SEA MOSS FLOUR (*E. cottonii*) AS AN INGREDIENTS OF PASTA: THE ANALYSIS OF ORGANOLEPTIC, PROXIMATE AND ANTIOXIDANT

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ABSTRACT

This research aims to assess the impact of adding Elkhorn Sea Moss Flour as a fiber source on the organoleptic characteristics and nutritional value of pasta. The treatments used are C0 = 0% addition of Elkhorn Sea Moss Flour; C1 = 30% ; C2 = 50%; C3 = 70%. The study utilized a completely randomized design (CRD) with one factor, comprising four concentration treatments replicated three times. The results showed that the addition of Elkhorn Sea Moss Flour to pasta resulted in significant increases in protein content, fiber, and antioxidant activity. Pasta with 70% Elkhorn Sea Moss Flour addition showed the highest fiber content and moderately high antioxidant activity, making it a potential functional food product. However, as Elkhorn Sea Moss Flour increased, there was a decrease in organoleptic parameters such as aroma, texture, and taste. Elkhorn Sea Moss Flour has great potential as an additive in functional food products, enriching fiber and antioxidant content, but its use should be carefully considered to ensure good consumer acceptance.

Keywords: antioxidant, eucheuma cottonii, organoleptic, pasta, proximate, good health.

دقيق طحالب البحر (*E. Cottonii*) كأحد مكونات المعكرونة :تحليل الخصائص العضوية والتقريبية ومضادات الأكسدة

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المستخلص

يهدف هذا البحث إلى تقييم تأثير إضافة دقيق طحالب البحر الخورن كمصدر للألياف على الخصائص الحسية والقيمة الغذائية للمعكرونة .المعالجات المستخدمة هي C0 = 0% إضافة دقيقElkhorn Sea Moss؛ C1 = 30%؛ C2 = 50%؛ ج 3 = 70%.استخدمت الدراسة التصميم العشوائي الكامل (CRD) بعامل واحد يتكون من أربع معاملات تركيز مكررة ثلاث مرات . أظهرت النتائج أن إضافة دقيق Elkhorn Sea Moss Flour إلى المعكرونة أدى إلى زيادة كبيرة في محتوى البروتين والألياف ونشاط مضادات الأكسدة .أظهرت المعكرونة التي تحتوي على 70% من دقيق طحالب البحر الخورن أعلى محتوى من الألياف ونشاط مضاد للأكسدة مرتفع إلى حد ما، مما يجعلها منتجًا غذائيًا وظيفيًا محتملاً .ومع ذلك، مع زيادة دقيق Elkhorn Sea Moss، كان هناك انخفاض في المعلمات الحسية مثل الرائحة والملمس والطعم .يتمتع دقيق Elkhorn Sea Moss Flour بإمكانيات كبيرة باعتباره مادة مضافة في المنتجات الغذائية الوظيفية، مما يزيد من محتوى الألياف ومضادات الأكسدة، ولكن يجب النظر في استخدامه بعناية لضمان قبول المستهلك الجيد.

الكلمات المفتاحية: مضاد للأكسدة، اليوكوما القطني، عضوي، معجون، تقريبي، صحة جيدة

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INTRODUCTION

Pasta, a beloved culinary delight originating from Italy, has become a staple in diets worldwide due to its versatility, delicious taste, and ease of preparation (1–4). Traditionally, pasta is made from durum wheat semolina, which provides a significant source of carbohydrates and gluten, giving the pasta its signature chewy texture (5,6). However, despite its widespread popularity, traditional pasta is relatively low in fiber content and lacks certain essential nutrients. As the focus on healthy eating and nutrition increases, researchers and food scientists have been exploring ways to enhance the nutritional profile of pasta without compromising its taste and texture (7,9). One promising avenue is the incorporation of seaweed as a potential basic ingredient (10). Seaweeds, also known as marine macroalgae, are a diverse group of plants that thrive in marine environments (2, 3). They have been consumed for centuries in various cultures and are now gaining recognition for their numerous health benefits and nutritional value (10,13,15). Among the various seaweed species, Elkhorn Sea Moss (*Eucheuma cottonii*) has emerged as a particularly promising candidate for its fiber content and other valuable nutrients (16,17). Fiber is an essential component of a balanced diet and plays a crucial role in digestive health [18–20]. It helps regulate bowel movements, prevents constipation, and may lower the risk of certain gastrointestinal disorders (21,24). Additionally, dietary fiber can contribute to weight management by promoting a feeling of fullness and reducing overall caloric intake. By incorporating Elkhorn Sea Moss Flour into pasta production, food manufacturers have the opportunity to increase the fiber content of the final product significantly. Seaweed-based pasta not only provides a unique and nutritious alternative to traditional pasta but also caters to the growing demand for functional and health-promoting foods. Moreover, Elkhorn Sea Moss contains essential vitamins, minerals, and antioxidants (25,26) that contribute to overall well-being. These nutrients may help support the immune system, maintain healthy skin, and provide valuable trace elements necessary for various bodily functions 927 , 28). Aside from its nutritional advantages, seaweed cultivation and harvesting are often considered environmentally sustainable practices (29,30). Seaweeds are known to absorb excess nutrients from seawater, which can help mitigate the negative impacts of nutrient pollution and promote cleaner marine ecosystems (31,32). While incorporating seaweed into pasta products presents an exciting opportunity, further research and development are necessary to optimize the formulation and ensure consumer acceptance. Organoleptic tests, consumer surveys, and market analyses will be crucial to determining the best combinations of Elkhorn Sea Moss Flour and other ingredients to achieve both nutritional excellence and a pleasurable eating experience.

MATERIAIS AND METHODS

The ingredient: The primary ingredients utilized in this study consist of Elkhorn Sea Moss (*Eucheuma cottonii*) flour, which was acquired from a farmer in Pamekasan, East Java, Indonesia. Other essential ingredients include eggs, salt, olive oil, wheat flour, and water. Additionally, various chemicals were employed for the analysis, including kjeldahl table, distilled water, sulfuric acid, methylene red, methylene blue, sodium hydroxide, boric acid, 4 M hydrochloric acid, alcohol, and sodium chloride.

Pasta preparation: Combine the ingredients using a mixer for approximately 5 minutes or until the dough reaches a smooth consistency. Shape the dough into a round form and cover it with plastic wrap. Allow it to rest for 1 hour at room temperature. Subsequently, roll out the dough to the desired thickness using a pasta maker. Next, boil the rolled dough in boiling water for 5 minutes or until the pasta floats. The specific formulation of the pasta used in this research is outlined in Table (1).

Table 1. The specific formulation of the pasta used in this research

Ingredients	Weight			
	C_o	C_1	C_2	C_3
Wheat flour (%)	100	70	50	30
Seaweed flour (%)	0	30	50	70
Egg (g)	25	25	25	25
Salt (g)	1	1	1	1
Water (ml)	20	20	20	20
Olive Oil (ml)	3	3	3	3

*** C = Combination**

Proximate content analysis

Protein, carbohydrate, fiber, ash, moisture, and fat contents analysis was carried out at Laboratorium Sentral Ilmu Hayati (LSIH), Division of Food Technology, Brawijaya University. All analysis was performed three times in accordance with published methods and standard procedure of AOAC-2012 food analysis (33–36).

Protein analysis: The Kjeldahl method was employed to determine the crude protein content. Initially, 1 g of dried plant sample was combined with a mixture of CuSO4 and KSO4 at a ratio of 1:7. To this mixture, 15 mL of concentrated H2SO4 was added in a digestion flask. The solution was heated until it achieved transparency and subsequently allowed to cool. The resulting solution was transferred into a volumetric flask, and distilled water was added to bring the volume to 100 mL. For the next step, 10 mL of the digested mixture was introduced into the Kjeldahl apparatus along with 10 mL of NaOH and 20 mL of Boric acid. Following the addition of 2-3 drops of methyl red indicator, the solution was heated until a yellow color developed. The solution was then titrated against 0.1 N HCl from a burette until a pink color emerged. The percentage of crude protein was calculated using the subsequent formula:

$$\textbf{Crude Protein}\ (\%) = \frac{(\textbf{Sample reading} - \textbf{Blank reading})\ x\ N\ x\ 0.014\ x\ D}{\textbf{Wt of sample x Volume}}\ x\ 100$$

Where; N = normality of acid; 0.014 = equlent weight of nitrogen; D = dilution

Carbohydrates analysis

Carbohydrates were found out by applying the following formula:

$$\textbf{Carbohydrate}\ (\%) = \textbf{100} - \%(\textbf{moisture} + \textbf{protein} + \textbf{lipid} + \textbf{ash contents})$$

Fiber: Two grams of the plant sample were combined with 200 mL of 2% NaOH in a beaker. The mixture was heated for 30 minutes in a water bath and allowed to cool to room temperature. The solution was then filtered using Whatman filter paper No.4. The filtrate was rinsed with hard water to eliminate any traces of acid. Subsequently, the filtrate was transferred to a crucible and dried in an oven at 105°C for a duration of 4 hours. The initial weight of the crucible (W1) was recorded.

Afterward, the crucible was subjected to a muffle furnace at 550°C for 4 hours. Following this heat treatment, the crucible was allowed to cool in a desiccator for 30 minutes before being weighed once more (W2). The total fiber content was determined using the following formula:

$$\textbf{Fiber}\ (\%) \frac{\textbf{W1} - \textbf{W2}}{\textbf{Wt of sample}}\ x\ \textbf{100}$$

Ash: One gram of sample was taken in sterilized crucible and weight crucible and note initial reading. Crucible placed in furnace at 550 ^{o}C for six hours and destroyed all organic contents except minerals in the sample ash. Weight again all samples and note readings. Apply following formula for ash percent:

$$\textbf{Ash}\ (\%) \frac{\textbf{W1} - \textbf{W2}}{\textbf{Wt of sample}}\ x\ \textbf{100}$$

Moisture

One gram powder of each weed sample was taken in a petridish and was weight along with petridish. The initial weight was noted and the petridish was placed in an oven at 105°C for 24 hrs. After 24 hrs the petridish was again weighted and the reading was noted. The moisture content was analyzed by using following formula:

$$\textbf{Moisture}\ (\%) = \frac{\textbf{Weight of sample before drying} - \textbf{Weight of sample after drying}}{\textbf{Weight of sample}}\ x\ \textbf{100}$$

Fat: A quantity of 1 gram of the sample was enclosed within a filter paper and positioned inside a thimble. This thimble was subsequently secured within a Soxhlet extractor, employing 1/3 of petroleum ether as the solvent, which possesses a boiling point range of 40 to 60°C. Over a duration of 4 to 6 hours, the petroleum solvent effectively absorbed the fat components. The weight of the beaker was then recorded, facilitating the determination of the overall fat content.

Organoleptic test analysis

Sensory evaluation, encompassing organoleptic and hedonic testing, was conducted on pasta. This evaluation encompassed factors such as taste, aroma, texture, and color. The assessment was performed by a panel of semi-trained individuals, comprising 30 students from the Faculty of Fisheries and Marine Sciences at

Airlangga University in Surabaya. The sensory analysis of the pasta adhered to the guidelines outlined in the Indonesian National Standard (SNI) 2346:2011. The outcomes from the hedonic test were categorized using a scale ranging from 1 to 9, reflecting the panelists' evaluations of the pasta's attributes.

Antioxidant activity: The antioxidant activity of the samples was determined based on their capacity to scavenge the stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical (37). A weight of 0.0005 grams of the sample was dissolved in 100 ml of methanol to create a solution. An additional solution containing 0.004% DPPH was formed by mixing 100 ml of methanol. In a test tube, 4 ml of the DPPH solution was combined with 1 ml of the sample solution. These test tubes were then placed in a dark environment and incubated for 20 minutes. After the incubation period, the prepared solutions were subjected to absorbance measurement at 517 nm. A control solution consisting of DPPH in methanol was used as a reference. The difference in absorbance between the control and the test sample indicated the percentage of DPPH radical scavenging. This experiment was repeated three times to ensure accuracy. It's worth noting that lower absorbance values corresponded to higher scavenging activity. The percentage of scavenging activity was determined using the following equation:

$$\textbf{scavenging activity } (\%) = \frac{\boldsymbol{Control - Test}}{\boldsymbol{Control}}\ \boldsymbol{x\ 100}$$

Data analysis

Data analysis is carried out using SPSS application. The results from nutrients testing were processed by applying ANOVA test. The calculation can be continued with Duncan's Multiple Distance Test to find out which treatment gives the best test results, treatments that are significantly different, and treatments that are not significantly different. Meanwhile, the data from the organoleptic test were analyzed using the Kruskal-Wallis's test.

RESUITS AND DISCUSSION

Proximate analysis: The results showed significant variations in the proximate composition of the paste based on the addition of Elkhorn Sea Moss Flour. The results showed that the addition of 70% Elkhorn Sea Moss Flour (C3) to pasta resulted in a significant increase in protein content (3.04 ± 0.12) compared to the control pasta (C0: 2.9 ± 0.08). This shows the potential of using Elkhorn Sea Moss Flour as an effective additive in increasing the protein content of pasta products. Although there was a noticeable increase, the protein value in pasta with C3 added was still relatively low when compared to previous studies that recorded increased protein in seaweed-containing food products. This could be due to factors such as variations in processing methods, the source of seaweed used, or differences in the concentration of seaweed addition. Elkhorn Sea Moss Flour, also known as Kappaphycus alvarezii, has been identified as having the potential to enhance the protein content of food products, particularly pasta (38). This advantage can be leveraged to develop food products that are not only richer in nutrients but also align with the increasing consumer demand for healthier food options. The protein composition of the legume flours has been found to be similar, indicating that differences in browning color may be attributed to the sugar content of these flours (39). Additionally, fortification of chickpea and broad bean flour, as well as isolated soy protein, has been suggested for the production of high-protein biscuits (40). Furthermore, the addition of moringa leaf flour to wheat flour cookies and banana flour has been studied, showing effects on physical and chemical characteristics, including protein content (41). These findings collectively support the potential of Elkhorn Sea Moss Flour to enhance the protein content of food products, aligning with the increasing demand for healthier food options. The results showed that there was a decreasing trend of carbohydrate content in pasta as the addition of Elkhorn Sea Moss Flour increased. Control pasta (C0) with 0% addition had the highest carbohydrate content (62.06 ± 0.20), while pasta with 70% addition (C3) had the lowest carbohydrate content (59.08 ± 0.20). This indicates a negative correlation between the addition of Elkhorn Sea Moss Flour and the carbohydrate content of the pasta. The addition of fiber, such as that found in Elkhorn Sea Moss Flour, can reduce the carbohydrate content of food products. Fiber tends not to be fully digested by the body and can affect the calculation of net carbohydrate content in a product (42). High fiber intakes protect from carbohydrate-induced hypertriglyceridemia (43). Nondigestible polysaccharides delivered as dietary fiber stimulate the production of short-chain fatty acids in the distal colon, which may alter energy metabolism and improve the metabolic function of skeletal muscle and adipose tissue (43). Furthermore, complex carbohydrates, regardless of their fiber content, have the greatest effect on satiety and reduction in food intake (44). It is also noted that the glycaemic carbohydrates are characterized by sugar type and by the likely rate of digestion described by in vitro measurements for rapidly available glucose and slowly available glucose (45). Elkhorn Sea Moss Flour not only has the potential to increase protein content, but can also play a role in reducing the carbohydrate content of pasta products. This effect has important implications especially for consumers who are looking for alternative food products with lower carbohydrate content in order to support a healthy lifestyle. While carbohydrate content may decrease, this reduction may be offset by an increase in other nutrients, such as protein or fiber, which can provide balanced health benefits. Lower carbohydrate content may contribute to a decrease in the glycemic index of a product, which may benefit individuals with diabetes or those trying to maintain blood sugar levels. Therefore, pasta with the addition of Elkhorn Sea Moss Flour may be a better choice for those concerned about glycemic health aspects. The results showed a significant increase in fiber content in pasta with the addition of Elkhorn Sea Moss Flour. Pasta at the 30% addition level (C1) achieved the highest fiber content (3.48 ± 0.047) compared to the control pasta (C0: 2.18 ± 0.03). This increase was as expected, given that seaweed in general is rich in beneficial dietary fiber. Interestingly, at 70% addition level (C3), there was a slight decrease in fiber content (3.09 ± 0.64). This may be due to the complex interactions between the fibers from Elkhorn Sea Moss and other components in the paste at high concentrations. These interactions may affect the ability of the fibers to disperse evenly in the paste matrix, resulting in a decrease in fiber content. These results highlight the importance of understanding the interactions between additives, such as Elkhorn Sea Moss Flour, and the food product matrix. These complex effects can affect the physical and chemical properties of the final product and require further research to understand in depth. Increased fiber content in pasta may provide health benefits to consumers. Dietary fiber can help improve digestion, control blood sugar levels, and support cardiovascular health. Therefore, pasta with Elkhorn Sea Moss Flour added at the 30% level (C1) may be a healthier option. These results show that there is an optimal addition level (30%) to achieve the highest fiber content. This optimization process is important for the food industry to create products with optimal nutritional value and in line with consumer preferences. The results showed significant changes in ash content in pasta with the addition of Elkhorn Sea Moss Flour. Pasta at 70% addition level (C3) had the highest ash content (3.32 ± 0.56). This increase indicates a higher accumulation of minerals in the final product, which may come from the Elkhorn Sea Moss Flour which is naturally rich in minerals. The increase in mineral accumulation in the final product may be attributed to the natural richness of minerals in Elkhorn Sea Moss Flour (46). Elkhorn sea moss, scientifically known as Kappaphycus alvarezii, is a red seaweed cultivated for its high mineral content, primarily used for the extraction of carrageenan and quaternary ammonium compounds (46). This supports the claim that the increase in mineral accumulation is due to the inherent mineral richness of Elkhorn Sea Moss Flour. Additionally, the Elkhorn Slough, where the Elkhorn Sea Moss is found, is noted for its unique physical features and high nutrient loading, which further supports the idea of a higher accumulation of minerals in the final product (47,48). The high nutrient loading in the Elkhorn Slough contributes to the abundance of minerals, which may be reflected in the Elkhorn Sea Moss Flour. An increase in ash content could be related to an increase in mineral content, such as calcium, magnesium, and others, which are commonly found in seaweed. These mineral contents have the potential to provide additional benefits to the nutritional value of the product, depending on the type and amount of minerals contained in Elkhorn Sea Moss Flour. The highest moisture was found in the paste with 30% added (C1: 30.6 ± 0.25). This indicates that the addition of fiber from Elkhorn Sea Moss Flour can affect the physical properties of the product, including moisture. Fiber has the ability to absorb and retain water, so an increase in moisture can occur with an increase in fiber concentration. Moisture balance in food products is a key factor in maintaining quality and shelf life. Therefore, further understanding of the effect of fiber addition on moisture can assist the food industry in designing formulations that maintain optimal physical properties and shelf life. Changes in ash and moisture content may reflect the complex interactions between Elkhorn Sea Moss Flour, the paste matrix and the processing process. This suggests that product formulation should be considered holistically, taking into account how each component may influence the other. In terms of fat content, pasta with 70% addition (C3: 5.29 ± 0.05) had the lowest fat content, although the difference was not that significant with control pasta (C0: 6.18 ± 0.16). This indicates that the addition of Elkhorn Sea Moss Flour does not affect the fat content substantially (Table 2).

Table 2. Proximate analysis of elkhorn sea moss flour during the research

Ingredients	Average value ± SD			
	C_0	C_1	C_2	C_3
Protein	**2.9 ± 0.08$_{c}$**	**2.65 ± 0.18$_{a}$**	**2.87 ± 0.12$_{b}$**	**3.04 ± 0.12$_{c}$**
Carbohydrates	**62.06 ± 0.20$_{c}$**	**56.34 ± 0.25$_{b}$**	**57.23 ± 0.11$_{d}$**	**59.08 ± 0.20$_{a}$**
Fiber	**2.18 ± 0.03$_{a}$**	**3.48 ± 0.047$_{ab}$**	**3.02 ± 0.04$_{bc}$**	**3.09 ± 0.64$_{c}$**
Ash	**0.51 ± 0.14$_{a}$**	**1.05 ± 0.42$_{b}$**	**2.7 ± 0.22$_{c}$**	**3.32 ± 0.56$_{c}$**
Moisture	**26.17 ± 0.16$_{a}$**	**30.6 ± 0.25$_{c}$**	**28.14 ± 0.25$_{b}$**	**26.18 ± 0.23$_{a}$**
Fat	**6.18 ± 0.16$_{b}$**	**5.88 ± 0.19$_{ab}$**	**6.04 ± 0.12$_{ab}$**	**5.29 ± 0.05$_{a}$**

***Different superscript letter notations in the same column indicate a very significant difference between treatments (p<0.05).**

Overall, this research shows that adding Elkhorn Sea Moss Flour to pasta can increase protein and fiber content, while reducing carbohydrate content. However, this change is not always linear as the concentration of Elkhorn Sea Moss Flour increases. These results are in line with literature that has observed similar effects from the addition of seaweed products to other food products. However, further research needs to be carried out to understand the complex interactions between Elkhorn Sea Moss Flour and other ingredients in the paste and ensure that changes in this composition do not affect the organoleptic quality of the final product. Based on the proximate data presented in the study, it can be concluded that the addition of Elkhorn Sea Moss Flour significantly affects the nutritional composition and organoleptic properties of pasta. In comparison, the literature shows that the addition of seaweed to food products has been the focus of significant research in recent years, primarily due to seaweed's potential as a rich source of fiber and other nutrients. One of the main findings in this study was the increase in fiber content in pasta with the addition of Elkhorn Sea Moss Flour. Fiber is an important component in the human diet because it can improve digestive health, reduce the risk of heart disease, and help control weight. Literature research shows that food products enriched with fiber, including products containing seaweed, have gained popularity due to the health benefits they offer. However, changes in proximate composition, such as a decrease in carbohydrate content and an increase in protein, seen in this study, must be balanced with careful consideration. For example, several literature studies show that reducing carbohydrates in food products can have an impact on the taste and texture of the product.

Organoleptic analysis

In the study, an organoleptic evaluation was carried out to understand the effect of adding Elkhorn Sea Moss Flour on the sensory properties of pasta, including color, aroma, texture and taste. The organoleptic assessment results showed significant variations in paste characteristics based on various levels of Elkhorn Sea Moss Flour addition. In terms of color, the paste with the addition of 70% Elkhorn Sea Moss Flour (C3: 5.70 ± 0.66) had a lighter color compared to the control paste (C0: 6.47 ± 0.57), although the difference was not that striking. These results indicate that the addition of Elkhorn Sea Moss Flour at a certain level can affect the color of the paste, which may be caused by natural pigments contained in seaweed. The addition of Elkhorn Sea Moss Flour can indeed affect the color of the paste, which may be attributed to the natural pigments present in seaweed. Elkhorn sea moss, scientifically known as Kappaphycus alvarezii, is a red seaweed that contains natural pigments such as fucoxanthin, which contributes to its coloration. Additionally, red seaweeds like Kappaphycus alvarezii are known to contain pigments such as phycoerythrin and phycocyanin, which can influence the color of the paste. These pigments are responsible for masking other pigments like carotenes and chlorophyll, ultimately affecting the overall color of the paste. Furthermore, it has been noted that the color of seaweed is related to the presence of carotenoids such as fucoxanthin, which can disguise other pigments like β-carotene and chlorophyll, thus impacting the color of the paste (51,52). In terms of aroma, texture and taste parameters, it can be seen that pasta with the addition of 30% (C1) has the highest value, indicating the organoleptic characteristics most preferred by the assessors. However, as the concentration of Elkhorn Sea Moss Flour increases to 70% (C3), these values tend to decrease. This may be caused by changes in the organoleptic components of pasta due to the addition of additional fiber, which can change the texture and taste of pasta. Studies have shown that the incorporation of fiber into pasta formulations can interfere with the structure of the pasta, potentially disrupting the continuity of the protein-starch matrix, and consequently lowering the firmness of the pasta compared to the control (53). Furthermore, the inclusion of high-fiber ingredients in pasta has been associated with a decrease in color, texture, cooking, and organoleptic properties, ultimately impacting the overall quality of the pasta (54). Additionally, the presence of fiber in pasta has been linked to a deterioration in texture characteristics, potentially altering the tenacity of the protein-starch product and affecting the integrity of the protein-starch network, as well as water absorption, swelling index, optimum cooking time, cooking loss, appearance, and taste (55). Moreover, the addition of fiber-rich ingredients such as pumpkin flour and hemp flour has been reported to worsen the organoleptic evaluation of pasta, potentially damaging the structure of the pasta and lowering its texture parameters (56).

Table 3. Organoleptic assessment results of elkhorn sea moss flour addition.

Parameter	Average value ± SD			
	C_o	C_1	C_2	C_3
Color	6.47 ± 0.57^a	6.50 ± 0.09^a	5.97 ± 0.56^b	5.70 ± 0.66^b
Aroma	6.47 ± 0.50^a	6.77 ± 0.78^a	6.03 ± 0.15^b	5.57 ± 0.69^c
Texture	6.37 ± 0.49^a	7.17 ± 0.51^b	6.17 ± 0.39^a	5.63 ± 0.55^c
Flavor	6.50 ± 0.90^a	6.87 ± 0.29^b	5.87 ± 0.34^c	5.50 ± 0.72^d

***Different superscript letter notations in the same column indicate a very significant difference between treatments (p<0.05).**

However, along with the nutritional benefits offered, the addition of seaweed is also identified in the literature as a factor that can influence the organoleptic properties of the product. The distinctive marine aroma and taste contained in seaweed can provide unusual characteristics to food products. Organoleptic studies on food products containing seaweed show that not all consumers like this aroma and taste. Therefore, the finding that the addition of Elkhorn Sea Moss Flour at certain levels resulted in a decrease in values in aroma, texture, and taste parameters is in line with expectations based on the literature. To address the organoleptic changes that may arise from the addition of seaweed, further research suggests several approaches. One of them is a modification in the processing process to reduce the strong aroma and taste of the sea. This method involves soaking, drying, or other treatment of seaweed before use in food products. The study also suggests a combination with other ingredients that have strong organoleptic characteristics to balance the aroma and taste of seaweed. Additionally, innovative approaches in product formulation may include the use of additional ingredients that provide the desired taste and aroma without eliminating the nutritional benefits of seaweed. Examples include the use of spices, seasonings or special packaging technologies that can maintain product quality without compromising organoleptic characteristics.

Antioxidant Analysis:

The use of antioxidants has been widely researched across various fields including medicine, nutrition, and skincare, among others (19, 44, 57, 58). Antioxidants are compounds that help neutralize free radicals in the body, which are unstable molecules that can cause damage to cells and contribute to aging and disease development (49, 50, 59, 60). In this research, antioxidant analysis using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method was carried out to evaluate the antioxidant content of pasta with the addition of Elkhorn Sea Moss Flour. The results showed a significant increase in antioxidant activity as the concentration of Elkhorn Sea Moss Flour increased. Pasta with the addition of 70% Elkhorn Sea Moss Flour (C3: 33.65 ± 0.572 %) showed the highest antioxidant activity compared to control pasta (C0: 14.03 ± 0.50 %).(Figure 1). These results are in line with the literature noting that seaweeds, including Eucheuma cottonii, are a rich source of antioxidants. Seaweed extract content several antioxidants (61,62). Antioxidant compounds in seaweed, such as flavonoids and polyphenols, have been known to have high free radical activity, which can help protect the human body from oxidative damage. Therefore, the increase in antioxidant activity in pasta with the addition of Elkhorn Sea Moss Flour is in line with expectations based on existing scientific knowledge.

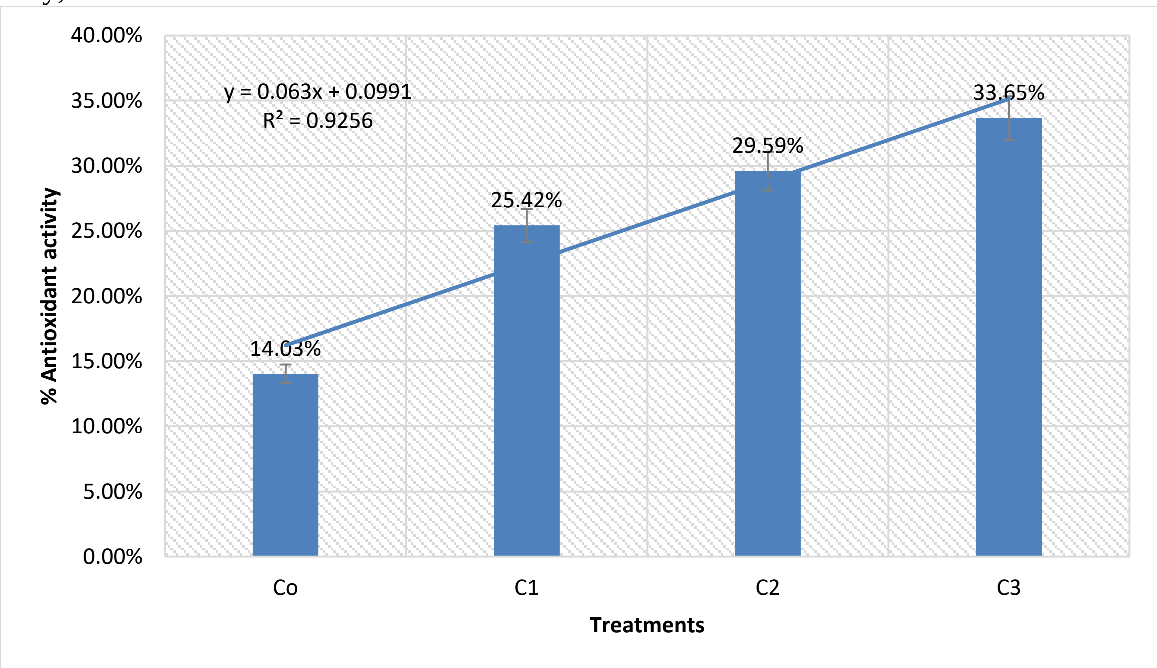

Fig. 1. Antioxidant activity of pasta with addition of elkhorn sea moss flour

The importance of antioxidant activity in food products is not only related to health benefits for consumers, but also related to product stability. Natural antioxidants can help maintain the quality of food products by protecting them from oxidation which can damage nutrients and reduce the product's shelf life. Therefore, increasing antioxidant activity in pasta with the addition of Elkhorn Sea Moss Flour provides multiple benefits, not only in terms of health but also in maintaining the quality of food products. In the context of functional food and nutraceutical product development, the increased antioxidant activity observed in this study indicates the potential of Elkhorn Sea Moss Flour as a valuable additive in the food industry. Therefore, the results of this study provide an important contribution to our understanding of the nutraceutical potential of Elkhorn Sea Moss Flour and strengthen the argument for its use in the development of healthy and nutritious food products.

Conclusion

Elkhorn Sea Moss Flour (*Eucheuma cottonii*) was tested as a basic ingredient for making pasta with high fiber content. The results showed that the addition of Elkhorn Sea Moss Flour to pasta resulted in a significant increase in protein content, fiber and antioxidant activity. Pasta with 70% added Elkhorn Sea Moss Flour shows the highest fiber content and quite high antioxidant activity, making it a potential functional food product. However, as Elkhorn Sea Moss Flour increased, there was a decrease in organoleptic parameters such as aroma, texture and taste. Therefore, these findings emphasize the importance of finding the right balance between improving nutrition and maintaining organoleptic characteristics in food product development. These results confirm that Elkhorn Sea Moss Flour has great potential as an additive in functional food products, enriching fiber and antioxidant content, but its use must be carefully considered to ensure good consumer acceptance.

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