating high levels of taste characteristics (GS, GCP, GA) and high levels of olfactory characteristics (MCP, MG, MA). This suggests that smoked emulsified sausages with 0.2% liquid smoke have an intense taste and flavor. Although batch 169 (conventional smoked emulsified sausages) is on the left side of the chart, it does not necessarily indicate negative characteristics. Its position is determined by its values on the F1

and F2 axes, reflecting a positive influence of olfactory, taste, and sensory characteristics.

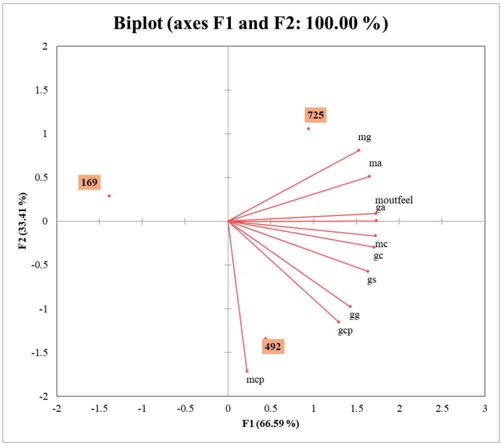

Figure 2. Principal Component Analysis (PCA) for consumer preference and sensory profile of 3 batches of emulsified structure products. Sample codes 169, 725 and 492 represent SEL1, SEL2 and SEL3, respectively

The experimental lots of cotlet were obtained by immersing the meat pieces in the brine with added smoke flavor. Conventional smoking involves directly exposing the product to natural smoke from wood burning. This process imparts a more complex and intense flavor characterized by notes of smoke, wood, and meat, which explains the presence of the control batch in the upper quadrant (Figure 3), where the smoky taste is predominant. Yin et al. (2021), in a study on the influence of industrial smoking on the aromatic profile of certain meat products, obtained similar results in sensory analysis regarding the smoky taste characteristic.

Figure 3 illustrates a distinct variation between batches of compact-structured preparations. The use of conventional smoking, as exemplified by the control batch (614), seems to result in a distinctive sensory profile characterized by a higher intensity of smoky taste.

In contrast, the application of the smoke flavor, represented by samples 270 and 836, seems to significantly influence the overall taste and sensation, with less impact on the latter batch. The subtle differences between samples with smoke flavor at different concentrations suggest the precise importance of the percentage of liquid smoke used, with sample 836 showing a better defined balance between taste and sensation, while sample 250 highlights a more temperate taste and a less sense of pleasure.

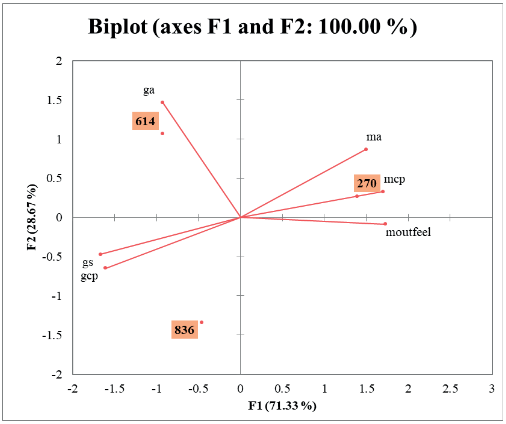

Figure 3. Principal Component Analysis (PCA) for consumer preference and sensory profile of 3 batches of compact structure products (pork loin). Sample codes 614, 270 and 83 represent SCL1, SCL2 and SCL3, respectively

Texture profile

The texture profile analysis encompassed the sensory characteristics of hardness, elasticity, juiciness, adhesiveness, and chewiness of the analyzed lots. The F1 axis primarily correlates with hardness and chewiness characteristics. Samples with higher values on the F1 axis are harder and more challenging to chew, whereas those with lower values are softer and easier to chew.

The F2 axis primarily relates to elasticity and succulence characteristics. Samples with higher values on the F2 axis are more elastic and juicy, while those with lower values are less elastic and drier.

The control batch of conventionally smoked sausages, SHL1 (503), is positioned at the top of the biplot (Figure 4), with higher values on the F1 axis and lower values on the F2 axis. This indicates that these sausages were perceived as harder, tougher to chew, and drier. For batches in which liquid smoke was utilized, specifically sausages with a concentration of 0.1% liquid smoke, SHL2 (381), positioning is observed in the center-left part of the biplot, with moderate values on both axes. This suggests that these sausages exhibit average hardness and chewiness, moderate elasticity, and moderate juiciness. Sausages formulated with a concentration of 0.2% liquid smoke, SHL3

(947), are situated on the lower left side of the biplot, with smaller values on both the F1 and F2 axes. This indicates that these sausages are soft, easy to chew, less elastic, and less juicy.

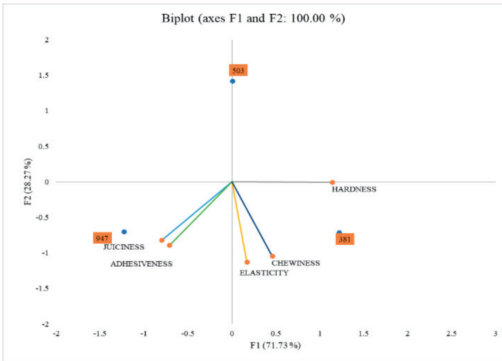

Figure 4. Principal Component Analysis (PCA) for consumer preference and sensory profile of 3 batches of heterogeneously structured products. Sample codes 503, 381 and 947 represent SHL1, SHL2 and SHL3, respectively

In this regard, a negative correlation has been highlighted between the amount of liquid smoke and the firmness of the sausages. An increased concentration of liquid smoke leads to softer sausages with improved masticability. Additionally, there is a direct relationship between the amount of liquid smoke and the flexibility and succulence of sausages. Thus, increasing the concentration of liquid smoke results in obtaining a more elastic and juicy texture of the products. Similar results were obtained by Yusnaini et al. (2012), who investigated the effect of different levels of dilution of liquid smoke in meat preparations, reporting after sensory evaluation that an increase in the amount of liquid smoke increases the tenderness of the meat.

For the batches of the emulsified structure product category (Figure 5), the results highlight a significant negative correlation between the amount of liquid smoke and the hardness of the emulsified sausages. The higher the concentration of liquid smoke, the softer and easier to chew the emulsified sausage become. Additionally, a significant positive correlation is observed between the amount of liquid smoke and the elasticity and juiciness of the emulsified sausages. Higher concentrations of liquid smoke lead to emulsified sausages that are more elastic and juicy.

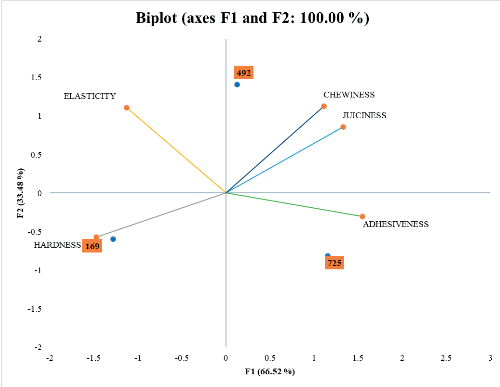

Figure 5. Principal Component Analysis (PCA) for consumer preference and sensory profile of 3 batches of products with emulsified structure. Sample codes 169, 492 and 725 represent SEL1, SEL2 and SEL3, respectively

The biplot indicates that conventionally smoked emulsified sausages (169) are situated in the lower left quadrant, denoted by modest values along both axes, F1 and F2. This validates the dry, tough, and difficult to mastic consistency of traditionally smoked emulsified sausages.

The biplot illustrates emulsified sausages containing 0.1% (492) liquid smoke, which are positioned in the center-right. The values along both axis are moderate. This position signifies an intermediate texture, as indicated by the mean values of succulence, firmness, chewiness, and elasticity.

The biplot illustrates emulsified sausages containing 0.2% (725) liquid smoke as the subject matter. The F1 axis represents small values, while the F2 axis represents large values. With a greater concentration of liquid smoke, this position verifies that smoked emulsified sausages have a tender, elastic, chewy, and squishy consistency. Probably as a result of the hydration of the emulsified sausages, liquid smokiness imparts a more appetizing texture to the sausages.

In regard to the samples falling under the compact structure product category (as illustrated in Figure 6), batch SCL1 (614) (conventional smoked cotlet), which is situated on the left-hand side of the chart, exhibited diminished levels of elasticity, succulence, and adhesiveness. In terms of firmness and chewiness, proximity to the F1 axis indicates that this sample is comparable to sample 836 (which contains 0.2% smoke flavor). Sample

270, which is a cotlet smoked with 0.1% liquid smoke, exhibits a greater degree of adhesion, succulence, and elasticity, as indicated by its position at the top of the chart.

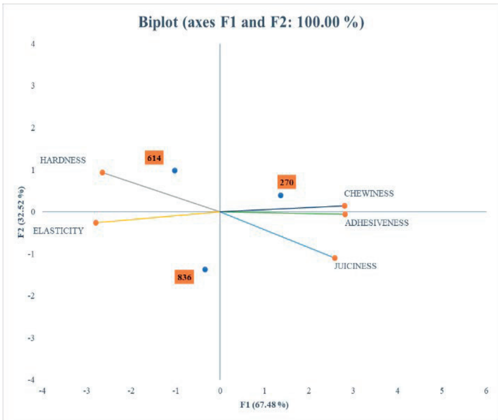

Figure 6. Principal Component Analysis (PCA) for consumer preference and sensory profile of 3 batches of products with compact structure. Sample codes 270, 614 and 836 represent SCL1, SCL2 and SCL3, respectively

In close proximity to the F2 axis, hardness and intense gnawing are less probable. Sample 836, which is a cotlet smoked with 0.2% liquid smoke, exhibits reduced elasticity, succulence, and adhesiveness, as evidenced by its position at the bottom of the graph. The PCA chart elucidates notable distinctions in texture between cotlets smoked conventionally (614) and those inhaled with liquid (270 and 836).

It appears that liquid smoke has a substantial effect on the succulence, adhesiveness, elasticity, and hardness of the smoked cotlet, but a lesser effect on its chewiness and hardness. The texture profile of the conventionally smoked cotlet (614) appears to be more preferable, as it is distinguished by increased succulence, superior adhesion, reduced hardness, and simplified chewing. The quantity of liquid smoke used did not exhibit a discernible correlation with the texture profile of the cotlet that had been smoked. The texture profile of the 0.1% liquid smoke sample (270) is comparable to that of the control sample (614), whereas the texture profile of the 0.2% liquid smoke sample (836) is less preferable.

Table 4 concentrates the data obtained from the hedonic test applied to the three types of meat preparations. The variance analysis (ANOVA) was used to determine whether there are statistically significant differences between the sausage samples (SHL1, SHL2 and SHL3) with regard to the variables analysed. The Tukey HSD test was used to individually compare the differences between smoked samples and to identify which samples differ statistically significantly from each other.

Table 4. Results of the acceptability test for samples with heterogeneous structure (hedonic test)

CATEGORY	APPEARANCE	COLOR	FLAVOR	TASTE	TEXTURE	GENERAL APPRECIATION
SHL1	6.35±1.60	6.95±1.54	7.05±1.57	7.40±1.35	6.75±1.65	8.00±0.97
SHL2	7.15±1.48	7.50±1.40	6.30±1.56	6.15±1.50	6.80±1.47	6.90±1.71
SHL3	7.10±1.48	7.10±1.48	6.45±1.54	7.45±1.47	6.80±1.40	7.45±1.05
Pr > F(sig.)	***0.007***	***0.479***	***0.098***	***0.008***	***0.993***	***0.033***

Values are expressed as means ± SE for a panel of 20 raters; $p > 0.05$ = non-significant differences, $p < 0.05$ = significant differences; $p < 0.01$ = distinctly significant differences; $p < 0.001$ = highly significant differences, determined by Tukey test. SH - heterogeneous structure.

The analysis of batch appearance revealed statistically significant differences between the control batches (SHL1) and the experimental batches (SHL3 and SHL2, $p < 0.05$), with the SHL1 batch obtaining a significantly lower score. Conversely, no statistically significant differences were observed between SHL2 and SHL3 lots ($p > 0.05$).

These results suggest a negative association between the use of traditional smoke and consumer perception of the visual appearance of smoked meat preparations. The SHL1 batch, which used traditional smoke, was perceived to be less visually attractive than the SHL2 and SHL3 batches, which contained liquid smoke (0.1% and 0.2%, respectively). However, it is important to point out that the score difference between the SHL1 and SHL2 lots is not practically significant.

Regarding the color of the batches, the results suggest that the use of liquid smoke may influence consumer perception of the color of smoked meat dishes. A low concentration of liquid smoke (0.1%) seems to be associated with a more intense and attractive color, while higher concentrations (0.2%) may have a lesser impact on the color.

The flavor analysis revealed insignificant variations ($p > 0.05$) in flavor, with the SHL2 sample receiving the lowest score. This suggests that the smell of the lot with liquid smoke is assessed as being less strong compared to those with traditional smoke. These results suggest a consumer preference for the more intense flavor of smoked meat preparations associated with traditional smoke.

Taste analysis revealed statistically significant differences between SHL1, SHL2, and SHL3 samples ($p < 0.05$). The SHL3 sample, which contained 0.2% liquid smoke, obtained a significantly higher score than the SHL1 (traditional smoke) and SHL2 (0.1% liquid smoke). The SHL1 sample obtained a significantly higher score than the SHL2. These results suggest a consumer preference for the stronger and richer taste of smoked meat preparations associated with traditional smoke. The SHL3 sample, with a higher concentration of liquid smoke, was also perceived to have a more intense taste.

The texture analysis did not identify statistically significant differences between the samples SHL1, SHL2, and SHL3 ($p > 0.05$). This result suggests that the texture of smoked meat preparations was not significantly influenced by the type of smoke used (traditional versus liquid). Similar reports in terms of general acceptability have also been made by Bhuyan et al. (2018).

The analysis of the results for appearance and color highlighted a significant preference of consumers for liquid smoke samples compared to the traditional smoke sample, while the attributes of flavor, taste, and overall appreciation were more appreciated in the traditionally smoked sample. These results suggest a dominant trend towards products containing liquid smoke, at a concentration of 0.2%. The harmonious combination of more intense color, stronger taste, and pleasant flavor of the SHL3 sample seems to have contributed to this preference.

Statistical analysis of sensory characteristics is found in Table 5, highlighting significant differences ($p < 0.05$) between the batches of products for appearance and taste attributes. The SEL1 batch, subjected to traditional smoking, obtained mean scores for appearance, significantly higher ($p < 0.05$) compared to the SEL2 and SEL3 batches treated with liquid smoke. No significant differences were observed between the batches in terms of color. These results suggest that the use of liquid smoke did not substantially influence the product's color perception.

The flavor analysis did not identify statistically significant differences ($p > 0.05$) between the batches of smoked meat products. This finding suggests that the use of liquid smoke did not significantly affect the olfactory perception of the product.

The taste analysis revealed statistically significant differences ($p < 0.001$) between lots of smoked meat products. The SEL1 batch containing traditional smoke obtained a significantly higher taste score compared to the SEL3 batches (0.2% liquid smoke) and SEL2 (0.1% liquid smoke). These results suggest a consumer preference for the stronger and richer taste of smoked meat preparations associated with traditional smoke. The SEL3 batch, with a higher concentration of liquid smoke, was perceived to have a more intense taste compared to the SEL2 batch.

The acceptability test showed no statistically significant variations between batches in terms of texture. This finding indicates that the use of liquid smoke did not exert a remarkable influence on the product's tactile perception.

The addition of liquid smoke had a significant impact on the sensory properties of emulsion-type preparations, mainly significantly influencing the appearance and taste of the products. These results suggest a significant preference of consumers for the classic smoked emulsion type preparations, appreciated for the more attractive appearance, stronger and richer taste. Although the liquid smoke significantly influenced the taste of the dishes, it failed to fully reproduce the complex and rich taste of traditional smoking.

Table 5. Results of the acceptability test for samples with emulsified structure (hedonic test)

CATEGORY	APPEARANCE	COLOR	FLAVOR	TASTE	TEXTURE	GENERAL APPRECIATION
SEL1	7.70±0.80	6.75±1.65	6.90±1.71	7.35±1.04	7.20±1.44	7.65±1.09
SEL2	6.25±1.07	7.50±1.40	6.45±1.54	6.00±1.45	6.75±1.65	6.90±1.71
SEL3	6.50±1.54	6.75±1.65	6.80±1.54	6.65±1.39	6.80±1.40	6.60±1.35
Pr > F(sig.)	***0.001***	***0.227***	***0.095***	***0.007***	***0.585***	***0.061***

Values are expressed as means ± SE for a panel of 20 raters; p > 0.05 = non-significant differences, p < 0.05 = significant differences; p < 0.01 = distinctly significant differences; p < 0.001 = highly significant differences, determined by Tukey test. SE - emulsified structure

The results of the statistical analysis of the acceptability test for compact-structured samples (Table 6) highlighted significant differences (p < 0.05) between batches in terms of taste, whereas for the attributes appearance, color, flavor, texture and overall appreciation no significant difference (p > 0.05) was identified.

Table 6. Results of the acceptability test for samples with compact structure (hedonic test)

CATEGORY	APPEARANCE	COLOR	FLAVOR	TASTE	TEXTURE	GENERAL APPRECIATION
SCL1	6.85±1.66	6.85±1.66	7.00±1.56	7.45±1.47	6.80±1.40	6.95±1.47
SCL2	6.35±1.60	7.50±1.40	6.45±1.54	6.15±1.50	6.75±1.65	6.90±1.71
SCL3	6.15±1.50	6.75±1.65	6.70±1.71	6.35±1.60	6.80±1.47	7.25±1.25
Pr > F(sig.)	***0.363***	***0.271***	***0.181***	***0.019***	***0.993***	***0.725***

Values are expressed as means ± SE for a panel of 20 raters; p > 0.05 = non-significant differences, p < 0.05 = significant differences; p < 0.01 = distinctly significant *differences*; p < 0.001 = highly significant differences, determined by Tukey test. SC - compact structure

The absence of significant differences in the perceptions of these sensory attributes suggests that the evaluation of these characteristics was not significantly influenced by the variables tested in this study.

The results indicated differences in evaluator preferences depending on the product structure. However, a significant preference was observed for the witness sample (SCL1), which did not contain liquid smoke, indicating an appreciation for the natural taste of the product. Liquid-smoked batches (SCL1 and SCL2) achieved moderate acceptability, suggesting a tolerance to the specific taste of liquid smoke.

CONCLUSIONS

The addition of liquid smoke caused significant differences in the qualitative and sensory characteristics of meat preparations, depending on their structural type.

In particular, emulsified preparations showed variations in perception of appearance, taste, and overall appreciation due to the use of liquid smoke.

Between batches, there was a distinct variation in the amount of collagen present; SCL1 values were much lower than SCL2 and SCL3 values. This might be explained by the use of conventionally smoking techniques.

For preparations with a heterogeneous structure, differences in sensory characteristics were less pronounced. There was a moderate preference for the control sample treated with traditional smoke, but also a significant appreciation for the batch treated with 0.2% liquid smoke.

Regarding compact-structured preparations, differences in sensory characteristics were less evident. There was a significant preference for the control sample, but also moderate acceptability for batches treated with liquid smoke.

In general, liquid smoke emerges as a viable alternative to traditional smoking for meat preparations with both heterogeneous and emulsified structures. It offers quality and sensory characteristics appreciated by consumers, such as an authentic texture and taste, suggesting an increased adaptability of this technique in the food industry.

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