e-ISSN 2581-0405
Asian Journal of Applied Research for Community Development and Empowerment
Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

Chemical and Sensory Characteristics of High-Protein Chicken and Purple Yam Snack Bars with Added Seaweed

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ARTICLE INFO

Article History:
Received: 02 July 2026
Final Revision: 07 July 2026
Accepted: 09 July 2026
Online Publication: 12 July 2026

KEYWORDS

Functional food, snack bar, purple yam, dried chicken meat, seaweed

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ABSTRACT

Snack bars are a type of ready-to-eat food product that is convenient, compact, and suitable as a snack. Snack bars are generally made from plant-based ingredients such as grains, nuts, and dried fruit, while the use of animal protein sources remains relatively limited. In addition, purple yam can be used as a source of carbohydrates that is rich in fiber and contains antioxidants beneficial to health. The production of snack bars requires a binding agent, one of which is seaweed containing carrageenan, which serves to improve texture quality, making the product more compact. This study aims to determine the effect of the proportions of purple yam flour and dried chicken meat, with the addition of seaweed, on the physicochemical and organoleptic characteristics of snack bars. This study employed a Completely Randomized Design (CRD) with two factors: Factor I—the ratio of purple yam flour to dried chicken meat (55:45, 40:60, 25:75)—and Factor II—seaweed content (20%, 30%, 40%). The data obtained were analyzed using ANOVA, followed by a DMRT post-hoc test at the 5% significance level. The optimal treatment was found in the treatment with a 45:55 ratio of purple yam flour to dried chicken meat and 40% seaweed. This treatment resulted in snack bars with a moisture content of 14.58%, ash content of 4.4%, fat content of 16.12%, protein content of 28.17%, carbohydrate content of 35.99%, and dietary fiber 8.74%. The hedonic organoleptic characteristics were as follows: color 3.5; aroma 4.0; texture 3.7; and flavor 3.9. The snack bars produced are expected to serve as a highly nutritious, functional snack alternative made from local food ingredients.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 3: Good Health and Well-being
SDG 9: Industry, Innovation and Infrastructure
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1 Research Background

Snack bars, as practical functional foods, are typically made from a blend of various highly nutritious ingredients. A snack bar is a bar-shaped food product containing a mixture of grains or nuts and is usually consumed as a snack [1]. Snack bars are generally made from vegetarian ingredients such as grains, nuts, and dried fruit. However, research on animal-based protein bars remains limited. Therefore, to enhance nutritional value and product variety, snack bars can be combined with animal protein sources such as meat, thereby serving as a practical, high-energy food alternative. Additionally, other ingredients such as tubers can be utilized as sources of carbohydrates rich in fiber and nutrients. One type of tuber with development potential is the purple yam.

Purple yam (*Dioscorea alata L.*) is a local food source with great potential, but it has not yet been fully utilized. In Indonesia, purple yam is widely cultivated in regions such as Java, Sulawesi, Kalimantan, and Sumatra. Purple yam production in Indonesia in 2021 reached approximately 50,000 metric tons, with the potential to increase as interest in local foods grows [2]. People generally prepare purple yam using simple methods, such as steaming, frying, or roasting. In fact, purple yam can be further processed into purple yam flour, which can be used as a raw material for producing various food products. One example is a snack bar, which is convenient and highly nutritious.

Snack bar products can be enriched with added animal protein, such as that from broiler chicken. Chicken meat is a highly nutritious food ingredient because it contains protein, essential amino acids, vitamins, and minerals that are excellent for human growth [3]. People prefer to consume chicken because it is easy to process into various dishes, reasonably priced, and low in fat. Broiler chicken production in 2024 is projected to reach 3,835,917 metric tons [4]. The Indonesian government, through the Coordinating Ministry for Food Affairs of the Republic of Indonesia, continues to encourage increased consumption of animal protein—particularly chicken—as part of its efforts to improve the population's nutritional status. Furthermore, chicken meat contains between 23 and 31 grams of protein per 100 grams, making it highly effective in meeting the population's daily protein needs [5].

Snack bars consist of a mixture of fruits, grains, and legumes bound together with a binder [6]. The choice of binder plays a crucial role in determining the texture and sensory acceptability of snack bars. Some commonly used binders include cornstarch, sugar, honey, eggs, and chocolate. In producing these snack bars, seaweed is used as the binder. Using seaweed as a binder can improve texture while increasing the snack bar's nutritional content. Per 100 grams of seaweed, there are 15.12 grams of fiber, 6.04 grams of protein, 0.012 grams of fat, 24.26 grams of ash, and 69.66 grams of carbohydrates [7]. This study was conducted to examine the chemical and sensory characteristics of snack bars made from purple yam flour and chicken meat, with seaweed added.

Given the great potential of purple yam, dried chicken meat, and Eucheuma spinosum seaweed, it is necessary to develop a functional snack bar that combines these three ingredients. The utilization of these ingredients not only supports the diversification of local food but also produces healthier snacks with high nutritional value. Research on snack bars generally still focuses on the use of cereals, nuts, or tubers as the main ingredients, while the development of snack bars based on dried chicken combined with local carbohydrate sources and seaweed is still limited. The combination of purple yam flour was chosen due to its carbohydrate and fiber content, while dried chicken meat was used as a source of high-quality animal protein. The addition of Eucheuma spinosum seaweed serves as a source of fiber as well as a natural binding agent that can improve the product's texture characteristics. Therefore, this research develops a snack bar based on dried chicken meat and purple yam flour with the addition of seaweed as a high-protein and fiber-rich snack alternative that is practical for communities with high nutritional needs, children, individuals with high physical activity, and women following a weight-management diet. This innovation is expected not only to enhance nutritional value but also to provide a new variety of practical snack bar products that meet consumer needs.

1.2 Literature Review

1.2.1 Snack Bar

Snack bars are convenient, bar-shaped food products made from various combinations of ingredients such as cereals, fruits, and nuts. The main ingredients in snack bars are flour, sugar, and fat [8]. Many commercial snack bar brands targeting specific market segments have emerged. This is because snack foods account for more than 20% of total energy intake and reduce the availability of essential nutrients [9]. Snack bars available on the market are typically made from wheat flour and other ingredients that are high in fat, simple carbohydrates, and sugar, and low in fiber. Therefore, there is a need to develop healthy snack bar products for general consumption [10].

1.1.1. Purple Yam

Purple yam, or *Dioscorea alata L.*, is related to gadung and gembili. Its tubers cannot be eaten raw because their sap can cause an itchy mouth. Purple yam is primarily used as a staple food; its tubers are irregularly shaped, large in size, and earth-brown in color [11]. Purple yam (*Dioscorea alata L.*) tubers can be utilized as a functional food because they contain a thick mucilage composed of glycoproteins and water-soluble polysaccharides—bioactive compounds that function as water-soluble dietary fiber and hydrocolloids, and are beneficial for lowering blood glucose and cholesterol levels, particularly (LDL) Low-Density Lipoprotein [12].

Purple yam has an advantage over other types of yam, namely the purple color found in its flesh, which is a source of anthocyanins. Anthocyanins act as antioxidants that help neutralize free radicals [13]. The anthocyanins in purple yam (*Dioscorea alata L.*) are cyanidin-based compounds, such as cyanidin 3-O-gentiobioside; alatanin; alatanin 2; alatanins A, B, and C; and alatanins D, E, F, and G [14]. Its high carbohydrate content makes purple yam flour a viable alternative carbohydrate source [15]. Purple yam flour has the advantage of containing anthocyanins that function as natural antioxidants with an antioxidant activity of 83.02% (RSA) [16]. Purple yam flour has an anthocyanin content of 82.72 mg/100 g dry weight and a total phenolic content of 185.18 mg EGA/100 g dry weight [17]. The starch in purple yam consists of 70% amylose and amylopectin. Amylopectin in purple yam flour accounts for 47.02%, while amylose accounts for 22.98% [18].

1.2.2. Chicken Meat

Chicken meat is a major source of animal protein, widely consumed by the public for its high nutritional value and relatively affordable price. The types of chickens used as a meat source include broiler chickens, free-range chickens, and culled laying hens, each of which has distinct characteristics in terms of texture, flavor, and economic value [19]. Broiler chickens are the most widely raised type, due to their rapid growth and high meat yield. The broiler chicken industry continues to expand because of their rapid growth, relatively low price, and tasty, tender meat [20].

Broiler chicken meat is an important source of animal protein for meeting the body's nutritional needs and is high in protein [21]. Protein plays a key role in regulating appetite and body composition. Increasing protein intake can enhance satiety and

 https://doi.org/10.29165/ajarcde.v10i3.1175

help control energy intake. Chicken meat contains a complete set of essential amino acids that are easily digested and absorbed by the body. The essential amino acids found in chicken meat are indispensable in the human diet; these include lysine, phenylalanine, methionine, cysteine, isoleucine, tyrosine, threonine, and tryptophan [21]. Chicken meat contains approximately 16.6–16.9% essential fatty acids. The main essential fatty acids present are linoleic acid (omega-6) at 15.96% and linolenic acid (omega-3) at 0.97% [22].

1.2.3. Seaweed (Eucheuma Spinosum)

Eucheuma sp. is widely found in various regions of Indonesia and accounts for more than half of the global seaweed market share. Eucheuma spinosum is one of the most common types of seaweed in tropical regions such as Indonesia. Eucheuma sp. is known as one of the primary sources of secondary metabolites among algae. Seaweed contains compounds such as flavonoids, alkaloids, and their derivatives, which possess antibacterial, antifungal, antiviral, and antioxidant properties [23]. Eucheuma sp. seaweed contains carrageenan, a polysaccharide and hydrocolloid composed of potassium, sodium, and magnesium esters, or potassium sulfate, with galactose and 3,6-anhydrogalactose copolymers [24]. The ability of seaweed hydrocolloids to retain water during snack bar matrix formation [25]. Carrageenan can form gels with good elasticity and stability during cold storage [26].

2. MATERIALS AND METHODS

2.1. Materials

The main ingredients used in this study were purple yam flour, dried chicken, seaweed, margarine, palm sugar, egg whites, and powdered milk.

2.2. Snack Bar Treatment Formulation

Dried chicken is made using the modified method of Jayathilakan *et al*. [26]. Boneless chicken meat is first washed with running water, then chopped using a chopper. The minced chicken is then evenly marinated with salt and lime to eliminate the fishy smell, and left to sit for 15 minutes to allow the spices to penetrate the meat. After the marination process, the chicken meat is dried using a dehydrator at 55°C for 5 hours. The dried chicken is blended into small particles before being used as an ingredient in the production of snack bars. Similarly, dried seaweed is first washed with running water, then boiled for 5 minutes until soft. After that, the seaweed is drained and cooled, then chopped into smaller pieces before being used in the snack bar formulation.

The ingredients used to make the snack bars were based on the study by Maghaydah *et al*., [27]. The first step involved mixing the dry ingredients—purple yam flour and dried ground chicken—in different composition ratios of 55:45, 40:60, and 25:75, then adding 10 g of powdered milk, 20, 30, and 40 g of seaweed, and 18 g of powdered palm sugar. All ingredients were stirred until evenly and homogeneously mixed. In the second mixing stage, 13 g of egg white, 1 g of salt, and 30 g of margarine were added and mixed using a mixer for 5 minutes. The dough, once smooth, was shaped into 8 x 2 cm pieces and baked in an oven preheated to 120°C for 25 minutes, then cooled at room temperature for 15 minutes.

2.3. Treatments and Experimental Design

Treatments and Experimental Design The experimental design used in this study is a completely randomized design (CRD) with a factorial pattern consisting of two factors. The first factor is the ratio of purple yam flour to dried chicken meat (55:45, 40:60, and 25:75), and the second is the seaweed concentration (20%, 30%, and 40%).

2.4. Chemical and Organoleptic Analysis

The physicochemical analysis of snack bars includes moisture, ash, fat, protein, and carbohydrate content. Dietary fiber analysis was conducted only on the best treatment. The organoleptic analysis of snack bars uses a hedonic test to measure panelists' preference levels for attributes such as color, aroma, texture, and flavor. The hedonic evaluation involved 30 untrained panelists who assessed each sample using a 7-point hedonic scale, where 1 indicated "dislike very much" and 7 indicated "like very much".

2.5. Statistical analysis

The data were expressed as mean ± standard deviation from two replications (n = 2). Statistical analysis was performed using Analysis of Variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a significance level of 5% ($p < 0.05$) when significant differences among treatments were observed.

3. RESULT AND DISCUSSION

3.1. Chemical Analysis

The results of the physicochemical analysis of the snack bars, including moisture content, ash content, fat content, protein content, and carbohydrate content, are shown in **Table 1**

Table 1. Chemical Analysis of Snack Bars

Sample Code	Moisture Content	Ash Content	Fat Content	Protein Content	Carbohydrate Content
A1B1	12.50±0.08^{d}	3.89±0.09^{c}	15.24±0.25^{a}	27.08±0.50^{a}	41.28±0.08^{a}
A1B2	13.81±0.05^{b}	4.17±0.13^{d}	15.63±0.34^{ab}	27.09±0.66^{a}	39.29±0.88^{b}
A1B3	14.58±0.06^{a}	4.51±0.13^{e}	16.12±0.19^{b}	28.81±0.68^{b}	35.99±0.49^{de}
A2B1	11.32±0.36^{f}	3.69±0.08^{b}	17.56±0.23^{c}	29.30±0.70^{b}	38.12±0.97^{bc}
A2B2	12.16±0.05^{de}	3.66±0.04^{b}	18.04±0.13^{c}	28.22±0.99^{ab}	37.92±0.86^{cd}
A2B3	13.62±0.19^{bc}	3.96±0.16^{c}	17.92±0.16^{c}	29.59±1.22^{b}	34.92±0.73^{e}
A3B1	11.82±0.08^{e}	3.21±0.06^{a}	20.01±0.48^{d}	35.03±0.57^{c}	29.93±0.22^{f}
A3B2	13.35±0.20^{c}	3.34±0.04^{a}	20.26±0.24^{de}	36.58±0.63^{c}	26.47±0.95^{g}
A3B3	14.27±0.08^{a}	3.58±0.09^{b}	20.83±0.09^{e}	36.12±0.41^{c}	25.20±0.15^{g}

Notes: A (ratio of purple yam flour to dried chicken meat); B (seaweed)

https://doi.org/10.29165/ajarcde.v10i3.1175

3.1.1. Moisture Content

The results of the analysis of variance (ANOVA) showed that there was a significant interaction ($p \leq 0.05$) between the treatment of the proportion of purple yam flour and dried chicken meat and the addition of seaweed on the moisture content of the resulting snack bars. The average moisture content of the snack bars ranged from 11.32% to 14.58%, with the highest moisture content observed in the treatment combining purple yam flour and dried chicken meat (55:45) with 40% seaweed (A1B3).

Table 1 shows that as the proportion of purple yam flour increases, the proportion of dried chicken meat decreases, and the proportion of seaweed increases, the moisture content of the snack bars also increases. This is due to the raw materials; the moisture content of purple yam flour (6.94%) is higher than that of dried chicken meat (2.41%). The differences in moisture content across each snack bar treatment are influenced by the moisture content of the raw materials. This is also due to the starch content in purple yam flour, the protein in chicken meat, and the fibre in seaweed, which have water-binding properties, thereby increasing the product's moisture content. Starch from yam flour is hydrophilic and can absorb and retain water during gelatinization, while also forming hydrogen bonds with myofibrillar proteins [28].

The analysis results show that as the amount of seaweed added increases, the moisture content also increases. This is because seaweed has a moisture content of 20.86%. Seaweed acts as a hydrogel, meaning it is capable of binding water within the product. A hydrogel is a hydrophilic polymer in the form of a cross-linked network, enabling it to absorb and swell in water and exhibit high water diffusion capacity. Hydrogels are soft and contain a high water content [29]. This is in line with the research by Farida *et al*. [25] on snack bar products based on the seaweed Eucheuma cottonii, which shows that the addition of seaweed affects the moisture content due to the ability of the seaweed's hydrocolloid components to retain water during the formation of the snack bar matrix. This property causes the moisture content in these snack bars to be relatively high as the amount of seaweed increases, exceeding the moisture content of snack bars according to SNI, which is a maximum of 4 g/100 g.

3.1.2. Ash Content

The results of the analysis of variance (ANOVA) indicate that there is a significant interaction ($p \leq 0.05$) between the treatment of the proportion of purple yam flour and dried chicken meat and the addition of seaweed on the ash content of the resulting snack bars. The mean ash content of the snack bars ranged from 3.21% to 4.51%, with the highest ash content observed in the treatment combining purple yam flour and dried chicken meat (55:45) with 40% seaweed (A1B3).

Table 2 shows that as the proportion of purple yam flour increases, the proportion of dried chicken meat decreases, and the proportion of seaweed increases, the ash content of the snack bars rises. This is because the ash content of purple yam flour is higher than that of chicken meat. The study found that the ash content of purple yam flour was 2.52%, while that of chicken meat was 0.92%. The main minerals found in purple yam include calcium, phosphorus, and iron [30].

Variations in the amount of seaweed added had a significant effect on the product's ash content. As the amount of seaweed increased, the ash content of the snack bars also increased due to the high mineral content in the seaweed. The minerals do not degrade during the ashing process, so they remain as inorganic residues measured as ash content. Based on the research results, the ash content of E. spinosum seaweed was 23.36%. According to Wilmulda [31], the ash content of a product can determine the levels of minerals and metals that are not incinerated during the ash content determination process. The macro-mineral content of E. spinosum seaweed includes calcium (Ca), chlorine (Cl), potassium (K), magnesium (Mg), and sodium (Na), as well as trace minerals such as zinc (Zn) and copper (Cu) [32]. The research results show a higher value compared to the standard ash content for snack bars, which is 1.72% [33].

3.1.3. Fat Content

The results of the analysis of variance (ANOVA) in (Appendix 6) show that there was no significant interaction ($p \geq 0.05$) between the treatments involving the proportions of purple yam flour and dried chicken meat and the addition of seaweed on the fat content of the resulting snack bars. Changes in fat content were more strongly influenced by each treatment individually rather than by a combination of the two. The mean fat content of the snack bars ranged from 15.24% to 20.83%, with the highest fat content observed in the treatment combining purple yam flour and dried chicken meat (25:75) with 40% seaweed added (A3B3).

Table 1 shows that a decreasing proportion of purple yam flour and an increasing proportion of dried chicken meat can increase the fat content of the snack bars. This is because the fat content of chicken meat is higher than that of purple yam flour. The study found that the fat content of dried chicken meat was 6.15%, while that of purple yam flour was 0.47%. The increase in fat content between treatments is mainly influenced by the proportion of dried chicken meat used.

The fat content of the snack bars produced exceeds the standard set by SNI 01-2886-1992, which is 1.4–14%. This is because some of the ingredients required in the snack bar production process have a relatively high fat content. Other added ingredients include margarine, eggs, and powdered milk. The snack bars are made with 30% margarine and 10% powdered milk. The fat content of these raw materials—such as margarine, which contains approximately 81% fat, and powdered milk, which contains 30% fat—contributes to the overall fat content. According to Sitorus *et al*. [34], margarine is a water-in-oil emulsion that generally has a fat-to-water ratio of 80% to 20%. The largest component in margarine's nutritional content is fat. Fat has the ability to dissolve vitamins A, D, E, and K, as well as enhance flavor and texture, which tends to be savory.

3.1.4. Protein Content

The results of the analysis of variance (ANOVA) showed that there was no significant interaction ($p \geq 0.05$) between the treatment of the ratio of purple yam flour and dried chicken meat with the addition of seaweed and the protein content of the resulting snack bars. The results indicate that the treatment involving the proportions of purple yam flour and dried chicken meat had a significant effect ($p \leq 0.05$) on protein content, meaning that these proportions significantly contributed to determining the protein content. Conversely, the treatment involving the addition of seaweed did not show a significant effect ($p \geq 0.05$) on the protein content of the resulting snack bars. The average protein content of the snack bars ranged from 27.09% to 36.58%, with the highest protein content observed in the treatment combining purple yam flour and dried chicken meat (25:75) with a 30% addition of seaweed (A3B2).

Table 1 shows that increasing the proportion of dried chicken meat and decreasing the proportion of purple yam flour can increase the protein content of the snack bars. This is because the protein content of chicken meat is higher than that of purple yam flour. The protein content of dried chicken meat, at 74.36%, is higher than that of purple yam flour, which is 6.77%. This is consistent with Baihaqi's [35] study, which found that increasing the substitution of chicken flour leads to a corresponding increase in the protein content of the resulting biscuit products. This increase is due to the high protein content in chicken meat, which makes a significant contribution to the product's total protein. According to Sholaikah [21], broiler chicken meat is an important source of animal protein for meeting the body's nutritional needs and has a high protein content. Chicken meat also contains a complete set of essential amino acids that are easily digested and absorbed by the body.

Theoretically, substituting animal-based protein ingredients in bakery products will increase the protein content because animal protein has a higher biological value than plant-based protein [36]. In addition, the essential amino acid profile of chicken meal is more complete, particularly in terms of lysine and methionine, which are generally the limiting amino acids in cereal-based products [37]. The protein content of the resulting snack bars complies with the standards set by SNI 01-2886-1992. The protein content of the snack bars produced is higher than the SNI standard of 25%, with the protein content range in this study reaching 26.14% to 34.84%.

3.1.5. Carbohydrate Content

The results of the analysis of variance (ANOVA) showed that there was no significant interaction ($p \geq 0.05$) between the treatments involving different proportions of purple yam flour and dried chicken meat, combined with the addition of seaweed, and the carbohydrate content of the resulting snack bars. The mean carbohydrate content of the snack bars ranged from 25.20% to 41.28%, with the highest carbohydrate content observed in the treatment combining purple yam flour and dried chicken meat (55:45) with 20% seaweed added (A1B1).

Table 1 shows that an increasing proportion of purple yam flour and a decreasing proportion of chicken meat can increase the carbohydrate content of the snack bars. This is because purple yam flour has a higher carbohydrate content, namely 83.31%. Its high carbohydrate content makes purple yam flour a viable alternative carbohydrate source [15].

3.2. Sensory Evaluation

Sensory evaluation was conducted using a hedonic test to assess the panelists' level of preference for the color, aroma, texture, and flavor of the snack bars on a 1–7 rating scale (strongly dislike – strongly like). A total of 30 panelists participated in the sensory evaluation for this study; they were Food Technology students at UPN "Veteran" Jawa Timur.

3.2.1. Color

The relationship between the proportion of purple yam flour, dried chicken meat, and the addition of seaweed on the hedonic organoleptic quality of the snack bar's color is shown in Figure 1.

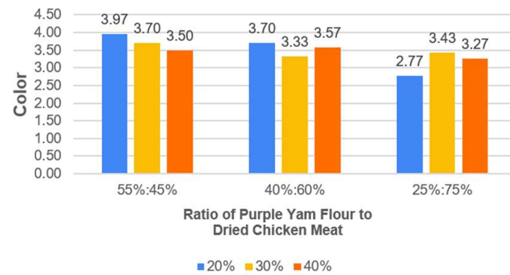

Figure 1. Effect of the proportions of purple yam flour, dried chicken meat, and the addition of seaweed on the color of the snack bars

The results of the Friedman test showed that there was a significant interaction ($p \leq 0.05$) between the proportions of purple yam flour and dried chicken meat with the addition of seaweed and the liking for the color attribute of the snack bars. The highest color preference score was obtained for the snack bar with a 45%:55% ratio of purple yam flour to dried chicken meat and a 20% addition of seaweed, resulting in an average score of 6.37 and falling into the "like" category. This was due to the snack bar's color becoming more appealing as the proportion of purple yam flour increased. The more purple yam flour was added and the less dried chicken meat was used, the higher the panelists' acceptance of the resulting snack bar color became. This is consistent with the study by Mujahanah *et al*. [38], which stated that the more purple yam flour added to cookie products, the higher the panelists' preference for the cookies' color.

The increase in the substitution of purple yam flour causes the color of the snack bar to become darker brown. Purple yam flour has a purple color derived from anthocyanin pigments. This is in line with Winata & Yunianta [39], who stated that there is a positive correlation between the concentration of anthocyanin pigments and the color intensity of a product. The brightness level of the product tends to decrease as the concentration of purple yam flour used increases. This is due to the presence of anthocyanin pigments in purple yam, which give a more intense purple color, making the product appear darker.

3.2.2. Aroma

The results of the Friedman test showed that there was a significant interaction ($p \leq 0.05$) between the proportions of purple yam flour and dried chicken meat, combined with the addition of seaweed, and the liking for the aroma attribute of the snack bars. The highest aroma likability score was obtained for the snack bar with a ratio of purple yam flour to dried chicken meat of 45% to 55% and 40% seaweed, which yielded an average score of 6.38 and fell into the "like" category. The relationship between the treatment of purple yam flour and dried chicken meat proportions and the addition of seaweed on the hedonic

https://doi.org/10.29165/ajarcde.v10i3.1175

organoleptic aroma quality of the snack bars is shown in Figure 2.

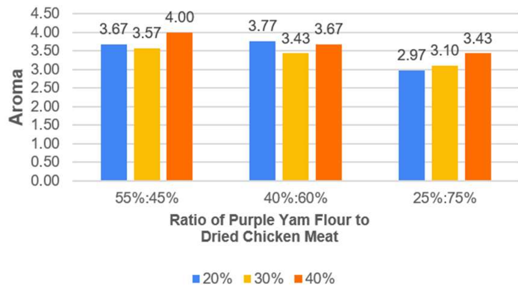

Figure 2. Effect of the proportions of purple yam flour, dried chicken meat, and the addition of seaweed on the aroma of snack bars

As the amount of purple yam flour increased and the amount of dried chicken meat decreased, the panelists' acceptance of the resulting snack bar's aroma increased. In the production of this snack bar, the chicken meat undergoes a preliminary treatment involving the addition of lime juice before the drying process. This is intended to minimize the fishy odor characteristic of the meat [40]. The resulting snack bar has a distinct purple yam aroma and lacks the fishy odor of the chicken meat, creating a combination that the panelists found appealing.

3.2.3. Flavor

The results of the Friedman test showed that there was a significant interaction ($p \leq 0.05$) between the proportions of purple yam flour and dried chicken meat, combined with the addition of seaweed, and the liking for the flavor attributes of the snack bars. The highest flavor preference score was obtained for the snack bar with a ratio of purple yam flour to dried chicken meat of 45% to 55% and 40% seaweed, which yielded an average score of 3.93 and fell into the "somewhat like" category. The relationship between the treatment of purple yam flour and dried chicken meat proportions and the addition of seaweed on the hedonic organoleptic quality of the snack bars' flavor is shown in Figure 3.

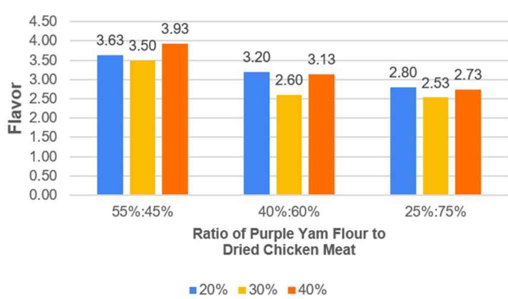

Figure 3. Effect of the proportions of purple yam flour, dried chicken meat, and the addition of seaweed on the flavor of snack bars

As the amount of purple yam flour increased and the amount of dried chicken meat decreased, the panelists' acceptance of the resulting snack bar's flavor increased. The panelists' preference for the snack bar's flavor, resulting from the addition of purple yam flour, was due to the distinctive sweetness of purple yam. As the concentration of added purple yam flour increased, so did the panelists' preference for the snack bar's flavor [41].

3.2.4. Texture

The results of the Friedman test showed that there was a significant interaction ($p \leq 0.05$) between the proportions of purple yam flour and dried chicken meat, combined with the addition of seaweed, and the acceptability of the snack bar's texture attributes. The highest texture likability score was obtained for the snack bar with a 45%:55% ratio of purple yam flour to dried chicken meat and a 40% addition of seaweed, which yielded an average score of 3.70 and fell into the "like" category. The relationship between the treatment of purple yam flour and dried chicken meat proportions and the addition of seaweed on the hedonic organoleptic texture quality of the snack bars can be seen in Figure 4.

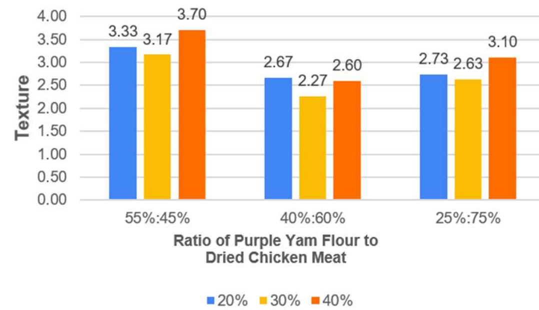

Figure 4. Effect of the proportions of purple yam flour, dried chicken meat, and the addition of seaweed on the texture of snack bars

As the amount of purple yam flour increased and the amount of dried chicken meat decreased, the panelists' preference for the snack bar's texture increased. This is because the panelists preferred a snack bar texture that did not feel coarse when chewed. Using a higher amount of dried chicken meat tends to result in a coarser texture, thereby reducing the panelists' acceptance of the texture attribute.

The addition of seaweed to the snack bar plays a role in forming a gel thru the hydrocolloid content such as carrageenan. Carrageenan is water-absorbing and produces a compact texture. Carrageenan has good water-binding capacity and gel-forming ability, where the gel's elasticity remains stable during cold storage [42]. According to Khalil *et al.* [43], carrageenan in seaweed forms a robust three-dimensional gel structure thru non-covalent bonds such as hydrogen bonds and electrostatic interactions. This dense network structure is capable of enhancing the rigidity and texture stability of starch-based products.

3.3. Analysis of Best Treatment

The best treatment was identified for snack bar A1B3, which used a 45:55 ratio of purple yam flour to dried chicken meat, with 40% seaweed added. The analysis of the best treatment focused on dietary fiber content. Dietary fiber is the part of plant tissue that cannot be hydrolyzed by enzymes in the stomach and small intestine. Dietary fiber offers various health benefits, including maintaining digestive tract health, helping to control blood glucose and cholesterol levels, improving insulin sensitivity, and reducing the risk of cardiovascular disease, colorectal cancer, and obesity [44].

Based on the research findings, it was determined that the dietary fiber content in the snack bar was 8.74%. The dietary fiber content in a product is influenced by the dietary fiber content in the raw materials used to make the snack bar. Purple yam contains

 https://doi.org/10.29165/ajarcde.v10i3.1175

5.71% insoluble fiber and 5.41% soluble fiber, while the dietary fiber content in Eucheuma spinosum seaweed is 45.30% [45]. According to the Indonesian Food and Drug Administration (BPOM, 2011), a food product can be categorized as a source of dietary fiber if it contains at least 3 g of dietary fiber per 100 g, while products with a dietary fiber content of at least 6 g per 100 g fall into the high-fiber category. Based on these criteria, the snack bar from the best treatment group in this study is classified as a high-fiber food because it contains 8.74% dietary fiber.

4. CONCLUSION

The results of the study showed that there was a significant interaction ($p \leq 0.05$) between the treatment of the proportions of purple yam flour and dried chicken meat, as well as the addition of seaweed, on moisture content, ash content, and the organoleptic attributes of color, aroma, texture, and flavor; whereas for the parameters of fat content, protein content, and carbohydrate content, there was no significant interaction ($p \geq 0.05$). The best snack bar formulation was obtained in sample A1B3, which consisted of a 55:45 ratio of purple yam flour to dried chicken meat with 40% seaweed added, resulting in a moisture content of 14.58%, ash content of 4.4%, fat content of 16.12%, protein content of 28.17%, carbohydrate content of 35.99%, and dietary fiber 8.74%. The organoleptic characteristics were as follows: color 3.5; aroma 4.0; texture 3.7; and flavor 3.9. These findings indicate that adding dried chicken and seaweed to snack bars made from purple yam flour is a promising strategy for producing nutrient-dense snacks with high protein and dietary fiber content without reducing consumer acceptance. Therefore, this formulation has the potential to be developed as a functional snack for individuals with high nutritional needs, children, physically active individuals, and women undergoing weight management programs.

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