

Consumer Preferences and Sensory Profiles of Commercially Processed Meat Analog Products in Indonesia

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ABSTRACT

The increasing global demand for beef challenges the sustainability of traditional meat production, leading to the emergence of meat analogs as a promising alternative. However, consumer unfamiliarity and low sensory appeal remain key challenges to broader acceptance. This study aimed to identify key sensory attributes using the Rate-All-That-Apply (RATA) method, assess consumer preferences through hedonic testing, and explore the relationship between texture and preference using partial least squares structural equation modeling (PLS-SEM). Four commercial meat analog products available in Indonesia were evaluated through a Focus Group Discussion (FGD) with 8 consumer participants and sensory testing with 32 consumer panelists. Results showed that rendang was the most preferred product (hedonic score: 4.97), driven by attributes such as meaty flavor, rendang flavor, oily shine, and tender, fibrous, and juicy textures. Steak ranked second (4.37), with similar favorable characteristics. In contrast, beef slice balado (3.78) and jerky (3.44) were less preferred, mainly due to texture characteristics that did not align with consumer expectations. PLS-SEM analysis confirmed that texture is a major factor influencing consumer preference. These findings emphasize the importance of improving texture quality to support the acceptance of meat analog products.

KEYWORDS

Consumer panelist, Consumer preferences, Meat analog, RATA, PLS-SEM



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INTRODUCTION

The global consumption of beef has increased nearly fourfold in 2020 compared to five decades earlier, primarily driven by population growth, rising income levels, and urbanization (McClements & Grossmann 2022). Furthermore, in 2012 the Food and Agriculture Organization (FAO) projected that global beef demand would rise by 75% from 2005, reaching 455 million metric tons by 2050 (Godfray et al. 2018). However, beef production may not be able to meet the increasing food demand for an estimated 9.7 billion people by 2050 (Rubio et al. 2020; Sakai et al. 2021). This challenge arises from the substantial resource requirements of conventional meat production, including land, water, and energy (Lynch & Pierrehumbert 2022).

Meat analogs have emerged as a promising alternative to conventional meat, offering a sustainable solution to the growing demand for meat-like food products (Zhang et al. 2022). A meat analog is a food product developed from plant-based or non-meat ingredients designed to replicate the sensory characteristics of conventional meat, including aroma, taste, texture, and nutritional composition (Chen et al. 2023). Moreover, meat analogs can be produced with greater efficiency, enabling optimal land utilization and lower production costs (McClements & Grossmann 2021).

The global market for meat analogs has expanded significantly in recent years. In the United States, sales of meat analogs increased by 37% between 2018 and 2019 (GFI 2021). Likewise, consumer interest in meat analogs in Indonesia has grown substantially. The global meat analog industry is projected to expand from USD 4.6 billion in 2018 to USD 85 billion by 2030 (Boukid 2020; Singh et al. 2021). The rapid market growth and positive consumer response indicate that meat analogs have the potential to meet global protein demands while serving as a more efficient and sustainable alternative to conventional meat.

The food industry has responded to this trend by developing various processed meat analog products that replicate the taste, aroma, and texture of conventional meat (Singh et al. 2023). Major fast-food chains, including McDonald's, KFC, and Burger King, have introduced plant-based menu options to cater to the increasing consumer demand for environmentally friendly food choices. Additionally, local businesses in Indonesia, such as Meatless Kingdom, Proteina, Protamil, Veggieway, Prodela, Made Good, Green Rebel, Burgreens, Green Grills, and Beau Bakery, have adopted this trend by offering a variety of meat analog-based products.

Common raw materials utilized in meat analog production include soybeans, wheat, legumes, and edible mushrooms such as shiitake and oyster mushrooms (Wang & Zhao 2023). These ingredients not only contribute to a meat-like texture but also provide substantial nutritional value. Several studies in Indonesia have explored the development of meat analog formulations using locally available ingredients, including banana blossom (Tambunan & Siregar 2022) and corn (Fadly & Purwayantie 2019). These efforts highlight the potential of utilizing indigenous resources to support the advancement of alternative protein products.

Onwezen et al. (2021) identified two primary challenges encountered by the food industry in the development of plant-based meat analogs such as limited consumer familiarity and low sensory appeal. Parry and Szejda (2019) emphasized that consumer purchasing decisions are significantly influenced by familiarity with the product, particularly when plant-based meat analogs exhibit sensory characteristics similar to conventional meat. Therefore, the success of novel meat analog products depends on their ability to replicate the taste, aroma, and texture of conventional meat (Moss et al. 2023), while simultaneously eliminating undesirable off-flavors or aftertastes (Adawiyah et al. 2019). Addressing these challenges is essential for enhancing consumer acceptance (Ettinger et al. 2022).

Food technology advancements help develop meat analog products by enabling sensory evaluations of commercial products, which serve as useful references for the food industry (Ruiz-Capillas & Herrero 2021). Comprehensive sensory analysis methods are required to better understand the sensory attributes of these products based on consumer preferences. The Rate-All-That-Apply (RATA) method can be employed to identify sensory profiles based on intensity levels, while the hedonic sensory test can be utilized to assess consumer preference levels for processed meat analog products. Additionally, the correlation between the sensory attributes of meat analogs and consumer preferences can be further analyzed using partial least squares structural equation modeling (PLS-SEM).

Currently, there is no studies have directly examined the sensory attributes of commercial meat analog products in Indonesia and their relationship with consumer preferences. Therefore, this study aims to identify sensory attributes based on intensity using the Rate-All-That-Apply (RATA) method, evaluate consumer preferences through the hedonic sensory test, and analyze the relationship between sensory attributes and consumer preferences using partial least squares structural equation modeling (PLS-SEM) to determine their influence on market acceptance. The findings of this research are expected to provide valuable insights for the food industry in the development of meat analog products that align with consumer preferences.

RESEARCH METHOD

Materials used in this study included commercial meat analog products in Indonesia such as Protamil beef slice balado, Meatless Kingdom rendang, Madegood jerky, and Green Rebel black pepper steak. Product selection was based on a Shopee platform search, prioritizing active sellers and highest sales as of July 2024. Due to limited market variety, samples represented different product types, as producers typically offer only one to two variants.



Figure 1. Commercial meat analog products in Indonesia rendang (a), black pepper steak (b), beef slice balado (c), jerky (d).

This study comprised nine stages, beginning with preparation, including a literature review on the RATA method, hedonic testing, and PLS-SEM analysis, alongside selecting commercial beef-based meat analogs in Indonesia. An online survey was conducted to assess consumption patterns, preferences, and expectations toward beef and its alternatives. The survey instrument was validated and reliable before distribution to 400 respondents aged ≥ 18 who regularly consume beef, determined by Slovin's formula and G*Power analysis. Simple random sampling was used, with selected participants from key provinces. Respondents in this online survey were internet users in Indonesia, based on data from *Asosiasi Jasa Internet Indonesia (APJII) 2024*. Focus Group Discussion ($n=8$) and sensory evaluation ($n=32$) based on health and allergy criteria. Subsequent phases included sample preparation, FGD to explore sensory perceptions, and sensory testing via RATA and hedonic methods. Data were analyzed using PLS-SEM to examine relationships between sensory attributes and consumer preferences, forming the basis for conclusions.

RESULTS AND DISCUSSION

Validity and Reliability

The questionnaire comprised five sections including beef consumption patterns, purchasing factors, expectations of meat analog products, expected sensory attributes, and consumer preferences. Validity tests on 19 items showed Pearson correlation coefficients exceeding the critical value ($r = 0.361$, $n=30$, $\alpha=0.05$), confirming item validity (Rudianto & Audi, 2020; Faulina, 2019). Reliability analysis yielded a Cronbach's Alpha of 0.854, indicating strong internal consistency (Budhiassa, 2016). These results demonstrate that the instrument was valid and reliable for the study's constructs, justifying its use with the full sample of 400 respondents.

Table 1. Questionnaire validity test results

Scope of inquiry	Question	R Count	Conclusion
Beef Consumption Patterns	Consumption frequency of processed beef	0.430	Valid
	Favorite beef preparations	0.398	Valid
	Consumption time	0.426	Valid
	Where to buy	0.366	Valid
Beef Purchasing Factors	Cow quality	0.468	Valid
	Price	0.645	Valid
	Status halal	0.504	Valid
	Hygiene	0.560	Valid
	Origin of meat	0.400	Valid
Meat analog preferences	Reasons buying processed <i>meat analogs</i>	0.407	Valid
	Estimated price for 1 pack <i>meat analog</i>	0.531	Valid
Sensory appeals	Texture	0.728	Valid
	Appearance	0.765	Valid
	Taste	0.663	Valid
	Aroma	0.449	Valid
Consumer Preferences	Ease of preparation	0.690	Valid
	Easy access to purchases	0.625	Valid
	Price Estimate	0.654	Valid
	Nutrients	0.438	Valid

Description: question valid at a significance level of 5% Pearson correlation test

Table 2. Questionnaire reliability test results

<i>Cronbach's Alpha</i>	<i>N of Items</i>
0.854	19

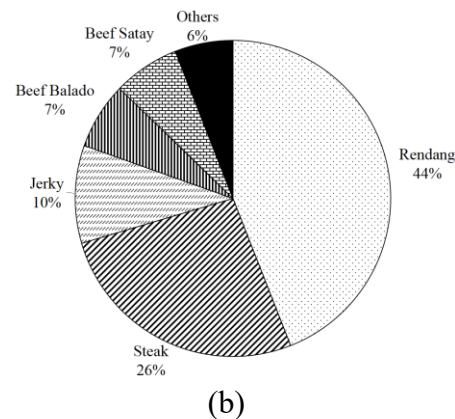
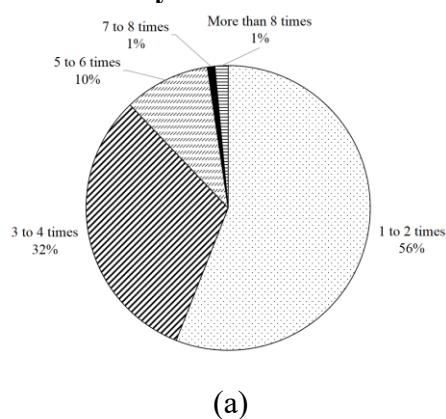
Consumer Profile

Category	Subcategory	Number of Respondents	Percentage (%)
Gender	Female	333	70.85
	Male	137	29.15
Age	18–25 years	410	87.23
	26–35 years	44	9.36
	36–45 years	13	2.77
	>45 years	3	0.64
Education Level	Bachelor's Degree	306	65.11
	High School or Equivalent	115	24.47

	Diploma	42	8.94
	Master's Degree	7	1.49
Occupation	Student	381	81.06
	Private Employee	63	13.40
	Entrepreneur	10	2.13
	Government Employee	9	1.91
	Unemployed	7	1.49
Monthly Income	< IDR 1,000,000	236	50.21
	IDR 1,000,000–3,000,000	161	34.26
	IDR 4,000,000–5,000,000	36	7.66
	> IDR 5,000,000	37	7.87
Domisili	West Java	211	44.89
	DKI Jakarta	109	23.19
	Banten	58	12.34
	Central Java	39	8.30
	East Java	35	7.45
	Riau	8	1.70
	North Sumatera	3	0.64
	Jambi	2	0.43
	South Sumatra	2	0.43
	South Kalimantan	1	0.21
	Bangka Belitung Islands	1	0.21
	Riau Islands	1	0.21

The survey collected data from 475 respondents, of whom 470 were regular beef consumers. The sample was predominantly female (70.85%) and young adults aged 18–25 (87.23%). Most respondents were students (81.06%), with smaller shares of private employees (2.13%), entrepreneurs (1.91%), and unemployed individuals (5.61%). Educational level was mainly bachelor's degree (65.11%), followed by high school graduates (24.47%) and diploma holders (8.94%). Half of the respondents earned less than IDR 1,000,000 monthly, and 34.26% earned between IDR 1,000,000 to 3,000,000. Geographically, 80.42% came from urban regions—West Java (44.89%), DKI Jakarta (23.19%), and Banten (12.34%)—reflecting higher internet accessibility. This demographic profile highlights a focus on young, female, urban consumers with limited income, providing key insights for targeted product development and marketing strategies.

Consumer Survey Results



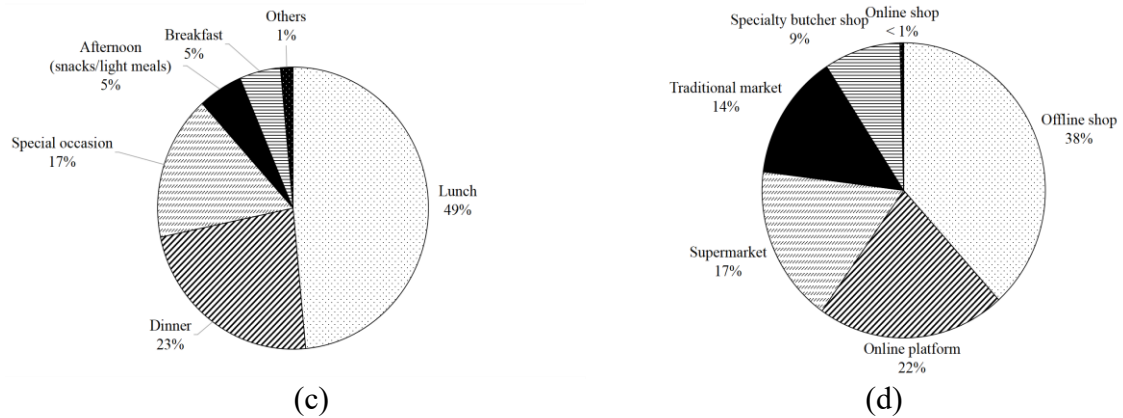


Figure 2. Consumption frequency results (a) preferred types of beef products (b) timing of consumption (c) purchase location (d)

The consumer survey examined consumption patterns of processed beef products, including frequency, preferred types, consumption times, and purchase locations. As shown in Figure 2a, 56% of respondents consumed beef products 1–2 times, and 32% consumed 3–4 times within the past two weeks, indicating moderate consumption. This aligns with Mokoginta et al. (2016) and Al Ashari & Muhdar (2024), who reported that young adults (18–25 years) typically consume beef 1–3 times per month. A smaller portion, 10%, consumed 5–6 times, and 2% consumed more than six times. These results suggest promotional efforts should target increasing consumption frequency among low-to-moderate consumers, while loyalty programs may retain frequent consumers.

Figure 2b shows rendang as the most favored product (44%), followed by steak (26%) and jerky (10%). This preference supports Holinesti & Ramadani (2022), who noted rendang's popularity due to its rich flavors and complex spices, indicating strong potential for rendang-based meat analog development. Preferences for steak, jerky, satay (7%), and sliced beef (6%) reflect diverse consumer tastes, suggesting opportunities for analog products in these categories. Regarding consumption timing (Figure 2c), lunch (49%) and dinner (23%) are the primary occasions for beef consumption, corroborating Wikara and Hidayati (2023), who identified lunch as the peak time for heavier meals. Special occasions (17%), snacks or light meals (5%), and breakfast (5%) offer additional opportunities for ready-to-eat or ready-to-cook meat analog products.

In terms of purchase locations (Figure 2d), offline shop such as Padang restaurants and eateries dominate (38%), followed by online food delivery platforms (22%) like ShopeeFood, GoFood, and GrabFood, reflecting demand for convenient lunch options consistent with Wikara and Hidayati (2023). Supermarkets (17%) and traditional markets (14%) provide a balance of variety and affordability, while butcher shops (9%) cater to premium meat seekers. Although e-commerce platforms currently account for less than 1% of purchases, they hold potential for meat analog distribution, especially with innovations like vacuum packaging and rapid delivery. Overall, these findings provide critical insights into consumer behaviors and preferences, enabling producers to tailor meat analog product development and marketing strategies to better align with market demand and enhance consumer acceptance.

Table 3. Survey results of beef purchasing factors

Factor	Very Important (%)	Important (%)	Somewhat Important (%)	Total (%)	Priority Category
Hygiene	71.70	25.53	2.13	99.36	Top priority

Halal status	69.79	27.66	1.60	99.05	Top priority
Price	59.57	37.48	2.13	99.18	Top priority
Meat quality	60.00	35.74	2.55	98.29	Important
Meat origin	27.23	46.17	17.02	90.42	Lower priority

The survey identified key factors influencing beef purchase decisions, with hygiene rated as the most important by 71.70% of respondents, supporting Menut et al. (2023) on its role in consumer trust. Halal status followed closely at 69.79%, consistent with Nawawi et al. (2020) and Septiani & Ridlwan (2020), who highlight its significance for Muslim consumers and as a quality indicator. Price was very important to 55.32% and important to 11.94%, underscoring the need for competitive pricing (Nurfauzi et al. 2023). Meat quality was very important to 60%, reflecting consumer focus on raw material integrity. Meat origin ranked lowest, with only 27.23% rating it very important, indicating it is a secondary concern when hygiene, halal certification, quality, and affordability are assured.

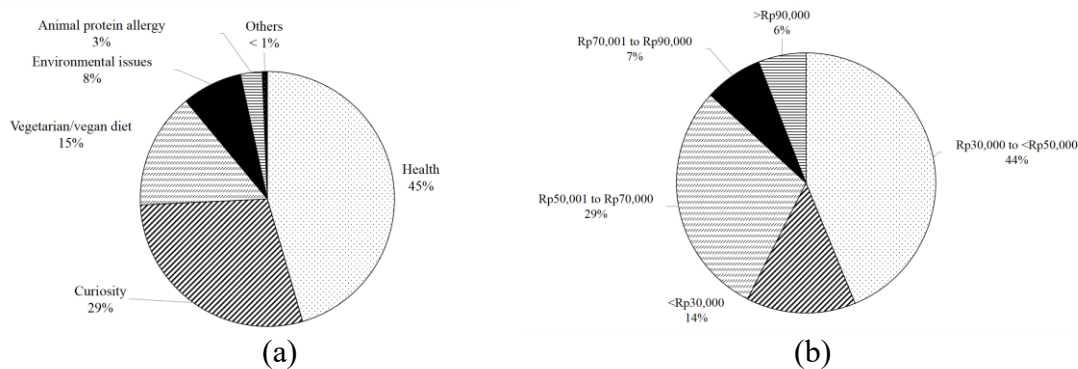


Figure 3. Reasons for trying processed meat analog (a) per ± 200 grams (b)

Figure 3a shows that health concerns, particularly reducing saturated fat and cholesterol intake, drive 45% of consumers to try meat analogs, supporting Bohrer (2019) who notes these products generally have lower fat and cholesterol than conventional meat. Curiosity accounts for 29%, indicating openness to food innovation, while 15% follow vegetarian or vegan diets, aligning with the plant-based trend described by Ismail (2020). Environmental concerns and intolerance to animal proteins represent 8% and 3%, respectively, with less than 1% citing weight management, consistent with Bohrer's (2019) findings on lower calories and higher fiber in meat analogs. Regarding price expectations (Figure 3b), 44% prefer IDR 30,000–50,000 per ~200g, 29% opt for IDR 50,001–70,000, and only 13% accept prices above IDR 70,000. Table 3 underscores price as a key purchase factor, emphasizing the need for competitive pricing without sacrificing quality. Michel et al. (2021) also highlight price and sensory attributes as critical to consumer acceptance of meat analogs.

Result of sensory attributes with consumer preferences correlation

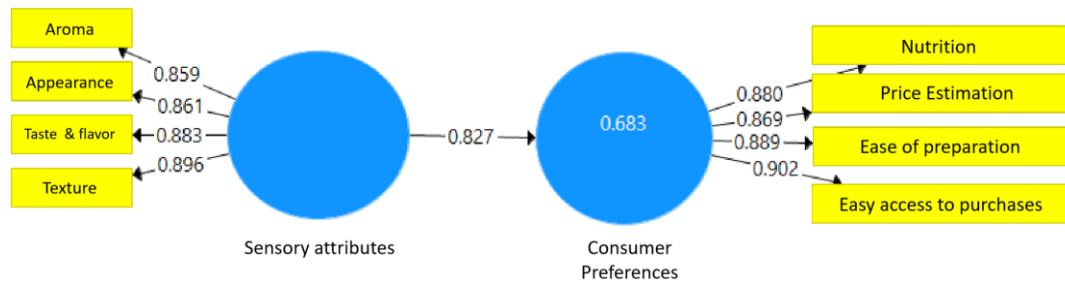


Figure 4. Correlation of sensory attributes with consumer preferences

Table 4. PLS-SEM result

	Outer Model				Inner Model	
	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)	Path Coefficient (O)	T Statistics (O /STDEV)	P Values
Sensory Attributes	0.898	0.929	0.766	-	-	-
Consumer Preferences	0.908	0.935	0.783	-	-	-
Sensory Attribute -> Consumer Preferences	-	-	-	0.827	34.302	<0.0001

The survey indicated a strong positive relationship between sensory attributes and consumer preferences for meat analog products, with a path coefficient of 0.827. The outer model included aroma, appearance, taste, and texture as exogenous variables, with loading factors between 0.859 and 0.896. Consumer preference, the endogenous variable, was measured by nutritional balance, affordability, preparation ease, and purchase accessibility, showing loadings from 0.869 to 0.902. All variables met validity criteria (loading factors ≥ 0.7 , AVE ≥ 0.5) and demonstrated high reliability (Cronbach's alpha and Composite Reliability > 0.7) (Singh & Kathuria 2016; Pering, 2020). The inner model showed a significant relationship ($t = 34.302 > 1.96$; $p < 0.0001$), confirming that improved sensory quality strongly enhances consumer preference.

Focus-Group-Discussion (FGD) Sensory Result

The Focus Group Discussion (FGD) involving eight untrained consumer panelists. Each panelist evaluated four commercial ready-to-eat meat analog products at home and completed an online questionnaire that included instructions and descriptions of sensory attributes. Evaluation was performed by selecting attributes they identified during tasting, rating their intensity on a 1–6 scale (from “Very Low” to “Very High”), or choosing “0” if the attribute was not detected. Panelists were also allowed to add any additional sensory attributes they experienced but were not listed. The entire FGD process—from tasting, questionnaire completion, to sensory conclusion discussion was guided and monitored by the researcher via Zoom Meeting. The finalized sensory attributes were used as a reference for developing the sensory questionnaire in the subsequent RATA test.

Table 5. Sensory attributes of FGD results

Rendang	Steak	Beef Slice Balado	Jerky
Appearance			
Oily Shine	Oily Shine	Oily Shine	Oily Shine

Aroma			
Meaty	Meaty	Meaty	
Texture			
Tender	Tender	Tender	Tender
Firm	Firm	Firm	Firm
Fibrous	Fibrous	Fibrous	Fibrous
Juicy	Juicy	Juicy	Juicy
Oily	Oily	Oily	Oily
Flavor			
Meaty	Meaty	Meaty	
Spicy	Spicy	Spicy	
Rendang	Black Pepper	Balado	Jerky
Taste			
Savory	Savory	Savory	Savory
Salty	Salty	Salty	Salty
Sweet	Sweet		Sweet
Mouthfeel			
Soft	Soft	Soft	Soft
Warm	Warm	Warm	
Aftertaste			
Savory	Savory	Savory	Savory
Spicy	Spicy	Spicy	
Salty	Salty	Salty	Salty
Sweet			Sweet

Table 5 shows that the FGD identified 22 relevant sensory attributes to be tested. Notably, none of the samples were found to have off-flavors, musty notes, or beany aromas, as previously reported in studies such as Yang et al. (2023). These attributes were likely absent because all the tested commercial meat analog products in Indonesia are heavily seasoned. The FGD analysis also indicated that texture-related attributes were consistently detected across all tested products. Therefore, texture was selected as the primary focus for further analysis using the RATA and PLS-SEM methods to determine which texture characteristics are most preferred by consumers.

Rate-All-That-Apply (RATA) Sensory Result

Sensory evaluation was analyzed using the Rate-All-That-Apply (RATA) and hedonic methods. The objective of this evaluation was to identify the sensory attributes of commercially available meat analog products in the Indonesian market. The test involved 32 untrained panelists. In the RATA test, panelists were asked to assess a range of sensory attributes present in meat analog products. The intensity scale used was as follows: 0 = absence of the attribute, 1 = very low, 2 = low, 3 = slightly low, 4 = slightly high, 5 = high, and 6 = very high. The intensity data of perceived sensory attributes were visualized using spider web graphs.

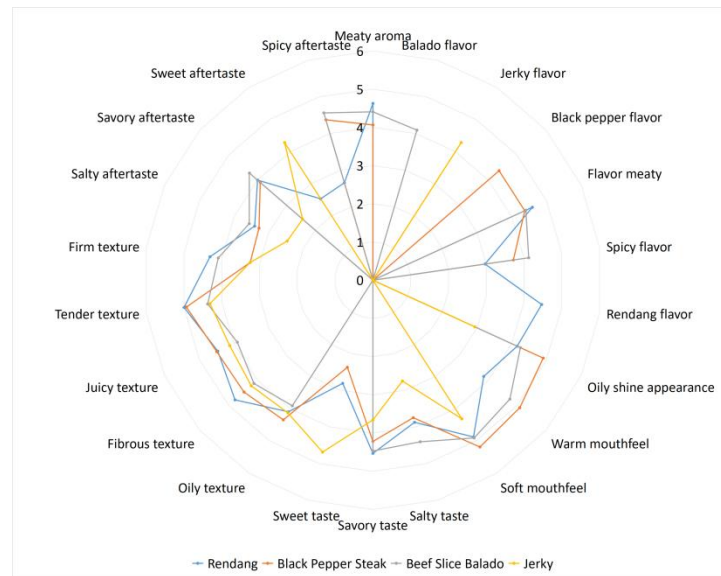


Figure 5. Visualization of sensory profiles of commercial meat analog in a spider web

As shown in Figure 5, the beef rendang analog product exhibited the highest intensities in soft and fibrous textures, soft mouthfeel, meaty aroma and flavor, and savory taste. This sensory profile aligns with the characteristics of traditional beef rendang, particularly in terms of meaty aroma, savory taste, and soft-fibrous texture, suggesting that the product may deliver a sensory experience similar to that of conventional beef rendang (Nabila et al. 2024). In the steak product, attributes with the highest intensities included soft and warm mouthfeel, soft, juicy, and fibrous texture, as well as an oily shine in appearance. The soft and juicy texture aligns with the expected sensory characteristics of steak products (Martinez et al. 2023).

The beef slice balado analog product showed the highest intensities in soft and warm mouthfeel, meaty flavor and aroma, savory taste, and spicy aftertaste. Meanwhile, the jerky analog product exhibited dominant intensities in sweet taste, sweet aftertaste, soft mouthfeel, tender texture, and jerky flavor. The pronounced sweetness is consistent with the typical profile of traditional jerky, which is often characterized by a distinctive sweet taste. However, a notable difference was observed in the texture, as the meat analog jerky was significantly tender than traditional beef jerky, which is typically firm and dry (Setijawaty et al. 2019).

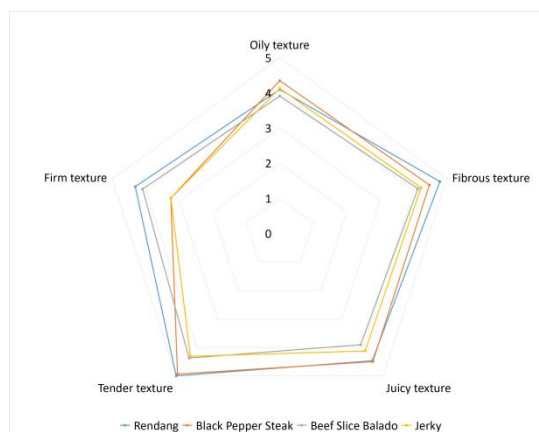


Figure 6. Visualization of texture profiles of commercial meat analog in a spider web

Texture analysis was conducted because texture is a key sensory attribute in comparing the characteristics of each commercial meat analog product. Firm texture was dominant in the rendang sample, while tender texture was more pronounced in both rendang and steak. Juicy texture also appeared prominently in rendang and steak, and fibrous texture was particularly evident in these two products. Meanwhile, oily texture was more noticeable in the steak sample. The beef slice product exhibited both firm and tender textures, whereas the jerky product was characterized by a dominant fibrous and oily texture. This analysis helps identify consumer preference tendencies related to the texture profiles of each product rendang, jerky, steak, and beef slice.

Table 6. Significance value (*p*-value)

Sensory attributes	Significance value
Oily shine appearance	<0.0001
Meaty aroma	<0.0001
Tender texture	<0.0001
Firm texture	<0.0001
Fibrous texture	<0.0001
Juicy texture	<0.0001
Oily texture	<0.0001
Meaty flavor	<0.0001
Spicy flavor	<0.0001
Rendang flavor	0.0015
Black pepper flavor	0.0033
Balado flavor	0.0055
Jerky flavor	<0.0001
Savory taste	<0.0001
Salty taste	<0.0001
Sweet taste	0.1351
Soft mouthfeel	<0.0001
Warm mouthfeel	<0.0001
Savory ftertaste	<0.0001
Spicy aftertaste	<0.0001
Salty aftertaste	<0.0001
Sweet aftertaste	0.1771

Table 6 presents *p*-value analysis of sensory attribute intensities across meat analog samples, showing significant differences ($p < 0.05$) for most attributes, including oily appearance, meaty aroma, textures (tender, firm, fibrous, juicy, oily), flavors (meaty, spicy, rendang, balado, black pepper, jerky), tastes (savory, salty), mouthfeel (soft, warm), and aftertastes (savory, spicy, salty). Sweet taste and sweet aftertaste showed no significant differences ($p = 0.1351$ and 0.1771), indicating similar sweetness levels across samples. Meaty aroma and flavor likely result from additives such as meat flavorings, mushroom extracts, or spices, while savory and salty notes derive from shiitake mushroom extract and legume proteins rich in glutamates, enhanced by added salt (Singh et al. 2023; Sogari et al. 2021). Sweetness may originate from natural sugars in soy and peas or caramelization. Oily and juicy textures are influenced by vegetable oils like coconut oil. Spicy attributes stem from chili and black pepper, and fibrous, firm textures arise from processed soy or pea protein isolates mimicking meat structure. These combined attributes align with Indonesian consumers' sensory expectations of traditional meat products (Maningat et al. 2022).

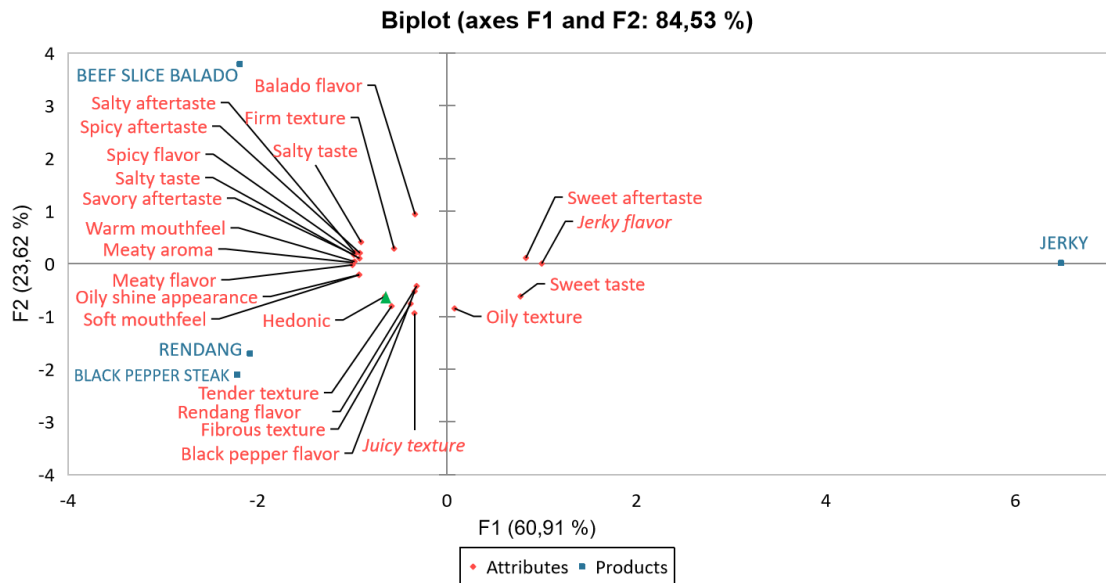


Figure 7. Representation of meat analog sensory profiles using PCA biplot graphs

The PCA biplot from the RATA method (Figure 7) illustrates relationships between samples and sensory attributes. The first two components explain 84.53% of total variance (F1 = 60.91%, F2 = 23.62%), exceeding the 70% threshold for valid interpretation (Sari & Sihombing, 2021). Jerky is positioned in Quadrant I, associated with sweet aftertaste and jerky flavor, near Quadrant IV with sweet taste and oily texture. Beef slice balado lies in Quadrant II, characterized by balado flavor, firm texture, salty and savory tastes, and spicy notes. Rendang and steak cluster in Quadrant III, sharing meaty flavor, oily shine, soft mouthfeel, tender, fibrous, and juicy textures. According to Munarko et al. (2023), sensory attributes close and far from the center, such as savory taste and aftertaste or spicy aftertaste and warm mouthfeel, indicate strong positive correlations. Vidal et al. (2020) stated that samples in the same quadrant, like rendang and steak, exhibit similar sensory profiles, likely due to shared ingredients such as shiitake mushrooms.

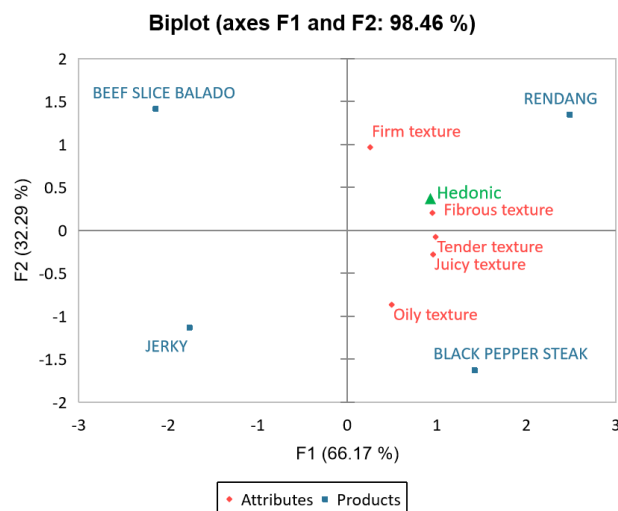


Figure 8. Representation of texture sensory profiles of commercial meat analog products using PCA biplot

A PCA of texture attributes was conducted to examine variations across meat analog samples and their impact on consumer preferences. As shown in Figure 8, the first two components explained 98.49% of total variance ($F1 = 66.17\%$, $F2 = 32.29\%$), indicating a strong model fit ($>70\%$ threshold). Hedonic points represent consumer liking, with closeness indicating greater preference and attribute influence (Haščík et al 2017). Fibrous and firm textures closely associated with the rendang analog and near the hedonic point, highlighting their strong contribution to preference (Gunaratne et al 2019). Tender, juicy, and oily textures were linked to the steak analog, moderately influencing liking. Conversely, beef slice balado and jerky were distant from both texture attributes and hedonic points, suggesting minimal impact on preference.

Hedonic Sensory Result

Table 7. Panelis preference of meat analog commercial products

Product	Rendang	Steak	Balado Beef Slice	Jerky
Overall Liking	4.97 ^c	4.37 ^{bc}	3.78 ^{ab}	3.44 ^a

Note: Different superscript letters within the same row indicate a statistically significant difference at the 5% level.

The hedonic sensory test assessed panelists' preferences for four commercial meat analogs: rendang, steak, beef slice balado, and jerky. Statistical analysis showed a significant difference in overall liking ($p < 0.0001$). Post-hoc Duncan's test (Table 7) revealed rendang had the highest mean score (4.97^c, moderately liked), not significantly different from steak (4.37^{bc}, moderately liked), indicating comparable acceptance. Jerky scored lowest (3.44^a, slightly disliked) but did not differ significantly from beef slice balado (3.78^{ab}, slightly disliked), both reflecting lower acceptance. Significant preference differences existed between rendang and jerky. Overall, rendang and steak were favored over beef slice balado and jerky, suggesting potential for product development targeting consumer preferences. The identical superscript indicates that panelists perceived a comparable level of liking for both products, in accordance with the interpretation of Duncan's test results (Minarsih et al. 2018).

Table 8. Relationship Between RATA and Hedonic Result

Meat analog product	Dominant sensory attributes	Sensory attributes near the hedonic point	Texture attributes near the hedonic point
Rendang	Meaty aroma; Meaty flavor; Savory taste; Tender texture; Fibrous texture; Soft mouthfeel	Meaty flavor; Rendang flavor; Oily appearance; Tender texture; Fibrous texture; Juicy texture; Soft mouthfeel	Fibrous texture; Firm texture
Steak	Oily appearance; Tender texture; Juicy texture; Fibrous texture; Warm mouthfeel; Soft mouthfeel	Meaty flavor; Black pepper flavor; Oily appearance; Tender texture; Fibrous texture; Juicy texture; Soft mouthfeel	Tender texture; Juicy texture; Oily texture
Beef Slice Balado	Meaty aroma; Meaty flavor; Savory taste; Soft mouthfeel; Warm mouthfeel; Spicy aftertaste	—	—
Jerky	Jerky flavor; Sweet taste; Tender texture; Soft mouthfeel; Sweet aftertaste	—	—

Results of the hedonic test indicated that the meat analog rendang product received the highest overall liking score. This preference was influenced by sensory

attributes such as meaty flavor, oily appearance, soft mouthfeel, tender texture, fibrous texture, juicy texture, and rendang flavor, all of which were located near the hedonic point in the PCA biplot. Further texture analysis revealed that firm texture also contributed positively to consumer liking, although this attribute was not identified as being in close proximity to the rendang product in the PCA analysis, as it appeared in a different quadrant than the dominant rendang-related attributes. This finding highlights the importance of conducting in-depth texture analysis to uncover relevant sensory attributes that may not initially emerge from the PCA but significantly influence consumer acceptance of meat analog rendang products.

The hedonic evaluation of the steak analog product showed no significant difference in liking compared to rendang, though it was significantly different from jerky. Sensory attributes located near the hedonic point for steak included meaty flavor, oily appearance, soft mouthfeel, tender texture, fibrous texture, juicy texture, and black pepper flavor. Texture analysis also suggested that oily texture contributed to consumer liking, although this attribute was not closely associated with the steak product in the PCA biplot due to its position in a different quadrant. These findings suggest that both texture- and flavor-related sensory attributes play a critical role in determining consumer acceptance of rendang and steak analog products.

In contrast, beef slice balado (3.78) and jerky (3.44) received significantly lower liking scores than rendang. Sensory attributes located in the same quadrant as beef slice balado included balado flavor, firm texture, salty and savory taste and aftertaste, spicy flavor, warm mouthfeel, and meaty aroma. Although these attributes are consistent with typical balado characteristics (Ramadhan & Games 2022), firm texture was perceived as having low intensity and was relatively disliked by consumers. Similarly, the jerky analog product was dominated by a sweet taste and sweet aftertaste, both perceived as overly intense, potentially masking other sensory attributes that could influence consumer meat analog preference. The tender texture of the jerky was also disliked, as it did not align with the expected characteristics of traditional jerky, which is typically firm, dry, and sweet-flavored (Setijawaty et al. 2019). These results suggest that the sensory intensity, particularly texture of both beef slice balado and jerky products should be optimized to better match consumer preferences, as texture plays a critical role in driving consumer liking of ue products.

Results of Correlation Between Texture Sensory Attributes and Consumer Preferences

The results from both the consumer survey and sensory evaluation in this study indicate that texture attributes play a pivotal role in determining consumer liking and preference. A correlation analysis was conducted using the partial least squares structural equation modeling (PLS-SEM) approach to evaluate the correlation coefficients and significance levels of five key texture attributes in relation to consumer preference. The focus on texture was based on its central importance in the development of meat analog products that aim to resemble real meat, reflecting consumer expectations for traditional meat-based dishes (Godschalk-Broers et al. 2022). Additionally, texture was the only sensory attribute consistently identified across all commercial meat analog samples in Indonesia, despite their differing culinary style. The texture attributes analyzed included tender texture, firm texture, fibrous texture, juicy texture, and oily texture. These data were derived from Rate-All-That-Apply (RATA) assessments, while consumer preferences for the texture attributes were evaluated based on liking scores reported for each individual product.

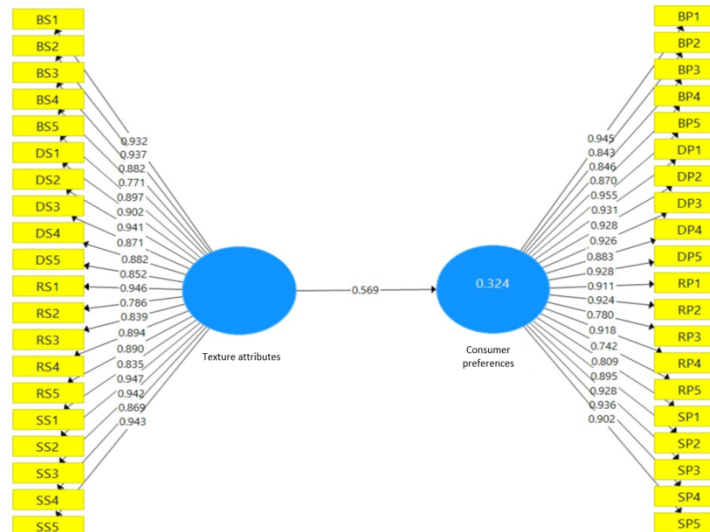


Figure 9 Correlation of texture sensory attributes with consumer preferences of commercial meat analog.

Figure 9 presents the correlation between texture attributes and consumer preferences for four commercial meat analog products: beef slice balado (BS), jerky (DS), rendang (RS), and steak (SS). Texture attributes (1: tender, 2: firm, 3: fibrous, 4: juicy, 5: oily). Preference variables are represented as BP, DP, RP, and SP, respectively. The PLS-SEM analysis revealed a path coefficient of 0.569, indicating a strong positive relationship between texture attributes and consumer preference, consistent with Kusnawan (2018). The model showed good reliability, with all factor loadings above 0.70 ranging from 0.771 to 0.947 for texture attributes and 0.742 to 0.955 for consumer preferences. These results confirm that tender, firm, fibrous, juicy, and oily textures significantly influence consumer acceptance of meat analog products in Indonesia.

Table 9. PLS-SEM Results for Texture Attributes and Consumer Preference

	Outer Model			Inner Model		
	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)	Path Coefficient (O)	T Statistics (O/STDEV)	P Values
Texture Attributes	0.986	0.987	0.791	-	-	-
Consumer Preferences	0.986	0.987	0.795	-	-	-
Texture Attributes -> Consumer Preferences	-	-	-	0.569	5.238	<0.0001

As shown in Table 9, the Average Variance Extracted (AVE) values for texture attributes (0.791) and consumer preference (0.795) exceed the 0.5 threshold, confirming convergent validity. The outer model demonstrates strong reliability, with Cronbach's alpha of 0.986 and Composite Reliability (CR) of 0.987 (Singh & Kathuria 2016; Pering, 2020). The inner model yields a t-statistic of 5.238 and a p-value < 0.0001, indicating a significant relationship between texture attributes and consumer preference (Iba & Wardhana 2024). These results support the hypothesis and emphasize texture as a key driver in meat analog acceptance (Zink et al. 2023)

CONCLUSION

Based on the results, the dominant respondent profile was regular meat consumers aged 18–25 years. Among the evaluated products, commercial meat analog rendang received the

highest hedonic score (4.97), with savory flavor, rendang flavor, oily shine appearance, soft mouthfeel, and tender, fibrous, and juicy textures identified as key drivers of consumer preference through RATA analysis. Texture analysis further highlighted firm and fibrous textures as the most influential attributes. The steak variant ranked second (4.37), with contributing attributes including savory flavor, oily sheen, black pepper flavor, and tender, juicy, and oily textures. In contrast, beef slice balado (3.78) and jerky (3.44) received lower liking scores. The former showed low preference due to its less favorable firm texture, while the latter was dominated by sweet flavor and an undesired tender texture inconsistent with typical jerky characteristics. These findings emphasize the critical role of texture in shaping consumer preferences for meat analog products. The PLS-SEM analysis confirmed a strong, significant relationship between texture attributes and consumer liking (path coefficient = 0.569), suggesting that enhancing textural quality may be key to increasing consumer acceptance.

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