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THE IMPACT OF BONE BROTH ADDITION ON THE SENSORY ACCEPTABILITY OF ASSORTED MEAT PRODUCTS WITH HETEROGENEOUS STRUCTURE

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Abstract

A significant challenge in today's food industry is managing leftover bone waste, which is often disposed of as household or abattoir waste if it is not economically used. This study aims to integrate beef bone broth into a functional product with a diverse meat structure. The study seeks to explore sensory changes induced by cattle bone broth properties on product quality and assess consumer acceptance. Two sets of sausages were made, one from pork shoulder and the other from pork loin, each with four groups: a control sample and three variations with 3%, 6%, and 9% cattle bone broth. Sensory analysis involved 80 untrained evaluators. Acceptability tests showed a strong preference for batches with bone broth, with over 60% positive feedback. The batches with a high percentage of acceptability by evaluators are represented by batches SAU2, SAU4, and SAU7. Among the sensory attributes associated with these batches were juiciness, tenderness, overall aroma, and bone broth aroma. Adding bone broth significantly enhanced pork sausages' sensory attributes and appeal, offering a sustainable approach to waste utilization and consumer satisfaction.

Key words*: broth bone, functional product, sensory acceptability.*

INTRODUCTION

Meat consumption is influenced by living standards, diet, livestock production, and consumer prices, as well as by macroeconomic factors such as uncertainty and GDP (gross domestic product) shocks. Compared to other goods, meat is associated with high production costs and high prices. Meat demand is higher among those with higher incomes and is influenced by urbanization, which brings changes in food consumption, favouring an increase in protein intake of animal origin. While the global meat industry provides food and livelihoods for billions of people, it also has a significant impact on the environment and global health (OECD & FAO, 2023).

Slaughterhouses and meat processing plants are essential sectors in the food industry, which is continuously adapting to meet the demand of a growing population with diverse dietary needs (Ungureanu et al., 2023).

While health considerations are important, consumers also appreciate the sensory experience when consuming meat products. Food producers and manufacturers must find a balance between adhering to health recommendations, such as reducing saturated fats and sodium content, and achieving desired sensory characteristics. Furthermore, consumer demands are evolving, and there is increasing interest in meat alternatives or plant products. To meet these requirements, innovation in product and technology development is required (Rodrigues et al., 2023).

In modern times, as consumer preferences and nutritional requirements for food have evolved, meat recipes are increasingly focused on reducing fat and salt levels. Pre-sacrifice factors, including species, age, type of feed, slaughter conditions, and post-saffering parameters, such as the rate of occurrence of rigor mortis and the technique of bleeding, influence the final quality of the meat. Moreover, anatomical regions with varying qualities influence the physico-chemical quality of the final products and how this, in turn, affects consumer preferences (Manoliu et al., 2023).

In the modern food industry, a significant problem is the management of residual bone waste, which, in the absence of economic use, is often treated as household or slaughterhouse

waste and disposed of in landfills. This practice not only creates difficulties in waste management, but can also have negative consequences for the environment and public health. Globally, animal bone waste is considerable, with an estimated annual output of over 130 million tons (Hart et al., 2022).

The development of effective strategies for the recovery of the remaining bones from the process of decoction of meat is essential for transforming them into value-added products by applying efficient strategies to ensure the sustainability of the meat industry. Promising approaches to bone recovery include producing concentrated bone soup, an alternative food product that offers remarkable nutritional benefits (Toldrá et al., 2021). Bone cells, which make up bone tissue, remain active throughout the life of an animal and produce the bone matrix. This matrix mainly contains various mineral salts, such as sodium, potassium, phosphorus, calcium, and magnesium, along with collagen, protein groups (such as proteoglycanes, glycoproteins, sialoproteines, etc.) and acid muco-polysaccharides (Aykın-Dinçer et al., 2021).

Generally speaking, distinctive sensory qualities have a significant impact on consumer perception. Customers' perceptions of the sensory attributes of meat vary depending on how familiar they are with the meat and how open they are to try new things (Ciobanu et al, 2023.

The aim of this study is to investigate the impact of bone soup additivation (in proportions of 3%, 6%, and 9% of the amount of meat used) on the sensory characteristics of a variety of heterogeneous meat preparations and to analyze the acceptability of products by consumers. By adding bone soup, we aim not only to improve the taste and texture of the products but also to harness food resources in a sustainable way, helping to reduce waste and increase the nutritional value of these preparations.

Given the wide variety of meat products available on the market, understanding and improving their sensory attributes is crucial for both producers and consumers.

MATERIALS AND METHODS

Obtaining experimental material

The research was carried out in the meat micro-production plant of the University of Life Sciences, where the technological process of obtaining sausages was performed. The raw and auxiliary materials were purchased from local producers, and the raw meat was subjected to selection and processing operations.

The beef-bone soup was purchased from the manufacturer ZWUP in a 1700 ml jar and stored at a cooling temperature. In order to obtain the assortments, an experimental protocol was prepared, resulting in 8 lots of products: 4 lots containing pork meat from pulp and 4 lots with pork from the back of pork (Table 1).

The process of making sausages involved specific steps, such as:

- preparation of the raw material for dry salting for a period of 24 h at a temperature of 2-4°C in the ripening room;
- after the salting period, grind the meat with a grinder (GRINDER WP - 105) with the size of the eyelids at a sieve of 6 mm,
- weighing and preparation of auxiliary materials and beef bone soup;- mixing the ingredients (cut meat and beef bone soup) until the composition is bound and homogeneous;
- the preparation of natural membranes and their filling with composition; the formation of sausages and their twisting and preparation for thermal treatment.

Table 1. Formulation of sausages added with bone broth in different percentages

	U. M.	Experimental batch of hind leg meat sausages				Experimental batch of pork shoulder sausages			
		SAU1	SAU2	SAU3	SAU4	SAU5	SAU6	SAU7	SAU8
Hind leg meat	kg	3	3	3	3				
Pork shoulder						3	3	3	3
Beef bone broth		0	0.09	0.18	0.27	0	0.09	0.18	0.27

The other ingredients were added in the following proportions: salt 25 g/kg, garlic 15 g/ Kg, coriander 3 g/ kg, pepper 5 g/Kg.
SAU1 – hind leg meat sausage control with 0% beef bone broth, **SAU2** – hind leg meat sausage with 3% beef bone broth, **SAU3** – hind leg meat sausage with 6% beef bone broth, **SAU4** – hind leg meat sausage with 9% beef bone broth, **SAU5** – pork shoulder sausage with 0% beef bone broth, **SAU6** – pork shoulder sausage with 3 % beef bone broth, **SAU7** – pork shoulder sausage with 6% beef bone broth, **SAU8** – pork shoulder sausage with 9% beef bone broth.

For the thermal treatment, the same specifications and stages (drying, smoking and cooking) were used for the experimental batches as shown in Table 2.

Table 2. Thermal treatment steps for added with bone broth

Heat treatment stage	Time	Temperature in the thermal centre	Humidity
	minutes	°C	%
Air drying	20	45	30
Smoking	30	50	30
Hot air drying	40	82	30

The sensory evaluation of the experimental lots was carried out in the IULS sensory analysis laboratory, which is equipped with the necessary equipment, such as individual tasting boxes, and the samples were served at a temperature of 16-18 degrees on white plates. The sensory panel was formed by a group of 80 naive evaluators, a group consisting of both female (60%) and men (40%) aged between 20 and 23 years, without health problems, and with a diet in which meat products are frequently consumed.

The samples were sliced with a professional slicer to ensure uniformity and were presented to the evaluators in batch order and coded with three randomly chosen digits to keep the samples anonymous. At the beginning of the session, the evaluators were explained the contents of the questionnaire and how to fill it out, as well as the explanation of the terms found in the questionnaire so that they could familiarise themselves with the terms encountered.

External Preference Mapping (EPM)

It is a technique used in sensory and market analysis to correlate consumer or respondent preferences with external product characteristics or contextual factors. This method is used to better understand how certain physical, chemical, sensory, or economic characteristics of products influence consumer perceptions and preferences.

For this test, evaluators were asked to rate the coded products (SAU1, SAU2, SAU3, SAU4, SAU5, SAU6, SAU7, and SAU8) on a scale from 1 to 10, depending on how much they liked the product, to find out from the total number how acceptable it is for the market.

The Hedonic Test

The attributes of visual appearance (whole piece and section), texture, smell, taste, freshness, and general acceptance were evaluated on a structured hedonic scale of 9 points (Dislike Extremely, Dislike Very Much, Dislike Slightly, Neither Like or Dislike, Like Moderately, Like Very Much, Like Extremely). To clean their palace, consumers were asked to wash their mouths with water between samples. All samples were presented in a sequential monadic test using a complete lock design. Consumers were not provided with any information about samples and received no financial incentive for their participation in order to prevent bias.

The check all-that-apply (CATA)

It is a method that aims to determine the sensory attributes characteristic of a specific product in a simplified way. The CATA method allows consumers to choose all possible attributes from a previously prepared list to describe the evaluated product. According to Henrique et al. (2015), terms can be generated by a trained sensory panel or by a group of consumers (for example, using discussion groups).

This differs from scaling tests because attributes are not evaluated in terms of intensities. In addition, terms are not limited to sensory attributes, but can also be linked to the use of the product or to the contexts in which they fall.

Participants started by evaluating the sensory profile of each sample using the CATA method. This approach involves providing consumers with a list of attributes intended for the sensory description of sausage products, and they indicate whether a particular attribute is relevant to describing those products. The list of attributes was established on the basis of previous studies and included 17 terms covering the appearance, smell, taste, and texture of sausages (Table 3).

Table 3. List of sensory attributes used for CATA evaluation

Sensory attributes	Characteristics
APPEARANCE	surface appearance, section appearance, red color
FLAVOUR	Spices flavour, bone broth flavour, pork meat flavour, smoked flavour, global flavour
TASTE	Spices taste, bone broth taste, pork meat taste, smoked taste, global taste
TEXTURE	hardness, elasticity, friability, cohesiveness, adhesiveness, succulence, chewiness, masticability

Hedonic responses can be used as additional data to help interpret the results, as CATA responses are directly related to consumer perceptions of product characteristics.
For CATA data, a contingency matrix for samples and attributes has been developed. Cochran's Q test was applied to this matrix to identify meanings between samples in terms of the frequency of attribute use (Meyners et al., 2013).

Statistical analyses

The data from the preference test were analyzed through variance analysis, taking into account consumers and sample causes of the variance. The Tukey test was used to check the significance of differences between averages ($p < 0.05$). The frequency of use of each term was determined for each sausage sample. The Multiple Factor Analysis (MFA) was carried out in the frequency table containing the answers for the CATA questionnaire. XLSTAT software was used for statistical interpretation (Addison V24).

RESULTS AND DISCUSSIONS

Following the start of the statistical analysis for the order of preferences, the results obtained are shown in Figure 1. Thus, the lots with the highest percentage of preference were SAU2 (the pork pulp lot with a bone soup ratio of 3%), SAU4 (the pig pulp batch with 9%), which obtained a percent range between 70 and 80%, and SAU7 (the back batch of pork with a 3% bone broth ratio). The remaining batches obtained percentages ranging from 40 to 60%. Similar results by applying a similar method were obtained by Nguyen et al. (2023), who in their comparative study concluded that meat preparations (pork sausages) were preferred to sausages made from vegetable protein.

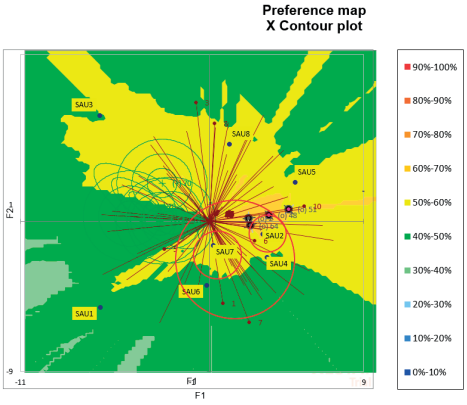

Figure 1. The order of preferences for the batches taken in the study

The check all-that-apply (CATA)

According to the results of the CATA test (Figure 2), significant differences in the frequency of attribute use between batches were identified. The rear sausages earned more appreciation than pulp sausages for most sensory characteristics. The differences between the average scores of pulp and back sausages were statistically significant for the following characteristics: bone broth flavour, juiciness, bone broth taste, fragility, chewingability, spice taste, overall taste, surface appearance, pork flavour, adhesiveness, and overall flavour. Factor analysis identified two groups of sensory characteristics: a group related to flavour and taste and a group linked to texture and appearance. The first dimension revealed a significant difference in the sensory profile of the SAU1 and SAU5 batches without bone soup additivation compared to batches with bone broth additivity. The sensory attributes that were distinct for the SAU6, SAU3, and SAU7 batches were "bone broth flavour", "spice flavour" and "suculence, fragility, and elasticity". For SAU8, SAU3, and SAU4, the attributes associated with these samples were "global flavour, smoked flavour and hardness", appreciations that can be proportional to the process of the soup added.

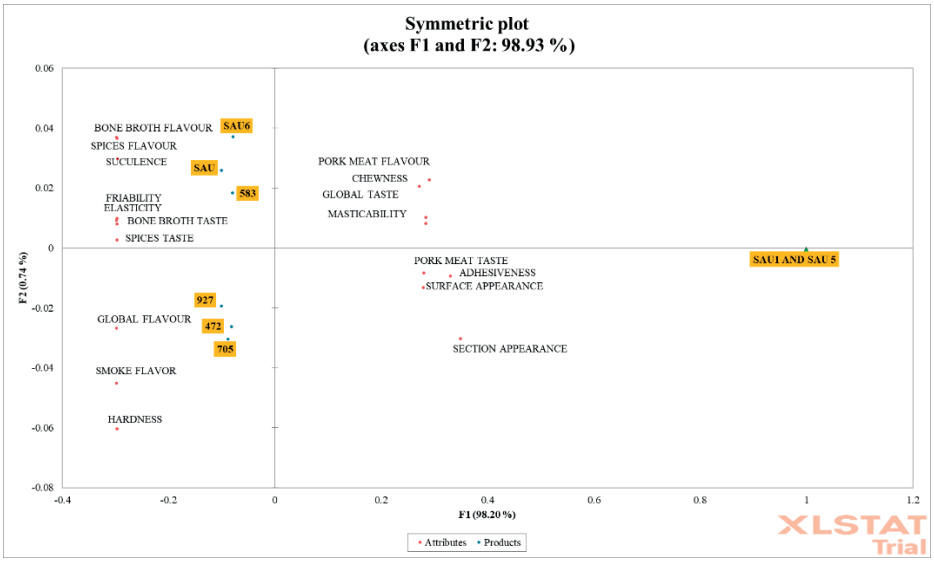

Figure 2. Illustration of the correlation of sensory attributes by evaluators by CATA test

The eight prepared sausage formulations were subjected to sensory analysis using a 9-point hedonic scale to select the panellists' preferred samples for each range. The hedonic scores for the sensory attributes (appearance, colour, texture, smell, taste, and general acceptability) of the batches of smoked sausages are presented in Table 4.

Following the study, the analysis of the hedonic test on experimental lots evaluated with the addition of different concentrations of bone broth indicates that attributes such as appearance, colour, smell, and taste were well appreciated by consumers, with values ranging from 7.2 to 7.9, regardless of the raw material used and the added concentration, the results were not differently significant. However, it can be noted that samples with higher concentrations of bone soup showed a less uniform texture, and the acceptability was slightly higher for samples that had a lower (3%) or average (6%) concentration of bones broth.

Table 4. Hedonic test results

SAMPLE	APPEARANCE	COLOR	TEXTURE	ODOR	TASTE	OVERALL ACCEPTABILITY
SAU1	7.4[a]	7.2[a]	7.2[a]	7.4[a]	7.4[a]	7.5[a]
SAU 2	7.4[a]	7.4[a]	7.3[a]	7.5[a]	7.8[a]	7.9[a]
SAU3	7.5[a]	7.4[a]	7.3[a]	7.6[a]	7.6[a]	7.8[a]
SAU4	7.6[a]	7.4[a]	7.9[a]	7.5[a]	7.5[a]	7.6[a]
SAU5	7.3[a]	7.3[a]	7.1[a]	7.2[a]	7.4[a]	7.8[a]
SAU6	7.3[a]	7.4[a]	7.3[a]	7.4[a]	7.3[a]	7.4[a]
SAU7	7.4[a]	7.4[a]	7.4[a]	7.7[a]	7.6[a]	7.7[a]
SAU8	7.6	7.5[a]	7.7[a]	7.5[a]	7.3[a]	7.5[a]

CONCLUSIONS

In considering this investigation into the acceptability of various assortments of sausages that have been additively made with varying amounts of bone broth, the SAU2, SAU4, and SAU7 batches are those that showed a high percentage of acceptance by the assessors. These batches were characterized by a variety of sensory attributes, including succulence, fragility, overall smell, and bone broth flavour.

The goods created for this study have benefited from the addition of sausages with bone broth; nevertheless, concentrations should be carefully considered as an excessive concentration may affect the texture of the products from a sensory perspective.

The addition of bone broth was viewed favourably in light of the hedonic test's subjectivity, as the batches achieved high ratings for the desired qualities.

Further investigations on the concentrations of bone broth are recommended, and more studies are also needed on meat products with different structures.

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