JAFOST
Journal of Agri-Food Science and Technology

P-ISSN 2686-0716 | E-ISSN 2746-5519

Journal homepage http://journal2.uad.ac.id/index.php/jafost
Journal email jafost@tp.uad.ac.id

Sensory Characteristics of Mocaf-Substituted Noodles Enriched with *Latoh* (*Caulerpa lentillifera*)

Mita Nurul Azkia[a,b*], Sri Budi Wahjuningsih[a,b]

[a]Department of Agricultural Products Technology, Faculty of Agricultural Technology, Universitas Semarang, Semarang, Indonesia
[b]Food Research for Safety, Security, and Sustainability (FORC3S), Semarang, Indonesia

[*]Corresponding author, Email: mitanurulazkia@usm.ac.id

Received 10/07/2025 Revised 22/08/2025 Accepted 26/08/2025

ABSTRACT

Noodles are widely consumed globally. However, conventional wheat-based noodles are limited in dietary fiber and functional compounds. Modified cassava flour (mocaf) and latoh (Caulerpa lentillifera) offer potential as natural ingredients to improve the nutritional value and sensory quality of noodles, and Latoh also serves as an alternative to conventional binders such as carboxymethyl cellulose (CMC) and carrageenan. This study aimed to evaluate the sensory characteristics and consumer acceptance of mocaf-based noodles formulated with three different binders: Latoh (MNL), carboxymethyl cellulose (MNCM), and carrageenan (MNCR). The noodles were prepared using a flour blend of 63% mocaf, 36% wheat flour, and 1% binder. Sensory analysis was conducted using a 9-point hedonic scale (taste, aroma, texture, appearance, and overall acceptability) and descriptive analysis. MNCM achieved the highest overall liking score (7.30), with superior ratings in appearance (7.50), taste (6.90), and aftertaste (6.80), indicating better consumer preference due to firmer texture and improved structure. MNCR showed the highest crispness (6.60) but lower fragility (5.00, $p<0.05$), reflecting brittleness. MNL demonstrated favorable values for fragility (6.80) and mouthfeel (6.10) but received slightly lower taste (5.80) and aftertaste (5.50), likely due to distinct seaweed flavor notes. Principal Component Analysis (PCA) confirmed strong associations of MNCM with elasticity, taste, and overall acceptability, while MNCR aligned with crispness. MNL, although less aligned with hedonic preferences, showed functional potential. In conclusion, CMC was the most effective binder for sensory appeal, while Latoh represents a promising natural alternative that requires further optimization to balance functional benefits with consumer acceptance.

KEYWORDS

Enrichment; *Latoh*; Mocaf; Noodles; Sensory

1. INTRODUCTION

Noodles are among the most widely consumed staple foods worldwide, valued for their convenience, affordability, and versatility [1]. However, conventional wheat-based noodles are generally low in dietary fiber and bioactive compounds, thereby limiting their functional health benefits. To improve their nutritional quality and reduce dependence on imported wheat, the use of local raw materials and functional ingredients has been widely explored [2], [3]. Modified cassava flour (mocaf) is considered a promising wheat substitute, as it not only adds value to cassava-producing regions but also exhibits favorable functional properties such as neutral taste and swelling capacity. Mocaf-based products are rich in dietary fiber and resistant starch, which play an essential role in maintaining glycemic balance. These components reduce postprandial glycemic response, delay carbohydrate digestion, and improve insulin sensitivity [4], [5], [6]. In this context, modified cassava flour (mocaf) has emerged as a promising wheat substitute due to its naturally low glycemic index, gluten-free nature, and suitability for individuals managing blood glucose levels [5], [6]. Produced through microbial fermentation of cassava, mocaf undergoes enhanced nutritional

https://doi.org/10.12928/jafost.v6i3.14145

and functional properties, making it highly applicable in food products, including noodles [7], [8]. The health-promoting potential of mocaf-based noodles has been demonstrated in animal studies. Mocaf-based noodles significantly reduced fasting blood glucose levels in diabetic rats, from >250 mg/dL to approximately 105 mg/dL. The treatment also decreased malondialdehyde (MDA) levels by 45% and increased serum insulin levels by 30%, indicating improved pancreatic β-cell function and a reduction in oxidative stress [9]. Despite these benefits, partial substitution with mocaf often alters the texture and sensory quality of noodles, highlighting the importance of suitable binders to maintain desirable product characteristics.

Binders play a crucial role in noodle production by improving elasticity, cohesiveness, and cooking quality. Carboxymethyl cellulose (CMC), a synthetic hydrocolloid, is frequently incorporated into noodle formulations to increase water retention, enhance firmness, and reduce cooking loss [10]. Carrageenan, a polysaccharide derived from red seaweed, functions as a stabilizer and gelling agent, contributing to viscosity, chewiness, and water absorption in noodles [11]. Although both are effective, their application requires refined processing, which may increase production costs and contribute to consumer concerns regarding naturalness and sustainability.

Latoh (*Caulerpa lentillifera*), a green seaweed traditionally consumed in Southeast Asia, offers a natural alternative to conventional binders. It is highly nutritious, containing approximately 32–33% total dietary fiber (dry weight), including soluble fiber, polyphenols, and sulfated polysaccharides [12], [13]. These bioactive compounds possess antioxidant and anti-inflammatory activities, and have been shown to inhibit α-glucosidase and DPP-IV activity in vitro, enhance insulin secretion from pancreatic β-cells, and promote glucose uptake via GLUT4 upregulation in adipocytes [14], [15]. In addition to its metabolic health benefits, the natural polysaccharides in *latoh* may improve noodle cohesiveness and texture in a manner comparable to CMC and carrageenan. Unlike carrageenan, which requires extraction and refinement, *latoh* can be used in a minimally processed form, potentially reducing costs and appealing to consumers seeking natural and sustainable ingredients. Nevertheless, while the applications of CMC and carrageenan in noodle production are well established, research on the incorporation of *C. lentillifera* remains limited.

Since consumer acceptance of noodles is strongly influenced by sensory qualities such as color, texture, taste, and overall acceptability, a comparative evaluation of different binders is essential. Previous studies have reported that noodles formulated with CMC exhibit greater elasticity and a firmer texture, while carrageenan produces a more brittle consistency [16], [17]. In contrast, noodles formulated with 1% *C. lentillifera* demonstrated good sensory acceptability, comparable or superior to noodles containing conventional hydrocolloids, while also offering additional nutritional benefits [18]. These findings highlight the importance of evaluating the sensory properties and consumer acceptance of *latoh*-enriched mocaf noodles in comparison with conventional additives such as CMC and carrageenan, as part of the broader effort to develop functional noodle products with enhanced health benefits and marketability. Therefore, this study aims to investigate the sensory characteristics of noodles partially substituted with mocaf and enriched with *latoh*, and to compare them with noodles formulated using CMC and carrageenan. The findings are expected to provide new insights into the utilization of marine resources as natural binders in functional noodle development, while supporting sustainable and innovative approaches to food diversification.

2. MATERIALS AND METHODS

2.1. Materials

The primary materials used in this study were modified cassava flour, *Caulerpa lentillifera*, CMC, and carrageenan. Mocaf was produced from locally sourced cassava in Grobogan, Central Java, Indonesia, through a fermentation process using a mocaf starter derived from tapioca waste, a by-product of rural agro-industrial activities. Fresh *latoh* (approximately one month old) was obtained from seaweed farmers in Jepara, Central Java, Indonesia. Food-grade CMC and carrageenan were purchased from MKR Chemical, Semarang, Indonesia, and used as hydrocolloid additives in the noodle formulation.

2.2. Noodles Preparation

A flour blend was prepared using 63% mocaf, 36% wheat flour, and 1% binding agent (either *Caulerpa lentillifera*, CMC, or carrageenan). The dry ingredients were mixed with water at a ratio of 1:0.3 (w/v) until a homogeneous dough was formed. The dough was then steamed for 15 minutes, followed by extrusion to produce moist noodles. The noodles were subsequently dried at 50 °C for 12 hours to obtain the final dried noodle product [9].

2.3. Sensory Analysis

Sensory evaluation of the cooked noodle samples was performed to assess both consumer acceptability using a hedonic test and detailed product characteristics through quantitative descriptive analysis (QDA) [2]. The study received ethical approval from the Health Research Ethics Commission of Dr. Moewardi General Hospital (Ref. No. 2.907/XII/HREC/2024). Sensory evaluation was conducted with an initial group of 50 male and female panelists aged 21–25 years. Panelists underwent screening and training in accordance with the Indonesian National Standard (SNI 2346:2015). The screening process included basic taste and aroma recognition, color perception, and sensitivity assessments using triangle discrimination, ranking, and scoring tests. A total of 15 trained panelists who successfully passed the screening were selected to perform both hedonic and QDA tests. Noodles were prepared by boiling for 7 minutes prior to evaluation. In the hedonic test, panelists evaluated appearance, texture, mouthfeel, taste, aftertaste, and overall acceptability using a 9-point hedonic scale (1 = dislike very much, 9 = like very much).

For the QDA, panelists assessed descriptive sensory attributes including color (light–dark), appearance (noodles separate–clump), elasticity (low–high), fragility (low–high), lift in mouth (low–high), and overall similarity to conventional instant noodles. In addition, specific flavor and aroma attributes were evaluated, namely seaweed aroma, umami aroma, seaweed taste, umami taste, umami aftertaste, sweet taste, floury taste, and bitter aftertaste. Panelists were trained to identify and rate each attribute using a structured 9-point intensity scale, and samples were presented in randomized order to minimize bias. Intensity scores were collected and analyzed statistically to compare the sensory profiles of noodles with different binders.

2.4. Data Analysis

The data were first analyzed using one-way analysis of variance (ANOVA) to determine statistically significant differences among noodle formulations. When significant effects were detected ($p<0.05$), Duncan's Multiple Range Test (DMRT) was applied as a post hoc analysis to identify specific differences between sample means. Both ANOVA and DMRT were performed using SPSS version 25.0 (IBM Corp., USA). To further explore the relationships between products and sensory attributes, Principal Component Analysis (PCA) was conducted using MATLAB (MathWorks, USA) by integrating hedonic and descriptive data into a single matrix. Biplot visualizations were generated to illustrate the distribution of samples and sensory descriptors, enabling the identification of key attributes contributing to product variation. This multivariate approach supports the identification of sensory drivers of liking and informs strategic product optimization.

3. RESULTS AND DISCUSSION

3.1. Hedonic Test

The hedonic evaluation of mocaf-substituted noodles formulated with different types of binders, CMC (MNCM), carrageenan (MNCR), and *Latoh* (MNL), was conducted to assess consumer preference. Table 1 presents the mean scores across several sensory attributes, including appearance, crispness, fragility, lift in mouth, taste, aftertaste, and overall liking. A 9-point hedonic scale (1 = disliked extremely; 9 = liked extremely) was used, providing insight into the overall acceptability of the noodle formulations.

The sensory evaluation results showed that most attributes, appearance, crispness, lift in mouth, taste, aftertaste, and overall acceptability, did not differ significantly among the three noodle formulations ($p>0.05$). This indicates that the use of different hydrocolloids (CMC, carrageenan, and *Latoh*) at the tested levels did not substantially alter the panelists' perception of these sensory characteristics. Such nonsignificant differences may be due to the similar texture-modifying functions of these hydrocolloids, which improve mouthfeel, moisture retention, and visual appearance without drastically changing flavor or texture profiles [19], [20]. However, a significant difference (p<0.05) was observed in the fragility attribute, where MNCR (carrageenan-based noodles) had a significantly lower score compared to MNCM and MNL. This suggests that carrageenan produced a more fragile noodle texture, possibly due to its weaker gel-forming ability compared to CMC and seaweed-derived binders like *Latoh* [21], [22]. CMC is known for forming stronger films and enhancing structural integrity, while *Latoh*, rich in dietary fiber and polysaccharides, also contributes to gel strength [23], [24].

Table 1. Hedonic score of noodles with different binder.

Sample	Appearance	Crispness	Fragility	Lift in mouth	Taste	Aftertaste	Overall
MNCM	$7.50^a \pm 1.58$	$5.90^a \pm 1.97$	$6.70^a \pm 1.77$	$6.60^a \pm 1.96$	$6.90^a \pm 1.45$	$6.80^a \pm 1.23$	$7.30^a \pm 0.82$
MNCR	$6.20^a \pm 1.87$	$6.60^a \pm 1.58$	$5.00^b \pm 1.56$	$5.20^a \pm 1.87$	$6.20^a \pm 1.87$	$6.10^a \pm 1.60$	$6.10^a \pm 1.60$
MNL	$6.00^a \pm 1.89$	$5.50^a \pm 1.96$	$6.80^a \pm 1.75$	$6.10^a \pm 1.91$	$5.80^a \pm 1.40$	$5.50^a \pm 1.58$	$6.50^a \pm 1.65$

Note: Values are presented as mean ± standard deviation. Different superscript letters within the same column indicate significant differences between samples, p<0.05.

Furthermore, the concentration of hydrocolloid used also affects noodle quality. Research has shown that the optimal concentration of carrageenan for producing a desirable texture is around 2%. Variations in concentration can be considered to achieve better sensory characteristics, as too low or too high levels may compromise texture or mouthfeel [25]. These findings highlight that while different hydrocolloids may result in similar overall sensory impressions, their specific functional roles, particularly in texture, can significantly affect certain attributes such as fragility. Understanding these differences is important for product development, as selecting the appropriate hydrocolloid can help optimize noodle texture according to consumer preference, even when overall acceptability remains unaffected. Furthermore, the results align with previous research emphasizing the role of hydrocolloids in fine-tuning specific textural characteristics without compromising general sensory quality [21], [22].

3.2. Sensory Descriptive Test

This study evaluated the sensory characteristics of mocaf-substituted noodles formulated with three different binders: carboxymethyl cellulose (CMC, MNCM), carrageenan (MNCR), and *latoh* (MNL) using Quantitative Descriptive Analysis (QDA). The analysis involved six attributes: color (light–dark), appearance (noodles separate–clump), elasticity (low–high), fragility (low–high), lift in mouth (low–high), and overall similarity to conventional instant noodles. The attributes were rated on a 9-point intensity scale by trained panelists, with higher scores indicating greater intensity.

The radar plot visually represents the sensory characteristics of the three noodle formulations; MNCM (CMC), MNCR (carrageenan), and MNL (*latoh*) (Figure 1). MNCM demonstrates a relatively balanced and consistent profile across all attributes, particularly showing higher values in overall acceptability and fragility. This suggests that the use of CMC contributes positively to both structure and overall sensory perception. CMC is known for its excellent water-binding capacity and film-forming ability, which can improve noodle integrity and mouthfeel without compromising other sensory aspects [26], [27]. These findings align with previous research showing that CMC effectively strengthens noodle texture while maintaining high consumer acceptability [28].

In contrast, MNCR, containing carrageenan, shows a strong score in appearance, but significantly lower values in fragility and lift in the mouth, indicating that the noodles may have a more fragile and brittle texture. This is consistent with carrageenan's behavior, which forms softer gels compared to CMC unless reinforced with specific ions such as potassium [29]. The brittleness observed in MNCR could negatively influence consumer perception, as noodles that break easily during cooking or handling are generally less preferred. This result is consistent with earlier studies indicating that carrageenan, while improving visual appearance, may reduce textural resilience in noodle products [25].

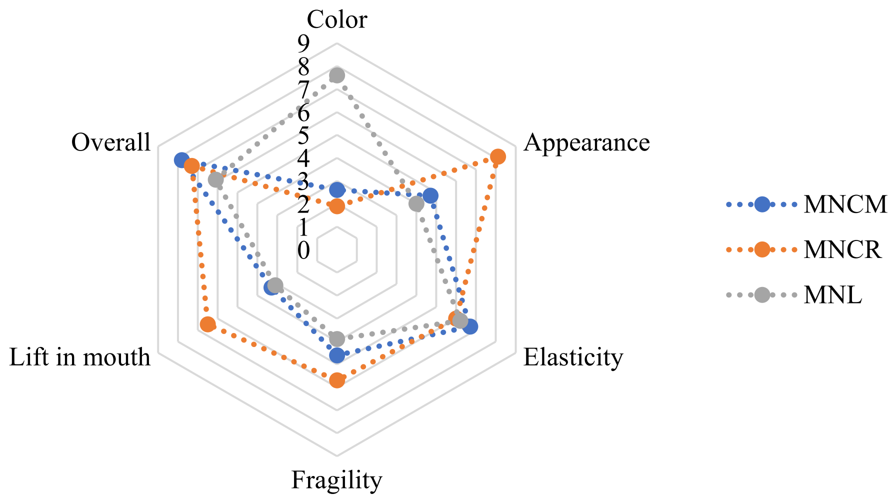

Figure 1. Radar plot of descriptive sensory attributes for mocaf noodles with different binders; MNCM (CMC), MNCR (carrageenan), and MNL (*latoh*).

MNL (with *Latoh*), a seaweed-based binder, exhibits a slightly higher rating in color, which is likely due to the natural pigments and fibers present in *Caulerpa lentillifera*. Seaweed ingredients can enhance color while also providing dietary fiber and functional polysaccharides that improve hydration and mouthfeel [30]. However, the lower ratings in taste and overall suggest that while *latoh* may enhance visual appeal, its flavor contribution or possible off-notes might reduce consumer acceptability [31]. Overall, MNCM appears to offer the most balanced sensory performance, especially in terms of fragility, elasticity, and overall acceptance, which are critical attributes in noodle quality. The use of CMC may therefore be the most effective hydrocolloid binder among the three tested options for maintaining structure without compromising sensory quality. Although *latoh* possesses excellent functional properties beneficial to health, further formulation modifications are necessary to improve its sensory attributes to a level comparable with MNCM. These findings suggest that selecting the appropriate type and concentration of hydrocolloid is essential not only for maintaining noodle structure but also for optimizing consumer acceptability, in line with previous studies on hydrocolloid-based noodle formulations [25], [32], [33].

As shown in Figure 2, the radar plot illustrates distinct differences in the flavor and aroma profiles of the three noodle formulations. MNL consistently exhibits the highest intensities in seaweed aroma, seaweed taste, and umami taste, followed by umami aroma and umami aftertaste. These sensory attributes align with the characteristics of *Caulerpa lentillifera*, which is rich in sulfated polysaccharides, free amino acids (particularly glutamic acid), and volatile compounds that contribute to the marine-like, umami-rich flavor profile [34]. The high intensity of seaweed-derived notes in MNL suggests that *latoh* contributes significantly to flavor enhancement, especially in terms of natural umami and marine-like sensory perception.

In comparison, MNCM shows moderate levels of umami aroma and taste. CMC is a neutral hydrocolloid primarily used for texture improvement and water retention, and does not contribute to taste or aroma [35]. Similarly, MNCR shows lower values across most flavor and aroma descriptors, including umami-related attributes, indicating a relatively milder sensory impact. Carrageenan, although derived from seaweed, has a low volatile compound content and lacks flavor-enhancing amino acids, thus contributing minimally to the overall taste [36]. This aligns with earlier research showing that carrageenan improves textural quality but has minimal influence on taste or aroma [25].

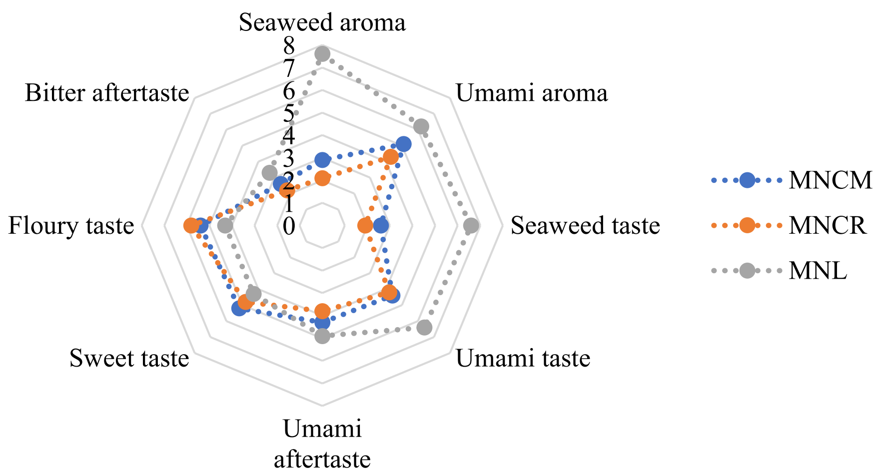

Figure 2. Radar plot of descriptive sensory attributes related to taste and aroma of mocaf noodles with different binders; MNCM (CMC), MNCR (carrageenan), and MNL (*latoh*).

Interestingly, MNL also shows slightly higher ratings in bitter aftertaste, possibly due to the presence of certain phenolic or sulfated compounds naturally occurring in *latoh* [37]. While these compounds may offer antioxidant benefits, they can sometimes impart bitterness or astringency, which could influence consumer preference if not balanced properly. This finding highlights the trade-off between functional benefits and sensory acceptability, emphasizing the need for strategies such as balancing formulations, blending with milder hydrocolloids, or using flavor-masking. Compared with other seaweed-derived hydrocolloids, *latoh* demonstrates a more pronounced contribution to flavor attributes. For instance, kelp (*Laminaria japonica*) extracts or alginate-based binders typically enhance texture and water-holding capacity but contribute less to umami and aroma, often resulting in milder and acceptable sensory changes [38]. *Latoh* provides both binding functionality and distinctive marine flavor, offering a dual role as a textural improver and flavor enhancer. However, this stronger sensory contribution can be a double-edged sword, as excessive seaweed notes or bitterness may reduce consumer acceptance if not carefully managed.

On the other hand, MNCM and MNCR scored slightly higher in sweet and floury taste, suggesting a cleaner and milder sensory profile that more closely resembles conventional noodles. This may be advantageous in markets where consumers prefer familiar flavors and are less receptive to strong marine notes. Previous studies have similarly noted that while seaweed enrichment enhances nutritional and functional properties, excessive intensity of seaweed flavors can reduce consumer acceptance in certain populations [39].

3.3. Principal Component Analysis

To further interpret the relationships among sensory attributes and noodle formulations, Principal Component Analysis (PCA) was applied to both hedonic and descriptive sensory data (Figure 3). PCA is a multivariate statistical technique that reduces data dimensionality and identifies patterns or clusters by capturing the largest variance in the data [40]. In this context, PCA enables visualization of how each noodle sample (MNCM, MNCR, and MNL) relates to the sensory attributes evaluated. The PCA biplot of the hedonic test (left) reveals the distribution of consumer preferences based on sensory attributes, with Component 1 and Component 2 explaining the major variance in the data set.

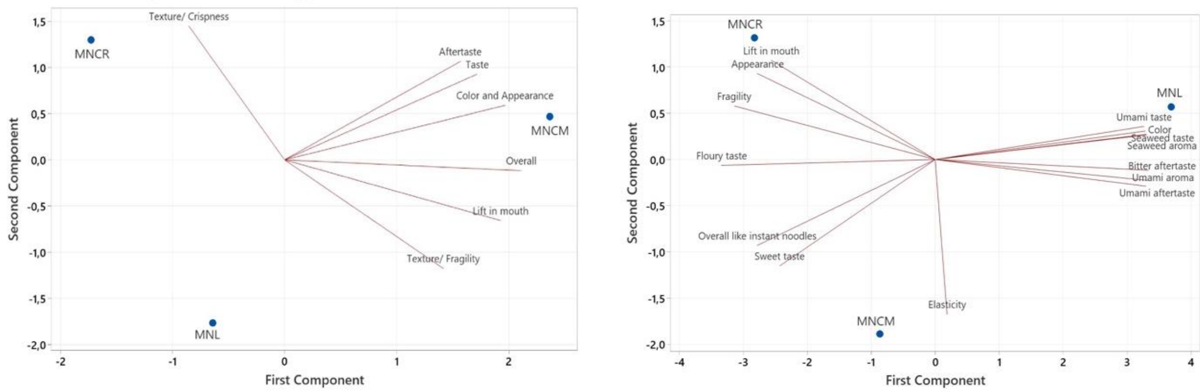

Figure 3. Principal Component Analysis (PCA) biplots of sensory data. Left: Hedonic attributes, right: Descriptive sensory attributes.

In the first PCA biplot (left), based on hedonic attributes such as appearance, elasticity, fragility, taste, aftertaste, and overall acceptance, the first two principal components (first component and second component) explain the majority of the data variance. MNCM is located close to vectors representing overall acceptability, taste, aftertaste, color, and appearance, indicating a strong positive association with these desirable consumer perceptions. This supports the radar plot findings, where MNCM consistently received higher scores in key sensory criteria, likely due to the textural enhancement and structural integrity provided by CMC.

MNCR, positioned near the crispness vector and distanced from overall acceptability, appears to perform well in specific textural aspects but may lack broader consumer appeal. Meanwhile, the MNL group was distinctly separated from most of the hedonic vectors, suggesting lower overall consumer preference compared to the other treatments. Although the MNL sample was still considered acceptable by panelists, it received lower ratings in hedonic attributes compared to the other samples. Particularly for its seaweed-related flavors, its distance from other key hedonic attributes implies that certain polarizing sensory characteristics, such as bitterness or unfamiliar marine aromas, may have reduced its overall appeal relative to the other formulations.

In the second PCA biplot (right), using descriptive sensory variables (e.g., seaweed taste, umami aroma, bitter aftertaste), MNL clearly aligns with vectors representing umami taste, seaweed aroma, seaweed taste, and umami aftertaste. This confirms the radar plot data and highlights *latoh*'s distinctive sensory impact, rich in marine-like and umami qualities due to its glutamic acid and sulfate content [36]. However, it is also associated with bitter aftertaste, which can negatively influence overall acceptability unless mitigated through formulation or flavor masking [37]. MNCM, again isolated near elasticity, reinforces its strength in structural texture rather than strong flavor notes. MNCR, positioned near appearance, lift in mouth, and fragility, reflects moderate performance in sensory characteristics but lacks alignment with either strong flavor or high consumer preference, indicating a more neutral profile. These relationships provide useful insights into how each hydrocolloid influences sensory outcomes beyond simple mean values. PCA clarifies which attributes are most characteristic of each formulation, enabling a more strategic selection of hydrocolloids depending on whether the goal is to enhance texture resilience (CMC), appearance (carrageenan), or flavor complexity (*latoh*).

Our findings are consistent with broader applications of PCA in food quality research. PCA has been extensively applied to establish quality evaluation models for various food products. Ma et al., 2025 [41] employed PCA to evaluate the comprehensive sensory quality of salted duck eggs by integrating sensory-related physicochemical indicators. Similarly, another research used PCA to assess sensory and physicochemical attributes of pea starch noodles, identifying key quality indicators to establish a comprehensive evaluation framework [42]. These studies highlight that PCA is not only effective in identifying attribute relationships but also in guiding product optimization. In our study, PCA effectively differentiated the influence of each hydrocolloid on sensory properties, reinforcing its utility as a tool for product development in noodle formulations.

4. CONCLUSION

This study demonstrated that the type of hydrocolloid binder influenced the sensory characteristics and consumer acceptance of mocaf-based noodles. MNCM (CMC-based noodles) achieved the highest overall liking score (7.30), supported by superior ratings in appearance (7.50), taste (6.90), and aftertaste (6.80). MNCR (carrageenan-based noodles) showed the highest crispness score (6.60) but lower fragility (5.00; $p<0.05$), indicating a more brittle texture. MNL (*latoh*-based noodles) obtained comparable scores in fragility (6.80) and lift in mouth (6.10) but slightly lower scores in taste (5.80) and aftertaste (5.50), reflecting the influence of strong seaweed flavor. Principal Component Analysis (PCA) confirmed that MNCM was closely associated with elasticity, taste, and overall acceptability, MNCR with crispness, and MNL with fragility. Overall, CMC was the most effective binder for enhancing sensory appeal, while *latoh* demonstrated potential functional benefits but requires formulation refinement to improve consumer preference.

AUTHOR CONTRIBUTION

Mita Nurul Azkia: Conceptualization, methodology, investigation, data curation, formal analysis, writing-original draft, visualization. **Sri Budi Wahjuningsih**: Conceptualization, supervision, validation, writing-review and editing, resources.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the National Research and Innovation Agency of Indonesia (BRIN) for providing research funding, to the Institute for Research and Community Services (LPPM) Universitas Semarang for supporting the facilities, and to all parties who contributed to this work.

REFERENCES

[1] G. G. Hou, Asian noodle manufacturing. *Duxford, UK: Woodhead Publishing and AACC International Press*, 2020, https://doi.org/10.1016/C2016-0-02429-4.

[2] S. B. Wahjuningsih, R. Rohadi, Z. D. Siqhny, R. I. Oktaviani, M. N. Azkia, and D. Haryati, "Evaluation of sensory profiles, protein digestibility, and mineral composition in mocaf-multi-grain noodles with different binding agents," *Trends in Sciences*, vol. 22, no. 8, p. 10099, 2025, https://doi.org/10.48048/tis.2025.10099.

[3] A. Hinggiranja, N. M. A. S. Singapurwa, I. G. P. Mangku, I. P. Candra, and A. A. M. Semariyani, "The characteristics of wet noodles from mocaf flour and moringa flour," *Formosa Journal of Science and Technology*, vol. 2, no. 4, pp. 1091–1104, 2023, https://doi.org/10.55927/fjst.v2i4.3647.

[4] Y. Khasanah, A. W. Indrianingsih, P. Triwitono, and A. Murdiati, "Production, biological activities and functional food of modified cassava flour (mocaf)," *Canrea Journal: Food Technology, Nutritions, and Culinary Journal*, vol. 7, no. 2, pp. 213–229, 2024, https://doi.org/10.20956/canrea.v7i2.1280.

[5] P. N. Utami and E. Farida, "Pengaruh tepung beras merah (*Oryza nivara*) dan tepung mocaf (modified cassava flour) terhadap indeks glikemik dan kandungan gizi cookies," *IJPHN*, vol. 3, no. 3, pp. 376–383, 2023, https://doi.org/10.15294/ijphn.v3i3.60951.

[6] S. B. Wahjuningsih, Haslina, S. Untari, and A. Wijanarka, "Hypoglycemic effect of analog rice made from modified cassava flour (mocaf), arrowroot flour and kidney bean flour on STZ-NA induced

diabetic rats," *Asian Journal of Clinical Nutrition*, vol. 10, no. 1, pp. 8–15, 2018, https://doi.org/10.3923/ajcn.2018.8.15.

[7] J. Firdaus, E. Sulistyani, and A. Subagio, "Resistant starch modified cassava flour (mocaf) improves insulin resistance," *Asian Journal of Clinical Nutrition*, vol. 10, no. 1, pp. 32–36, 2017, https://doi.org/10.3923/ajcn.2018.32.36.

[8] S. B. Wahjuningsih and B. Kunarto, "Pembuatan tepung mokal dengan penambahan biang fermentasi alami untuk beras analog," *Jurnal Litbang Provinsi Jawa Tengah*, vol. 11, no. 2, pp. 221–230, 2013, https://doi.org/10.36762/jurnaljateng.v11i2.309.

[9] S. B. Wahjuningsih, D. Anggraeni, Z. D. Siqhny, A. Triputranto, M. R. Kusumastuti, and M. N. Azkia, "Exploring antidiabetic effects of enriched mocaf noodles: a combined computational and in vivo study," *Current Research in Nutrition and Food Science Journal*, vol. 13, no. 1, pp. 231–242, 2025, https://doi.org/10.12944/CRNFSJ.13.1.15.

[10] Md. S. Rahman, Md. S. Hasan, A. S. Nitai, S. Nam, A. K. Karmakar, Md. S. Ahsan, M. J. A. Shiddiky, and M. B. Ahmed, "Recent developments of carboxymethyl cellulose," *Polymers*, vol. 13, no. 8, p. 1345, 2021, https://doi.org/10.3390/polym13081345.

[11] T. Udo, G. Mummaleti, A. Mohan, R. K. Singh, and F. Kong, "Current and emerging applications of carrageenan in the food industry," *Food Research International*, vol. 173, p. 113369, 2023, https://doi.org/10.1016/j.foodres.2023.113369.

[12] N. Syakilla, R. George, F. Y. Chye, W. Pindi, S. Mantihal, N. Ab Wahab, F. M. Fadzwi, P. H. Gu, and P. Matanjun, "A review on nutrients, phytochemicals, and health benefits of green seaweed, *Caulerpa lentillifera*," *Foods*, vol. 11, no. 18, p. 2832, 2022, https://doi.org/10.3390/foods11182832.

[13] X. Chen, Y. Sun, H. Liu, S. Liu, Y. Qin, and P. Li, "Advances in cultivation, wastewater treatment application, bioactive components of *Caulerpa lentillifera* and their biotechnological applications," *PeerJ*, vol. 7, p. e6118, 2019, https://doi.org/10.7717/peerj.6118.

[14] M. K. Setiadi and A. Husni, "Aktivitas antioksidan dan tingkat penerimaan konsumen yoghurt yang diperkaya rumput laut *Caulerpa lentillifera*," *J Pengolah Has Perikan Indones*, vol. 27, no. 5, pp. 417–430, 2024, https://doi.org/10.17844/jphpi.v27i5.53538.

[15] B. R. Sharma and D. Y. Rhyu, "Anti-diabetic effects of *Caulerpa lentillifera*: stimulation of insulin secretion in pancreatic β-cells and enhancement of glucose uptake in adipocytes," *Asian Pac J Trop Biomed*, vol. 4, no. 7, pp. 575–580, 2014, https://doi.org/10.12980/APJTB.4.2014APJTB-2014-0091.

[16] A. Kristiningsih, K. Wittriansyah, S. W. Utami, and S. Purwaningrum, "Effect of addition of carrageenan concentration on quality of breadfruit (*Artocarpus atili*) and Cannabis (*Canna edulis*) wet noodles," *Jurnal Agroindustri*, vol. 12, no. 1, pp. 39–47, 2022, https://doi.org/10.31186/j.agroindustri.12.1.39-47.

[17] Suharman and B. I. Pambudi, "Effect of seaweed addition (*Eucheuma cottonii*) and CMC on organoleptic assessment of mocaf noodles," p. 020020, 2023, https://doi.org/10.1063/5.0105837.

[18] S. B. Wahjuningsih, Haslina, N. Nazir, M. N. Azkia, and A. Triputranto, "Characteristic of mocaf noodles with sago flour substitution (*Metroxylon sago*) and addition of *Latoh* (*Caulerpa lentillifera*)," *Int J Adv Sci Eng Inf Technol*, vol. 13, no. 2, pp. 417–422, 2023, https://doi.org/10.18517/ijaseit.13.2.18205.

[19] T. Lux, J. Krapf, F. Reimold, A. Lochny, A. Erdoes, and E. Floeter, "Amaranth-alginate hydrogels: rheological, textural, and sensory properties for gluten-free noodles," *Future Foods*, vol. 11, p. 100676, 2025, https://doi.org/10.1016/j.fufo.2025.100676.

[20] W. Y. Koh, P. Matanjun, X. X. Lim, and R. Kobun, "Sensory, physicochemical, and cooking qualities of instant noodles incorporated with red seaweed (*Eucheuma denticulatum*)," *Foods*, vol. 11, no. 17, pp. 1–19, 2022, https://doi.org/10.3390/foods11172669.

[21] M. Mendes, J. Cotas, D. Pacheco, K. Ihle, A. Hillinger, M. Cascais, J. C. Marques, L. Pereira, and A. M. M. Gonçalves, "Red seaweed (*Rhodophyta*) phycocolloids: A road from the species to the industry application," *Mar Drugs*, vol. 22, no. 10, p. 432, 2024, https://doi.org/10.3390/md22100432.

[22] W. Y. Koh, P. Matanjun, X. X. Lim, and R. Kobun, "Sensory, physicochemical, and cooking qualities of instant noodles incorporated with red seaweed (*Eucheuma denticulatum*)," *Foods*, vol. 11, no. 17, p. 2669, 2022, https://doi.org/10.3390/foods11172669.

[23] N. A. H. A. Nasir, M. H. Yuswan, N. N. A. K. Shah, A. Abd Rashed, K. Kadota, and Y. A. Yusof, "Evaluation of physicochemical properties of a hydrocolloid-based functional food fortified with *Caulerpa lentillifera*: A D-optimal design approach," *Gels*, vol. 9, no. 7, p. 531, 2023, https://doi.org/10.3390/gels9070531.

[24] R. Chaiklahan, C. Suaisom, N. Chirasuwan, and T. Srinorasing, "Separation and characterization of high- and low-molecular-weight polysaccharides from *Caulerpa lentillifera*," *Carbohydrate Polymer Technologies and Applications*, vol. 10, p. 100776, 2025, https://doi.org/10.1016/j.carpta.2025.100776.

[25] P. S. Widyawati, T. I. P. Suseno, A. I. Widjajaseputra, T. E. W. Widyastuti, V. W. Moeljadi, and S. Tandiono, "The effect of κ-Carrageenan proportion and hot water extract of the *Pluchea indica less* leaf tea on the quality and sensory properties of stink lily (*Amorphophallus muelleri*) wet noodles," *Molecules*, vol. 27, no. 16, p. 5062, 2022, https://doi.org/10.3390/molecules27165062.

[26] A. Rezagholizade-shirvan, M. Soltani, S. Shokri, R. Radfar, M. Arab, and E. Shamloo, "Bioactive compound encapsulation: Characteristics, applications in food systems, and implications for human health," *Food Chem X*, vol. 24, p. 101953, 2024, https://doi.org/10.1016/j.fochx.2024.101953.

[27] B. Naseer, H. R. Naik, S. Z. Hussain, I. Zargar, Beenish, T. A. Bhat, and N. Nazir, "Effect of carboxymethyl cellulose and baking conditions on in-vitro starch digestibility and physico-textural characteristics of low glycemic index gluten-free rice cookies," *LWT*, vol. 141, p. 110885, 2021, https://doi.org/10.1016/j.lwt.2021.110885.

[28] N. I. N. Nasruddin, M. S. Md Jamil, I. Zakaria, and S. I. Zubairi, "Optimization of noodle formulation using commercialized empty fruit bunch palm oil carboxylmethyl cellulose (CMC) and flours with different protein content," *J Teknol*, vol. 80, no. 5, 2018, https://doi.org/10.11113/jt.v80.10594.

[29] F. Jabeen, Zil-e-Aimen, R. Ahmad, S. Mir, N. S. Awwad, and H. A. Ibrahium, "Carrageenan: Structure, properties and applications with special emphasis on food science," *RSC Adv*, vol. 15, no. 27, pp. 22035–22062, 2025, https://doi.org/10.1039/D5RA03296B.

[30] M. F. Manzoor, M. T. Afraz, B. B. Yılmaz, M. Adil, N. Arshad, G. Goksen, M. Ali, and X. Zeng, "Recent progress in natural seaweed pigments: Green extraction, health-promoting activities, techno-functional properties and role in intelligent food packaging," *J Agric Food Res*, vol. 15, p. 100991, 2024, https://doi.org/10.1016/j.jafr.2024.100991.

[31] S. R. Dahlstedt, J. P. Trigo, K. Stedt, F. Rosqvist, I. Undeland, H. Pavia, C. J. B. Rune, D. Giacalone, and P. Sandvik, "Sensory evaluation of seaweed – a scoping review and systematic assessment of sensory studies," *Applied Food Research*, vol. 5, no. 2, p. 101057, 2025, https://doi.org/10.1016/j.afres.2025.101057.

[32] E. K. Parassih, E. Y. Purwani, and W. El Kiyat, "Optimisation of cassava dried noodle using hydrocolloid and protein isolates: A tropical noodle," *Future of Food: Journal on Food, Agriculture and Society*, vol. 8, no. 4, pp. 1–84, 2020, https://doi.org/10.17170/kobra-202010131943.

[33] S. B. Wahjuningsih, Sudjatinah, M. N. Azkia, and D. Anggraeni, "The study of sorghum (*Sorghum bicolor L.*), mung bean (*Vigna radiata*) and sago (*Metroxylon sagu*) noodles: Formulation and physical characterization," *Current Research in Nutrition and Food Science*, vol. 8, no. 1, pp. 217–225, 2020, https://doi.org/10.12944/CRNFSJ.8.1.20.

[34] W. Zhou, Y. Wang, R. Xu, J. Tian, T. Li, and S. Chen, "Comparative analysis of the nutrient composition of *Caulerpa lentillifera* from various cultivation sites," *Foods*, vol. 14, no. 3, p. 474, 2025, https://doi.org/10.3390/foods14030474.

[35] S. Kraithong and S. Rawdkuen, "Quality attributes and cooking properties of commercial Thai rice noodles," *PeerJ*, vol. 9, 2021, https://doi.org/10.7717/peerj.11113.

[36] A. Górska, D. Mańko-Jurkowska, and E. Domian, "Comparative gelation characteristics of carrageenan via rheological and optical techniques: Glazing gels with different sweeteners," *Food Hydrocoll*, vol. 152, p. 109941, 2024, https://doi.org/10.1016/j.foodhyd.2024.109941.

[37] N. Osakabe, T. Shimizu, Y. Fujii, T. Fushimi, and V. Calabrese, "Sensory nutrition and bitterness and astringency of polyphenols," *Biomolecules*, vol. 14, no. 2, p. 234, 2024, https://doi.org/10.3390/biom14020234.

[38] T. Chen, Y. Li, Y. Wang, J. Chen, L. Fan, and Z. Liu, "Study on quality changes of kelp gel edible granules during storage," *Foods*, vol. 13, no. 14, p. 2267, 2024, https://doi.org/10.3390/foods13142267.

[39] J. D. Wilkin, K. Ross, T. Alric, M. Hooper, J. V. Grigor, and B.-S. Chu, "Optimisation of concentration of *Undaria pinnarifida* (wakame) and *Himathalia elongate* (sea spaghetti) varieties to effect digestibility, texture and consumer attribute preference," *Journal of Aquatic Food Product Technology*, vol. 30, no. 8, pp. 932–943, 2021, https://doi.org/10.1080/10498850.2021.1958114.

[40] I. T. Jolliffe and J. Cadima, "Principal component analysis: A review and recent developments," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 374, no. 2065, p. 20150202, 2016, https://doi.org/10.1098/rsta.2015.0202.

[41] R. Ma, B. Li, Y. Wang, J. Wang, X. Yang, B. Xu, and J. Sun, "Quality assessment framework for salted duck eggs: Indicator model," *Journal of Food Composition and Analysis*, vol. 145, p. 107751, 2025, https://doi.org/10.1016/j.jfca.2025.107751.

[42] E. Asiamah, Y. Wang, J. Gan, D. Geng, M. R. Nemţanu, S. Sharafeldin, and Y. Cheng, "Effects of pre-gelatinized starch and dry starch supplementation on the structural and functional integrity of single-component smooth pea starch noodles," *Int J Biol Macromol*, vol. 319, p. 144267, 2025, https://doi.org/10.1016/j.ijbiomac.2025.144267.