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Determine The Sensory Characteristics and Drivers of Liking for Sausage Products Using Check-All-That-Apply Method

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Despite the growing demand for more sustainable food production and consumption like plant-based products, there has not been much research on the sensory properties of plant-based sausages. This research aims to compare the sensory characteristics of plant-based sausages and meat sausages, as well as determine the drivers of likings for sausage products. 8 samples (6 meat products and 2 plant-based products) were evaluated by 103 consumers using the check-all-that-apply (CATA) method with 33 attributes. The consumers also rated their overall liking of each sample. The results showed a large difference in appearance and texture between plant-based sausages and meat sausages, with plant-based sausages more associated with “coarse surface”, “tooth packing” and “crumbliness”. The liking scores of plant-based sausage samples were significantly lower than that of meat sausage samples. The results of the penalty-lift analysis showed that “smooth surface”, “firmness”, “springiness” and “dense surface” were must-have attributes for sausages, while “coarse surface”, “crumbliness”, “fishy odor” and “bitterness” should not be presented in sausage products. The results of this study could potentially be applied to improve the formulation of plant-based sausages.

1. Introduction

Global meat consumption and production are increasing significantly nowadays (Drofenik et al., 2021). Sausages are one of the most widely consumed meat products in the world due to their convenience and sensory attributes. While meat proteins are the key factor to create the desired texture for sausages, meat production is one of the most polluted production and replacement are needed. Plant protein as an alternative to meat protein is an upcoming trend to make the global food systems more sustainable (Casson et al., 2019). From 2018 to 2020, overall alternative protein sales in the world increased by 38 %, especially plant-based burgers. Plant-based sausages were also one of the most popular products made from alternative proteins. They were the third preferred segment in plant-based meats in the US. In spite of the popularity of this product in several countries, there were not many brands producing plant-based sausages in most countries, especially in Vietnam (Joseph et al., 2020). From a sensory viewpoint, meat products possess distinct taste, odor and textural properties which are not easily recreated by using plant-based materials. Sensory evaluation can play a crucial role in improving the acceptance for plant-based products, as well as finding which sensory attributes drive consumer liking (Ares et al., 2014).

Check-all-that-apply (CATA) is one of the rapid descriptive methods that is often used to describe the sensory profiles of meat processing products like fermented sausage (Dos Santos et al., 2015), meat (Jorge et al., 2015), cooked ham (Henrique et al., 2015). It has been used to obtain rapid product profiles by consumers’ words. When consumers evaluate products by CATA, they are presented with a list of attributes that can include sensory attributes, emotional terms or/and hedonic terms. Then, consumers will check all terms which are detected by themselves about products. CATA questions had been proven they could be an alternative method for the time consuming conventional descriptive methods such as Quantitative Descriptive Analysis.

Liking questions are usually used with CATA to obtain hedonic responses about products. In this way, penalty analysis can be conducted to obtain the sensory attributes that were liked or not liked by consumers (Meyners et al., 2013). A nine point scale is the often used scale to obtain consumers’ acceptability for a wide range of products (Lim, 2011).

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In this study, eight commercial sausage products, both plant-based and meat-based, were tested in order to identify consumers' acceptance and investigate the key drivers of liking for sausages.

2. Materials and methods

2.1 Samples

8 commercial sausages with different ingredients were used in the study (see Table 1). All the sausages were stored at 0-4 °C to prevent quality changes and were removed from the refrigerator to warm up for 1 h before testing. Both smoked and fresh sausages were boiled for 5 min before conducting the sensory evaluation. All samples were served in transparent plastic containers with lids. Samples were monadically served based on William square order with a random 3-digit number code.

Table 1: Type of sausage of the 8 samples and their main ingredients

Sample	Type of sausage	Main ingredients
MM1	Meat-based, smoked	Pork and beef
MF1	Meat-based, fresh	Pork
MF2	Meat-based, fresh	Pork, chicken and fish
MF3	Meat-based, fresh	Pork and chicken
MS1	Meat-based, sterilized	Beef and chicken
MS2	Meat-based, sterilized	Pork and chicken
PF1	Plant-based, fresh	Wheat protein
PS1	Plant-based, sterilized	Soy protein and wheat protein

2.2 Participants

In this study, 103 consumers (18–24 y old, 50 % female, 50 % male) were randomly recruited from the campus of Ho Chi Minh City University of Technology. According to a study by Mammasse and Schlich (2014), this number of participated consumers is adequate for characterizing the product differences. All the participants used sausage products at least once a week, have no health issues affecting their sensory perceived ability and showed interest in participating in the study.

Table 2: List of CATA attributes by sensory modality

Sensory modality	Attributes
Appearance	Pink color, Bright color, Brown color, Orange color, Dark color, Dense surface, Porous surface, Smooth surface, Coarse surface
Odor	Pork odor, Beef odor, Chicken odor, Fishy odor, Soy odor, Corn odor, Potato odor, Cheesy odor, Smoky odor, Cinnamon odor, Lemongrass odor, Peppery odor
Taste	Saltiness, Umaminess, Sweetness, Sourness, Bitterness
Texture	Hardness, Firmness, Softness, Springiness, Toughness, Crumbliness, Mealiness, Tooth packing

2.3 Testing procedure

The participants first evaluated the sensory profiles of each sample using CATA method. This method presents the consumers with a list of attributes for sensory description of sausage products, and the consumers check if an attribute is appropriate to describe the products. The list of attributes was defined by referring to previous studies. The list consisted of 33 terms which describe the appearance, odor, taste and texture of sausage products (Table 2). After evaluating the sensory characteristics, the participants were asked to rate their overall acceptability by using a nine point scale that begins with 1 - "dislike extremely" and ends with 9 - "like extremely".

2.4 Data analysis

The overall liking scores were analyzed using two-way analysis of variance (ANOVA) with samples and consumers as sources of variation and least significant difference post hoc test. Consumer segmentation was performed by using hierarchical clustering on principal components.
For the CATA data, a contigency table was calculated for samples and attributes. Cochran's Q test was performed on this contigency table to detect significances between samples for frequency usage of attributes.

Correspondence analysis (CA) was performed to get a low dimensional representation of the relationship between samples and attributes from the CATA question (Meyners et al., 2013).
Finally, penalty analysis was performed to identify the drivers of liking. For each attribute, the difference between the mean liking across all observations for which the attribute was checked and the mean liking across all observations for which the attribute was not checked showed how much liking changes when an attribute is present compared to when it is absent. If this difference is positive, the attribute under consideration is needed in the products; if the difference is negative, the attribute should not be presented in the products. Results are visualized in a bar chart in order to identify attribute which needs to be prioritized. For significant testing, a t-test was performed to compare the two mean values. All the data analysis was done on R software, version 4.1.3.

3. Results and Discussion

3.1 Consumer's preference of the sausage samples

The result showed statistically significant differences in overall liking between the samples (Table 3). Sample MS2, a meat sausage, had the highest mean liking score of 6.61 ± 1.42 and sample PS1, a plant-based sausage, had the lowest mean liking score of 3.74 ± 2.09.
In general, all the meat-based samples, except MM1, showed a liking score of above 6.0. The liking scores of two plant-based samples were lower than that of meat-based samples and under 6.0. It showed that plant-based sausages were not accepted by consumers for their sensory attributes and were not preferred to meat-based ones. This result is similar to the previous study on sausages in Denmark (Tarrega et al., 2017). In that study, two plant-based samples were not preferred to the others. Similar results were also obtained in the liking score of plant-based burgers (Birke Rune et al., 2022). One of the reasons why plant-based meat, particularly plant-based sausages, was not preferred by consumers is the difference between their sensory attributes and meat-based products, especially in odor and taste. Despite no difference in overall acceptance, consumers preferred the odor and taste of meat-based sausages over plant-based ones (Hassan et al., 2019).

Table 3: Mean and standard deviation (SD) of overall liking score for 8 sausage samples

Sample	Mean ± SD
MS2	6.61 ± 1.42^{a}
MF1	6.48 ± 1.53^{b}
MF2	6.25 ± 1.52^{c}
MF3	6.01 ± 1.59^{d}
MS1	5.98 ± 1.70^{d}
PF1	5.72 ± 1.85^{e}
MM1	4.68 ± 1.74^{f}
PS1	3.74 ± 2.09^{g}

* Sample with the same letters are not statistically significant at α = 0.05

To look further into the difference in preference between consumers, hierarchical clustering on principal components (HCPC) was performed to identify consumer groups based on centered liking scores. The results of segmentation were shown in Figure 1a and their preference samples were illustrated in Figure 1b. The consumers were separated into three groups. Group 1 preferred the samples MF1, MF2, and MF3, group 2 preferred the plant-based sample PS1 and group 3 preferred the sample MS1 and MS2.
Generally, it can be concluded that consumers of group 1 preferred meat-based fresh sausages. For group 3, the meat-based sterilized sausages had a higher preference from consumers. For group 2, there was an indication that consumers preferred plant-based sterilized sausages. The smoked meat sausages and plant-based fresh sausages were not distinctively preferred by any consumer groups.

3.2 Sensory characteristics of sausage samples

According to the results of Cochran's Q test, significant differences of usage frequency between samples were found in all the attributes except for "potato odor". The usage frequency of "potato odor" was low and indifferent between samples, which indicates the potato aroma was hard to detect by consumers and can be omitted from future studies. These results were similar to other research using the CATA method, which showed that there is rarely no difference in attributes between products (Thun et al., 2022).

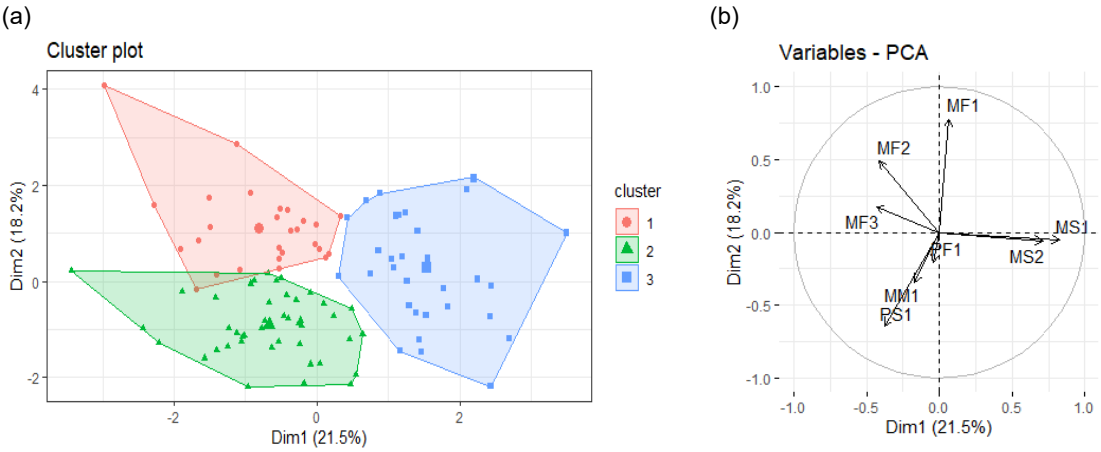

Figure 1: Illustration of (a) the consumer segmentation and (b) the correlation circle indicating the preferred samples for each group (b)

The results of Correspondence Analysis (CA), which showed similarities and differences between samples, are illustrated in Figure 2. Since the first two dimension showed a total of 63.82 % in variance, no more dimension was considered. The first dimension showed a large difference in the sensory profile of sample PS1 from the other samples, especially in texture. The sensory attributes which were distinctive for sample PS1 were “dark color”, “coarse surface” (for appearance), “bitterness”, “cinnamon odor” (for odor and taste), “crumbliness” and “tooth packing” (for texture). These attributes were the typical characteristics of plant-based sausages, which was similar to the study of Michel et al. (2021). These showed that plant-based sausages still had a large difference in sensory profile when compared to meat sausages.

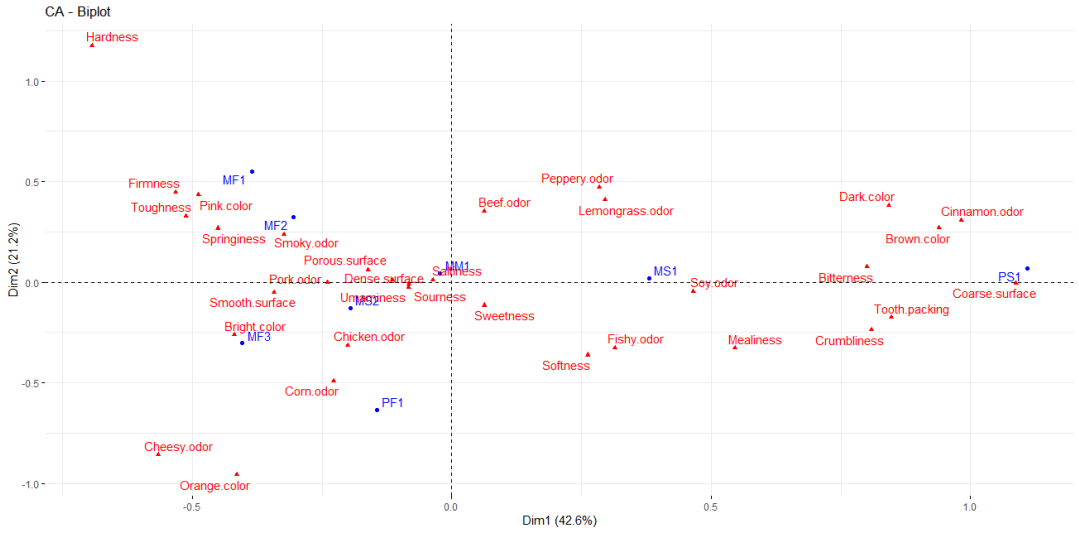

Figure 2: The first two dimensions of CA based on χ2 – distance

The second dimension highlighted the difference in flavor between a plant-based sample, PF1 to other meat sausages. PF1 was associated with “corn odor”, “cheesy odor”, “orange color”. No texture attribute was specifically associated with sample PF1, which showed that this sample is closely similar in texture to meat sausage samples.

The meat sausage samples were closely similar in the first dimension, which highlighted that the texture of meat sausage samples was not distinctly different from each other. The second dimension showed the contrast between the smoked samples MF1 and MF2 (which were associated with a “smoky odor” and “firmness”) and samples MF2 and MS2 (which were associated with “pork odor” and “chicken odor”). One particular attribute that showed no strong association with the sausage samples was “hardness”. This showed that consumers did not usually consider using this attribute to describe the sensory of sausage products.

3.3 Determining the drivers of liking

The results of the penalty-lift analysis showed that there were 11 attributes (“chicken odor”, “corn odor”, “hard”, “lemongrass odor”, “orange color”, “peppery odor”, “pores”, “potato odor”, “soft”, “tooth packing”, “umami”) which did not have statistically significant difference in liking penalty ($p > 0.05$). These attributes were therefore likely not influence the liking of consumers when they were present/absent in the sausage products.

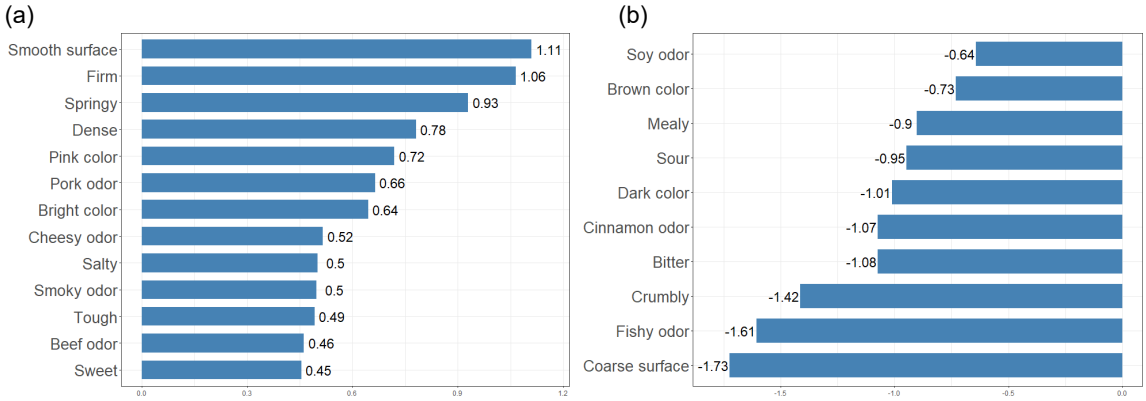

Figure 3: Penalty-lift analysis result for (a) positive attributes and (b) negative attributes

To identify the directions for plant-based sausage improvement, the penalty-lift results were showed separately into positive attributes (signify that the presence of the attributes increases the liking of consumers) in Figure 3a and negative attributes (signify that the absence of the attributes increases the liking of consumers) in Figure 3b. In Figure 3a, the positive attribute with the highest penalty in liking was “smooth surface” (appearance), followed by 3 texture attributes (“firmness”, “springiness” and “dense surface”). These results showed that texture was the key driver of liking for sausage products. In a recent study on ways to improve plant-based products, Michel et al. (2021) also highlighted the important roles of texture attributes (like firmness, springiness, crumbliness) in increasing the liking of consumers. They suggested that the greatest chance for successful plant-based products is to replicate the flavor and texture of meat products. The color of sausage products also played an important role, with “pink color” and “bright color” having high positive impact on consumer’s acceptance. “Pork odor”, “beef odor”, “cheesy odor” and “smoky odor” were positively preferred by consumers. Braghieri et al. (2016) also found that the drivers of consumer’s acceptance for sausages were mainly flavor and texture.

In Figure 3b, the attribute which had the highest negative impact on liking scores is “coarse surface” (the direct opposite of “smooth surface”). This again highlighted the utmost importance of a smooth surface for sausage products. Many negative attributes (“coarse surface”, “crumbliness”, “bitterness”) were associated with plant-based sausage samples PS1. Revilla et al. (2022) showed that replacing meat with plant-based protein decreased the textural properties of sausages. Higher percentage of plant-based protein reduced the hardness and chewiness, due to the weaker network of plant-based protein compared to myofibrillar protein. The weaker network results in samples with 100 % plant-based protein to have softer and more crumbly texture. For odor, “fishy odor”, “bitter” and “cinnamon odor” should not be presented in sausage products. These are atypical for sausages, and the unfamiliarity may make the samples with these attributes unappealing to consumers. Koch et al. (2021) showed that consumers may evaluate a product as unappealing if the products have large differences from the normal food which consumers have accepted.

4. Conclusions

This study had determined the sensory attributes of sausage products using the CATA method. The results from CATA indicated that the plant-based sausages had large differences in texture when compared to meat sausages, often associated with “coarse surface”, “tooth packing” and “crumbliness”. This had further clarified the results of ANOVA of consumer’s acceptance, which indicated that plant-based sausages were much less preferred by consumers than meat sausages. The consumer segmentation showed that some consumers liked plant-based sausages, which was a good sign for these sustainable products on the market.

For product improvement direction, the results of penalty-lift analysis showed that appearance and texture were the key drivers of liking for sausage products. “Smooth surface”, “firmness”, “springiness” and “dense surface” had high positive penalty on liking, which suggested the inclusion of these attributes is necessary for sausages. In contrast, “coarse surface”, “fishy odor”, “crumbliness” and “bitterness” were highly negative attributes and

should be removed from sausage products. These results suggested further modifications to improve the consumer's acceptance for plant-based sausages. Further investigation is needed on other plant-based products to fully understand the consumer's perception and how to push consumers to consume these healthy and more environmental-friendly products.

Nomenclature

ANOVA – analysis of variance
CA – correspondence analysis
CATA – check-all-that-apply

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