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# Seaweed -Enriched Cucuk Gigi: Effects on Dietary Fiber and Sensory Properties

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## ABSTRACT

Cucuk Gigi is a traditional Indonesian snack widely favored by the public. In recent years, there has been a growing interest in enhancing the nutritional value of local foods by incorporating functional ingredients. This study aimed to evaluate the effect of seaweed (*Eucheuma cottonii*) addition on the sensory properties and dietary fiber content of Cucuk Gigi. A completely randomized design (CRD) was employed, consisting of four treatment groups: F0 (control), F1 (40g seaweed), F2 (50g), and F4 (60g). Sensory evaluation was conducted by 25 semi-trained panelists using a hedonic scale ranging from 1 (dislike very much) to 4 (like very much) for color, aroma, taste, and texture. Dietary fiber content was assessed using the gravimetric method. The results indicated that the addition of seaweed did not significantly affect the sensory attributes of color, aroma, or taste ($P > 0.05$), although a significant difference was observed in texture ($P < 0.05$). Among the formulations, F4 (60g seaweed) received the highest overall sensory acceptance and exhibited the greatest fiber content at 5.32%, compared to 3.85% in the control group. In conclusion, the incorporation of seaweed into Cucuk Gigi effectively enhances its dietary fiber content without compromising sensory acceptability. These findings suggest that seaweed can serve as a functional ingredient in traditional Indonesian snacks, contributing to the development of healthier, fiber-rich local food products.

## INTRODUCTION

Cucuk Gigi, also commonly referred to as Tusuk Gigi, is a traditional Indonesian snack widely cherished across diverse regions for its unique texture and flavorful profile. Typically made from rice flour or a blend of tapioca and maizena (cornstarch), this snack is characterized by its elongated shape, chewy yet puffy consistency, and its distinct combination of sweet and mildly spicy flavors **(Puspita, 2021)**. Its popularity reflects the deep-rooted cultural significance of traditional snacks in Indonesia's culinary heritage.

While it has long been enjoyed for its taste and nostalgic appeal, Cucuk Gigi presents a promising opportunity to evolve into a modern, health-oriented product. One way to achieve this transformation is by incorporating nutritionally beneficial ingredients

such as seaweed, which can enhance the snack's functional and nutritional value **(Raja *et al.*, 2022)**.

Seaweed (marine macroalgae) is widely recognized as a rich source of dietary fiber, essential micronutrients, and health-promoting bioactive compounds such as fucoidan, laminarin, and polyphenols **(Murai *et al.*, 2021; Salido *et al.*, 2024; El Haci *et al.*, 2025)**. On average, seaweed contains 24.5% soluble fiber and 21.8% insoluble fiber in dry conditions, although the specific content can vary depending on the species and processing method **(Peñalver *et al.*, 2020)**. Compared to other plant-based sources of fiber, such as papaya and kale, seaweed offers a superior fiber profile and additional bioactive benefits. Furthermore, it contains vitamins, minerals, and phytochemicals associated with improved metabolic and immune function **(Matos *et al.*, 2024)**. Its integration into traditionally low-fiber foods like Cucuk Gigi may thus contribute not only to improved digestive health but also to the broader effort of combating non-communicable diseases linked to poor dietary fiber intake.

According to the World Health Organization **(WHO, 2023)**, insufficient fiber intake is a key risk factor for non-communicable diseases (NCDs) such as heart disease, diabetes, and certain cancers. Several studies have linked regular seaweed consumption with reduced risks of cardiovascular disease, hypertension, and some cancers **(Peñalver *et al.*, 2020; Lomartite *et al.*, 2021)**. These benefits are attributed to seaweed's antioxidant, anticancer, and antiviral properties, which arise from its content of fucoidan, laminarin, phlorotannins, and sulfated polysaccharides **(Peñalver *et al.*, 2020; Murai *et al.*, 2021)**. Incorporating seaweed into Cucuk Gigi could enhance its role from merely a traditional snack to a functional food capable of supporting preventive health measures. This transformation aligns with the growing global demand for healthier snack options and the increasing consumer awareness of food as a means of promoting wellness.

Previous studies have demonstrated the practicality of integrating seaweed into staple or snack foods. For example, adding 15g of seaweed pulp to analog rice improved textural properties without compromising quality **(Damat *et al.*, 2021)**. Similarly, higher levels of seaweed inclusion at 10, 20, and even 30% have significantly boosted fiber content and enhanced organoleptic qualities, including taste, aroma, and mouthfeel **(Handayani & Aminah, 2011)**. Building on this evidence, our study seeked to develop a seaweed-enriched version of Cucuk Gigi that meets the nutritional and sensory expectations of modern consumers while respecting the traditional character of the snack.

Despite its nutritional potential, seaweed remains underutilized in Indonesian diets. National seaweed production stands at approximately 1.7 million tons annually, yet only 15% is allocated for direct human consumption, resulting in a per capita intake of merely 0.2kg **(Dwiyitno, 2011)**. This contrasts sharply with countries like Japan, where consumption can reach up to 1.6kg per capita, reflecting broader acceptance and dietary integration.

The low domestic consumption indicates a gap in product innovation and consumer engagement. Developing culturally familiar yet nutritionally enhanced snacks, such as seaweed-infused Cucuk Gigi, could be a practical entry point to increase public interest in

seaweed-based products. Recent consumer trend studies suggest growing openness to functional foods and marine-sourced ingredients, especially among younger demographics **(Anderson & Pomeroy, 2023)**. Such innovations offer an opportunity to reposition seaweed from a niche ingredient to a mainstream dietary component, particularly when introduced through traditional food formats.

This study evaluated the effect of incorporating varying concentrations of seaweed (*Eucheuma cottonii*) on the dietary fiber content and sensory (organoleptic) characteristics of Cucuk Gigi, a traditional Indonesian snack. The objective was to identify an optimal formulation that enhances the snack's nutritional profile, particularly its fiber content, while maintaining desirable sensory qualities such as color, aroma, taste, texture, and overall acceptability.

## MATERIALS AND METHODS

### 1. Time and study location

This study was carried out between August and December 2023 at two key research institutions, including the Pangkep Food Ingredient Research Institute under the Ministry of Food and Drug Safety and the National Innovation Research Institute. These facilities provided the necessary infrastructure and technical support for conducting both the formulation and analysis of the seaweed-enriched Cucuk Gigi snacks, including assessments of nutritional composition and sensory evaluation. The collaboration between these institutions ensured a rigorous and comprehensive research process, aligning with national standards for food innovation and safety.

### 2. Materials and tools

The ingredients used in this study included *E. cottonii* paste, Rose Brand rice flour, Mesena-brand cornstarch, Regina-brand salt, and cane sugar. Additional ingredients such as coconut milk, fruit, and mineral water were also incorporated. Many of these raw materials, particularly the seaweed, were sourced from local fishing communities in the Pinrang and Wajo regions, ensuring the use of regionally available and sustainable resources. The tools employed in the preparation and analysis processes comprised standard kitchen and laboratory equipment, including blenders, mixers, chopsticks, digital scales, measuring cups, bowls, and spoons, all of which supported the accurate formulation and consistent handling of the snack samples.

### 3. Research design and stages

The research employed a Completely Randomized Design (CRD) with a one-factor factorial arrangement consisting of three levels of seaweed paste addition: 40, 50, and 60g per dough batch. Each treatment was conducted with three replications. The specific product formulation used in the study is outlined in Table (1). The experimental procedure was carried out in two main stages. The first stage involved the production of Cucuk Gigi variants with different concentrations of seaweed paste, followed by a sensory evaluation to determine the most acceptable formulation based on key organoleptic attributes such as color, aroma, taste, and texture. In the second stage,

dietary fiber analysis was conducted on the selected seaweed-enriched Cucuk Gigi sample, as well as on the control sample (without seaweed), to assess the impact of seaweed incorporation on fiber content.

**Table 1.** Composition of seaweed-enriched Cucuk Gigi snack across different treatments

| Material | Treatment (F= formulation) | | | |
|---|---|---|---|---|
| | F1 | F2 | F3 | F4 |
| Rose brand flour | 250 g | 250 g | 250 g | 250 g |
| Seaweed | 0 g | 40 g | 50 g | 60 g |
| Cornstarch | 2 g | 2 g | 2 g | 2 g |
| Egg | 10 g | 10 g | 10 g | 10 g |
| Sugar | 2 g | 2 g | 2 g | 2 g |
| Salt | 2 g | 2 g | 2 g | 2 g |
| Coconut cream | 200 mL | 200 mL | 200 mL | 200 mL |

## 4. Manufacturing procedure

The detailed manufacturing procedure is illustrated in Figs. (1 and 2). The production of seaweed-enriched Cucuk Gigi begins with careful cleaning of the seaweed to remove any dirt and impurities. The cleaned seaweed is then soaked in water for 12 hours to soften its texture, making it easier to process. After soaking, the seaweed is blended with water in equal parts to create a smooth paste. Next, all the ingredients, including the seaweed paste, rice flour, cornstarch, sugar, salt, coconut milk, and egg, are accurately weighed according to the formulation and combined. The mixture is stirred and kneaded thoroughly until the dough becomes pliable and evenly mixed. A specialized mold is prepared, into which the dough is placed and twisted to form thin strands. These strands are then cut to the desired size and repeatedly passed through a slicing machine to ensure consistent thickness. The sliced dough pieces are spread out to air dry for approximately 4 hours at room temperature to reduce their moisture content in preparation for frying. Once dried, the pieces are fried in hot oil at 170°C for 3–5 minutes until they achieve the preferred crispness and golden color. The resulting product is a traditional Cucuk Gigi snack enriched with seaweed.

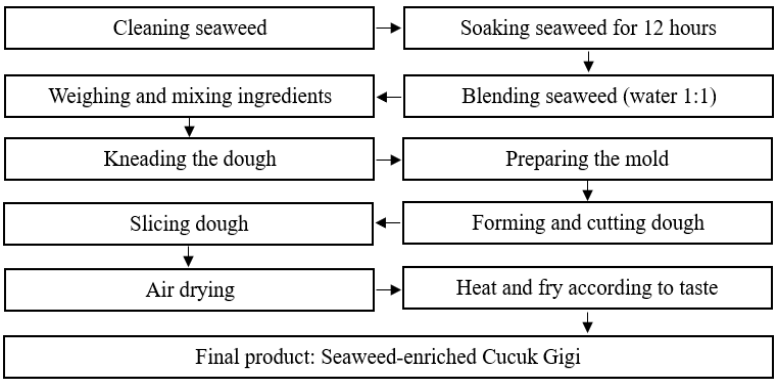


**Fig. 1.** Manufacturing process of Cucuk Gigi. Cleaning and soaking seaweed for 12 hours; Blending seaweed (water ratio 1:1); Weighing and mixing all ingredients;

Kneading the dough; Preparing mould and forming/cutting the dough; Slicing, air-drying, and frying according to desired crispiness; and leading to the final product


**Fig. 2.** Production process of the Cucuk Gigi snack. (a) Preparation of raw materials (rice flour, tapioca flour, seaweed, and seasonings); (b) Dough mixing process; (c) Mechanical cutting of the dough into stick shapes; (d–e) Frying by trained community members during a demonstration session; (f) Final product packaging and labelling

## 5. Sensory evaluation

Sensory evaluation in this study was conducted using a hedonic test to assess the panellists' preference level across four sensory attributes: color, aroma, taste, and texture. A four-point hedonic scale was employed, where 1 = dislike very much, 2 = dislike, 3 = like, and 4 = like very much. This assessment aimed to determine the overall acceptability of the Cucuk Gigi formulations enriched with seaweed. The evaluation was conducted by 25 semi-trained panellists who had received prior orientation and guidance on assessing sensory attributes based on standardized procedures, as **Marques *et al.* (2022)** outlined. The panellists were adults aged between 20 and 35 years, consisting of 13 females and 12 males, all with prior experience in food sensory evaluation through academic coursework or structured training. This approach ensured consistency and reliability in the sensory data collected.

## 6. Fiber content test procedure

The crude fiber content of the Cucuk Gigi samples was determined using the gravimetric method, as described by **Sudjana (1986)** and adopted by **Alsuhendra and Ridawati (2008)**. Approximately 1– 2g of each sample was accurately weighed and placed into a 500mL Erlenmeyer flask. To this, 50mL of 1.25% sulfuric acid ($H_2SO_4$) was added, and the mixture was refluxed for 30 minutes. After cooling, 50mL of 3.25% sodium hydroxide (NaOH) was added, and the mixture was refluxed again for another 30 minutes. The hot solution was then filtered through pre-weighed filter paper. The residue was sequentially washed with 50mL of heated 1.25% $H_2SO_4$, followed by 50mL of 96%

ethanol to remove impurities and neutralize the sample. The filtered residue was dried in a hot air oven at 105°C until a constant weight was achieved. The crude fiber content was calculated based on the weight difference before and after drying.

### 7. Data analysis

The average values obtained from the sensory evaluation and crude fiber content measurements were presented in tabular form and analyzed descriptively. Statistical analysis was conducted at a 95% confidence level. Differences among treatments were assessed using the Kruskal–Wallis test, a non-parametric method suitable for comparing more than two independent groups. When significant differences were identified ($P< 0.05$), the analysis was followed by the Mann–Whitney U test to determine which specific treatments differed significantly. All statistical analyses were performed using IBM SPSS Statistics version 26. Non-parametric tests were selected because the data did not meet the assumptions of normality and homogeneity of variance, as determined by preliminary Shapiro–Wilk and Levene's tests. A *P*-value of less than 0.05 was considered statistically significant, indicating that the observed differences between treatments were unlikely due to random variation.

## RESULTS AND DISCUSSION

The results of the sensory evaluation for the Cucuk Gigi snack enriched with various levels of seaweed are presented in Table (2). The attributes assessed include color, aroma, taste, and texture, with each rated using a 4-point hedonic scale by 25 semi-trained panelists. Overall, higher seaweed levels, particularly at 50– 60g, tended to receive slightly better acceptability scores than the control and lower seaweed concentrations, though differences were generally minor. When broken down by attribute, color and aroma scores showed minimal variation across treatments, with panelists preferring samples containing moderate to high seaweed content. Taste responses were uniform, indicating neutral to mildly favorable perceptions regardless of seaweed amount. The texture was the most affected attribute, with moderate seaweed addition notably improving the product's chewiness and structure.

Statistical analysis using the Kruskal–Wallis test revealed that texture was the only sensory attribute that differed significantly across treatments ($P= 0.00$), indicating that seaweed addition had a measurable effect on the product's texture. Before this, a normality test (Shapiro-Wilk) was conducted on the sensory data, which showed that the data did not follow a normal distribution, thus justifying the use of the non-parametric Kruskal–Wallis test for analysis. For the other attributes, color ($P= 0.41$), aroma ($P= 0.21$), and taste ($P= 0.91$), no statistically significant differences were observed among treatments. These findings suggest that while seaweed incorporation does not negatively impact sensory characteristics such as color, aroma, or taste, it enhances textural properties statistically. Adding up to 60g of *E. cottonii* seaweed did not reduce the sensory acceptability of Cucuk Gigi and even contributed positively to specific sensory

attributes, particularly texture. This supports the potential of seaweed as a functional ingredient in traditional snacks without compromising consumer preference.

**Table 2.** Results of sensory evaluation

| Treatment | Color | Aroma | Taste | Texture | Average |
|---|---|---|---|---|---|
| F1 | 3.30±0.38 | 3.44±0.62 | 2.96±0.43 | 3.08±0.23 | 3.20±0.21 |
| F2 | 3.24±0.43 | 3.20±0.50 | 2.96±0.20 | 3.44±0.16 | 3.21±0.19 |
| F3 | 3.42±0.56 | 3.14±0.38 | 3.00±0.53 | 3.38±0.48 | 3.24±0.20 |
| F4 | 3.42±0.52 | 3.30±0.50 | 3.03±0.52 | 3.30±0.38 | 3.27±0.16 |
| *P* value | 0.41 | 0.21 | 0.91 | 0.00 | |

Sensory quality was evaluated through panelists' assessment of the product's taste, aroma, color, and texture. Sensory perception is defined as a physio-psychological process involving the awareness or recognition of an object's attributes by the sensory organs in response to external stimuli. It also encompasses the mental reactions or sensations that occur when these sensory receptors are stimulated **(Prachi & Maurya, 2024)**. The sensory evaluation in this study aimed to capture panelists' overall acceptance of the product based on these four key attributes. The detailed results of the sensory testing are presented below:

**Color attribute**

Color is a key aspect of the overall appearance of food and can be assessed descriptively as an important sensory attribute. Beyond serving as a quality indicator, color also signals freshness, ripeness, and even the degree of cooking or processing, thereby influencing consumer expectations and acceptance. The visual appeal of food greatly affects appetite stimulation, as humans are naturally drawn to foods that look vibrant and appetizing **(Spence *et al.*, 2022)**. The sensory evaluation results presented in Table (2) indicate no statistically significant difference in panelists' preference for the color of the Cucuk Gigi samples across the different levels of seaweed addition. However, as depicted in Fig. (1), increasing seaweed content resulted in a progressively darker hue of the product. Notably, the formulation with the highest seaweed concentration (F4) was rated most favorably in terms of color. This browning effect is primarily attributed to the Maillard reaction, a chemical process occurring during heating between the proteins present in the seaweed and sugars in the dough, which generates brown pigments and contributes to a perceived "well-cooked" or mature appearance **(Nagai *et al.*, 2005)**. This reaction is facilitated by frying the product at 170°C for 3–5 minutes, conditions sufficient to promote Maillard browning without burning the product.

Additionally, seaweed contains natural pigments such as chlorophyll (green) and carotenoids (yellow to brown), largely derived from the microalgae composing the seaweed biomass. These pigments not only affect the visual appearance but also possess antioxidant properties that may provide added health benefits **(Jayasinghe *et al.*, 2016)**. The presence of these bioactive compounds can enhance the functional value of the snack, contributing to its appeal as a nutritious and visually attractive product. Moreover, seaweed is reported to exhibit antimicrobial properties, including antibacterial and

antifungal effects, which may help extend the shelf life of food products when used as an ingredient **(Banu *et al.*, 2020)**. This multifunctionality underscores the potential of seaweed as a valuable additive that can improve both the sensory and preservative qualities of traditional snacks such as Cucuk Gigi. Fig. (3) presents the visual characteristics of the Cucuk Gigi snack for each treatment.

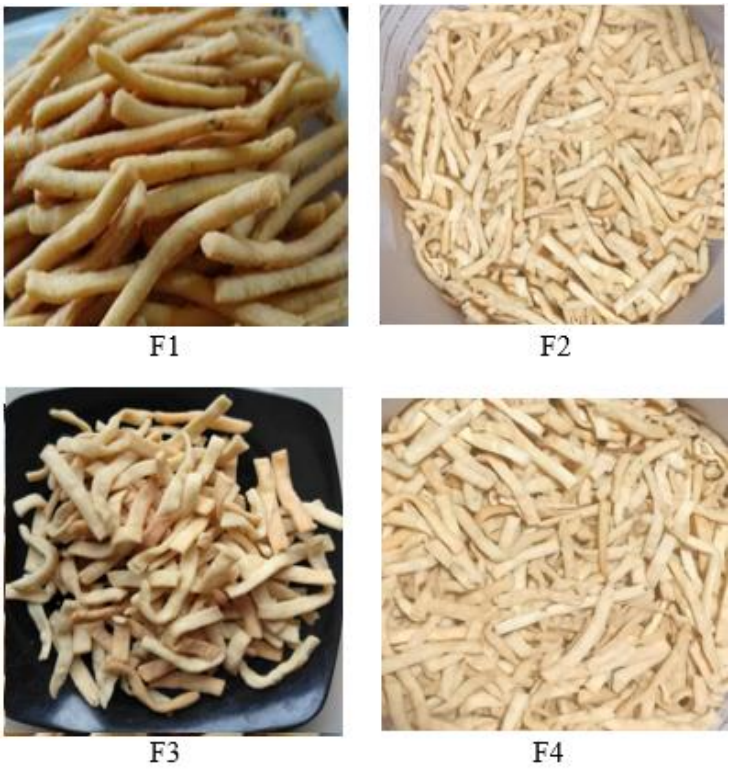


**Fig. 3.** Cucuk Gigi products from seaweed formulations

**Aroma attribute**

Aroma refers to the volatile compounds released by food or beverages that are perceived by the olfactory receptors in the nasal cavity. It plays a critical role in shaping consumers' initial perception and overall sensory experience of a food product. Among the key sensory cues, aroma is often one of the first to be detected and can significantly influence appetite, palatability, and emotional response to food **(Forde, 2016)**. A pleasant aroma not only enhances food enjoyment but also serves as a decisive factor in consumer acceptance, particularly for traditional or culturally familiar products. In this study, the sensory testing results demonstrated that the addition of *E. cottonii* seaweed to Cucuk Gigi did not significantly alter the aroma profile of the product across the different treatment levels. All formulations, ranging from the control (F1) to the highest seaweed concentration (F4), were similarly rated by panelists in terms of aroma, indicating that seaweed did not introduce undesirable or overpowering olfactory notes. These findings are in agreement with **Mamat *et al.* (2018)**, who reported that the incorporation of 6% seaweed flour in muffin production yielded optimal aromatic quality without compromising sensory appeal.

Moreover, although the statistical analysis in this study did not show a significant effect, previous research has suggested that seaweed contributes to a mild umami aroma, which can enhance overall flavor complexity. **Frøst *et al.* (2021)** observed that increasing the amount of seaweed in pancakes led to a richer, more savory scent, potentially linked to the presence of glutamates and other natural flavor-enhancing compounds found in marine algae. In addition, our sensory panellists provided qualitative feedback, noting subtle savoury and broth-like aroma notes in formulations with higher seaweed content, supporting the presence of umami-related volatiles. Analytical studies, such as those by **Yamaguchi and Ninomiya (2000)**, identify free amino acids like glutamic acid and 5'-nucleotides in seaweed as key contributors to umami taste and aroma, further reinforcing this sensory observation. Therefore, while no significant differences were observed quantitatively in this study, the qualitative impact of seaweed on aroma may still contribute positively to the sensory depth and identity of the Cucuk Gigi product. These findings support the continued exploration of seaweed as a functional ingredient that can enhance sensory properties without negatively affecting consumer preferences, particularly in traditional snack formulations.

**Taste attribute**

Taste is one of the most influential factors determining consumer acceptance or rejection of a food product. Human taste perception encompasses four primary components: bitterness, sourness, sweetness, and saltiness. The perception of taste is influenced by various factors, including temperature, the presence and concentration of chemical compounds, and their interactions with other food components. Taste is detected by specialized receptors located on the surface of the tongue and the epiglottis **(Cole & Kramer, 2016)**.

As shown in Table (2), the addition of seaweed did not result in a statistically significant difference in the taste of the Cucuk Gigi formulations. Among the treatments, F4, containing 60g of seaweed per dough batch, equivalent to a 6% addition, was rated the highest in taste, although the differences across treatments were not significant. These findings align with the study by **Handayani and Aminah (2011)**, which found that incorporating 5% seaweed flour into cake formulations did not cause a noticeable change in taste. Nevertheless, the addition of seaweed appears to enhance the overall liking of the product. This may be attributed to the umami properties of seaweed, which can impart a savory flavor profile. According to **Frøst *et al.* (2021)**, such umami enhancement may contribute positively to consumer preference, particularly in traditional foods like serabi, where a richer, more complex taste is desirable. Furthermore, this study's quantitative descriptive analysis (QDA) from trained panellists indicated a mild but perceptible increase in umami intensity correlating with higher seaweed levels. This sensory data aligns with chemical analyses reporting elevated free glutamate content in *E. cottonii*-enriched samples, confirming the technical basis for the umami effect **(Amalia *et al.*, 2021)**.

**Texture attribute**

The texture and consistency of a food product are critical factors influencing both taste perception and consumer acceptance. A desirable texture can enhance the eating experience by affecting the stimulation of the olfactory receptors and salivary glands, which in turn may stimulate appetite **(Chen & Rosenthal, 2015)**. In this study, the texture of Cucuk Gigi was evaluated based on panelists' sensory acceptability using a hedonic scale. To minimize potential bias and isolate the texture of the base product, samples were tested without the addition of kinca (sweet coconut sauce), which could alter the perceived consistency. As shown in Table (2), texture was the only attribute with a statistically significant difference among treatments ($P< 0.05$), indicating that the addition of seaweed had a measurable impact. Panelists' average liking scores for texture ranged from 3.0 to 3.5, which falls within the "like" category. The highest levels of texture preference were observed in treatments F2 and F4, corresponding to formulations with 40 and 60g of seaweed, respectively. These products exhibited a firmer, denser texture that was described as pleasantly crunchy, a quality that panelists found appealing.

The enhanced texture in these formulations is likely attributed to the presence of hydrocolloids naturally found in *E. cottonii* seaweed. Hydrocolloids function as gelling agents, binding water and strengthening the dough structure. Specifically, the sulfated polysaccharides such as carrageenan and agar present in *E. cottonii* form a three-dimensional network that traps water molecules, increasing the viscosity and elasticity of the dough matrix **(Onyango *et al.*, 2021)**. This gelation effect reduces water mobility and stabilizes the dough during heating, preventing excessive expansion and collapse of air cells. As a result, the dough becomes denser and less able to expand during cooking, which reduces the formation of large air pockets and contributes to a more compact and crisp texture **(Mamat *et al.*, 2018)**. Although this leads to a thicker, heavier mouthfeel, such characteristics were positively received by panelists, who preferred the firmness and crunchiness of the seaweed-enriched Cucuk Gigi. These findings are consistent with earlier research by **Rosyidi *et al.* (2008)**, who reported that the incorporation of seaweed flour in chicken nuggets improved texture by enhancing structural integrity and bite. Similarly, in the context of traditional snacks, seaweed addition appears to enhance tactile quality without compromising other sensory attributes. This suggests that seaweed not only contributes nutritional value but also improves the product's physical appeal.

**Fiber content**

The best-performing treatment in this study was identified based on the highest average sensory scores across the four key attributes: taste, color, texture, and aroma. The formulation designated as F4, which included the addition of 60g (6%) of *E. cottonii* seaweed per dough batch, was rated the most favorable by panelists. This product was characterized by a visually appealing yellowish-brown color, a distinctive and pleasant aroma typical of traditional Cucuk Gigi, a sweet and savory flavor profile, and a dense yet palatable texture with minimal internal cavities, attributes that contributed to its high overall acceptability.

To assess the functional improvement of the product, a fiber content analysis was conducted on both the control (without seaweed) and the F4 treatment. As shown in Fig. (4), the fiber content of the F4 formulation was 5.3g per 100g, whereas the control product contained only 3.8g per 100g. This represents a notable increase of 1.5g of dietary fiber or an enhancement of approximately 39.5% compared to the untreated version. The increase can be attributed to the naturally high fiber content found in *E. cottonii*, which contains up to 24.5% soluble fiber and 21.8% insoluble fiber in its dry form **(Peñalver *et al.*, 2020)**. From a nutritional standpoint, the fiber content in the F4 formulation meets approximately 17.7% of the recommended daily fiber intake for adults, as outlined by the **Indonesian Ministry of Health (2019)**. This contribution is considered meaningful, particularly in populations where daily fiber intake often falls short of recommended levels. According to **WHO (2023)**, the global average fiber intake is typically below 20g per day, suggesting that even small additions, such as 1.5g from a single snack portion, can support this dietary gap. Regularly consuming such fiber-enriched traditional snacks may help improve digestive health, regulate blood sugar, and support satiety, especially when incorporated into a balanced diet. These findings highlight the potential of incorporating seaweed not only to improve the sensory characteristics of traditional snacks but also to enhance their nutritional profile, contributing to the development of locally sourced functional foods.

These findings are in alignment with prior research conducted by **Widati *et al.* (2021)**, which demonstrated that the addition of seaweed in concentrations ranging from 2.5% to 7.5% effectively increased the dietary fiber content of meatball products. This evidence supports the hypothesis that seaweed, particularly *E. cottonii*, can serve as a valuable functional ingredient capable of enhancing the nutritional value of various traditional food items. Similarly, in the current study, the incorporation of 6% seaweed into Cucuk Gigi significantly elevated its fiber content, suggesting its potential to be positioned not merely as a traditional snack but as a nutritionally enriched functional food.

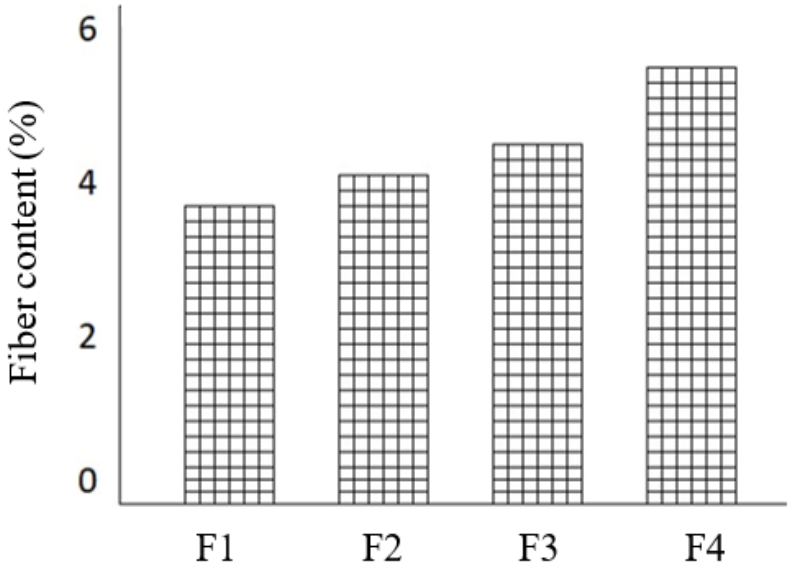


**Fig. 4.** Fiber content in the Cucuk Gigi product across different treatments (F)

The concept of functional foods refers to products that offer additional health benefits beyond basic nutrition, particularly in the prevention and management of chronic diseases. Dietary fiber is a key component in this category, as it contributes to gastrointestinal health, regulates blood glucose levels, reduces cholesterol, and supports healthy weight management. Given the rising global concern over diet-related non-communicable diseases, such as cardiovascular disease, obesity, and type 2 diabetes, the development of fiber-rich traditional foods can play an important role in community-based nutrition interventions.

Regarding nutritional enhancement, the F4 formulation contained approximately 1.5 g more dietary fiber than the control, amounting to about 17.7% of adults' recommended daily intake (RDI) of 28 g **(Indonesian Ministry of Health, 2019)**. Compared to typical commercial fried snacks, such as crackers or chips, which often contain less than 1 g of dietary fibre per serving **(USDA, 2021)**, F4 offers a substantially higher fibre contribution. This suggests that seaweed-enriched Cucuk Gigi meets sensory expectations and provides a superior nutritional profile, particularly fibre, making it a promising alternative to conventional low-fiber snack options.

In this context, Cucuk Gigi enriched with seaweed presents a promising alternative to conventional snacks that are typically high in refined carbohydrates and low in essential nutrients. The use of locally sourced ingredients such as *E. cottonii* also aligns with sustainable food development strategies by promoting regional biodiversity, supporting coastal economies, and reducing reliance on imported nutritional additives. Moreover, previous findings by **Damayanti *et al.* (2020)** reinforce the idea that seaweed-based products can function as accessible and culturally acceptable sources of fiber for the general population. Overall, these findings highlight the dual benefit of incorporating seaweed into traditional snack formulations: improving the nutritional profile while maintaining or even enhancing sensory acceptability. This positions seaweed-enriched Cucuk Gigi as a viable functional food candidate that can contribute meaningfully to

public health, nutrition, and food innovation in Indonesia and similar regions. These outcomes illustrate how the integration of locally sourced marine ingredients can elevate the quality of traditional snacks, offering both sensory appeal and improved nutritional attributes. Such findings open opportunities for product innovation rooted in indigenous food practices that respond to modern dietary needs.

## CONCLUSION

This study demonstrated that the incorporation of *Eucheuma cottonii* seaweed at varying concentrations influenced both the dietary fiber content and sensory qualities of Cucuk Gigi, a traditional Indonesian snack. Among the tested formulations, the addition of 6% seaweed (F4) was identified as the most optimal, producing a product with significantly higher dietary fiber while maintaining favorable sensory attributes, including color, aroma, taste, and texture. These findings indicate that seaweed enrichment can be effectively used to improve the nutritional value of traditional snacks without compromising consumer acceptance, supporting its potential application in the development of locally based functional foods.

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