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Macronutrient Content of Seaweed Noodles (*Eucheuma cottonii*) and Their Use as a Learning Medium

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Abstract: This study aimed to analyze the macronutrient composition of seaweed noodles (*Eucheuma cottonii*) formulated with different levels of seaweed flour substitution and to develop the research findings into a poster-based learning medium. A laboratory experiment was conducted using a one-factor completely randomized design (CRD) comprising four treatments: P0 (100% wheat flour:0% seaweed flour), P1 (90%:10%), P2 (80%:20%), and P3 (70%:30%), with three replicates per treatment. Carbohydrate, protein, and fat contents were determined using the Anthrone, Biuret, and Soxhlet methods, respectively. Macronutrient data were analyzed using one-way analysis of variance (ANOVA) at a 5% significance level, followed by the least significant difference (LSD) test. Seaweed flour substitution significantly affected the carbohydrate, protein, and fat contents of the noodles. The carbohydrate contents of P0, P1, P2, and P3 were 56.278%, 71.631%, 68.402%, and 65.490%, respectively. The corresponding protein contents were 4.355%, 7.441%, 6.458%, and 5.337%, while the fat contents were 1.117%, 1.262%, 1.097%, and 0.896%, respectively. Among the tested formulations, P1 exhibited the highest carbohydrate and protein contents. The poster-based learning medium received feasibility scores of 85% from the content expert, 85% from the design expert, 85% from the media expert, and 90% from the student participants, yielding an overall mean score of 86.25% and placing it in the highly feasible category. These findings demonstrate that *E. cottonii* substitution affects the macronutrient profile of noodles and that the resulting research findings can be effectively developed into a feasible research-based learning medium.

Keywords: Macronutrients; seaweed noodles; *Eucheuma cottonii*; learning media; poster

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INTRODUCTION

Seaweed (*Eucheuma cottonii*) is one of Indonesia's abundant marine biological resources, particularly in Central Sulawesi. According to the Ministry of Marine Affairs and Fisheries (2023), Indonesia is the world's second-largest seaweed producer, with an annual production of approximately 10.1 million tons, of which *Eucheuma cottonii* accounts for about 70% of total national production. This seaweed species contains a range of nutritionally important components, including complex carbohydrates, protein, dietary fiber, minerals—particularly iodine, calcium, and magnesium—and bioactive compounds such as carrageenan (Safia et al., 2020). Its dietary fiber content has been reported to reach 35–50% of dry weight, supporting its potential as a functional food ingredient (Pamungkas et al., 2023). Despite this potential, seaweed utilization in Indonesia remains largely oriented toward the export of raw materials, such as dried seaweed, while its processing into value-added food products remains limited (Soejarwo & Yusuf, 2018).

Noodles are widely consumed in Indonesia as an alternative staple food. Data from the Indonesian Noodle Manufacturers Association (2022) indicate that noodle consumption in Indonesia reaches approximately 13.2 billion servings annually, making the country the second-largest noodle consumer worldwide. Wheat flour-based noodles are an important source of dietary energy because of their high carbohydrate content; however, they generally contain relatively low levels of dietary fiber and minerals (Billina et al., 2014). This nutritional limitation, combined with the underutilization of seaweed in processed foods, provides an opportunity to develop seaweed-enriched noodles with improved nutritional characteristics while simultaneously increasing the added value of domestically produced marine resources.

The limited utilization of *Eucheuma cottonii* in processed food products, particularly noodles, is accompanied by a lack of comprehensive information on how different levels of seaweed flour substitution affect the macronutrient composition of the final product. Previous studies have mainly focused on the physical, physicochemical, and organoleptic characteristics of seaweed-based noodles, whereas information on changes in carbohydrate, protein, and fat contents at specific substitution levels remains relatively limited (Manurung et al., 2019). Windara et al. (2014), for example, reported that the addition of *Eucheuma cottonii* affected the physical characteristics of wet noodles, but did not comprehensively evaluate changes in their macronutrient composition. Therefore, further investigation is required to clarify the relationship between seaweed flour substitution level and the carbohydrate, protein, and fat contents of noodle products.

To address this research gap, the present study developed noodle formulations containing *Eucheuma cottonii* flour at substitution levels of 10%, 20%, and 30% and evaluated their macronutrient composition. The scientific contribution of this study lies in the comparative assessment of several substitution levels under a Completely Randomized Design (CRD), allowing the effects of seaweed flour incorporation on noodle macronutrient composition to be statistically evaluated. Carbohydrate, protein, and fat contents were analyzed using the Anthrone, Biuret, and Soxhlet methods, respectively, which are established analytical procedures used for food composition analysis (Laenggeng, 2024).

In addition to evaluating the nutritional characteristics of the noodles, this study extends the dissemination of its findings through the development of a research-based educational poster. Integrating research findings into learning resources is consistent with approaches that connect scientific inquiry with educational practice (Darung et al., 2020). Posters can present scientific information in a concise, visual, and accessible format and may help increase students' learning interest and motivation (Siregar et al., 2022). In this study, the poster was therefore positioned as a supplementary educational output derived directly from the experimental findings rather than as the primary scientific novelty of the research.

Based on this background, the study had two main objectives. First, it aimed to determine and compare the carbohydrate, protein, and fat contents of *Eucheuma cottonii*-enriched noodles produced with different seaweed flour substitution levels. Second, it aimed to develop and assess the feasibility of a poster-based biology learning medium containing the nutritional findings generated by the study. In food science, the findings provide empirical information on the macronutrient profile of seaweed-enriched noodles and may serve as a reference for further functional food development. In biology education, the study provides a research-based instructional medium whose feasibility was evaluated before its potential educational application.

The variables analyzed in this study comprised carbohydrate, protein, and fat contents. Carbohydrate content was determined using the Anthrone method, protein content using the Biuret method, and fat content using Soxhlet extraction, in accordance with the analytical procedures applied in this study and with reference to food composition analysis described by Muchtadi (2014). All parameters were quantitatively analyzed for statistical comparison across treatments.

METHOD

Research Design

This study employed a quantitative descriptive design with a laboratory experimental approach. Laboratory analyses were conducted to quantitatively characterize and interpret the macronutrient composition of seaweed noodles formulated with *Eucheuma cottonii*. Carbohydrate, protein, and fat contents were determined using the Anthrone, Biuret, and Soxhlet methods, respectively.

The experiment was arranged using a one-factor Completely Randomized Design (CRD), with the proportion of *E. cottonii* seaweed flour as the treatment factor. Four treatment levels were evaluated, each with three replicates, resulting in a total of 12 experimental units. The treatment formulations were adapted with modifications from Laenggeng (2024). The treatments were defined as follows: P0 = control (100% wheat flour: 0% seaweed flour), P1 = 90% wheat flour: 10% seaweed flour, P2 = 80% wheat flour: 20% seaweed flour, and P3 = 70% wheat flour: 30% seaweed flour. The percentage of seaweed flour was calculated based on the total amount of wheat flour used. The experimental design is presented in Table 1.

Table 1. Completely randomized design

Treatment Code	Seaweed Flour : Wheat Flour Ratio	Replicates	Total Samples
P0	0% : 100%	3	3
P1	10% : 90%	3	3
P2	20% : 80%	3	3
P3	30% : 70%	3	3

Preparation of Equipment and Materials

The first stage involved preparing the equipment and materials required for the experiment. All equipment was sterilized before use to minimize contamination by microorganisms or extraneous materials that could interfere with the analytical procedures. This step was performed to ensure that the equipment and materials used in the study were free from microbial contamination, including both vegetative cells and spores.

Preparation of *Eucheuma cottonii* Noodles

The noodle-production procedure began with the preparation of *E. cottonii* seaweed flour. Seaweed flour was incorporated at concentrations of 10%, 20%, and 30% and combined with wheat flour at proportions of 90%, 80%, and 70%, respectively, according to the designated treatment formulations.

The ingredients were mixed to form a dough, which was kneaded until a smooth and elastic consistency was obtained. The dough was then passed through a noodle roller four times, with the thickness gradually adjusted until a smooth and uniform sheet was produced. The dough sheets were subsequently passed through a noodle cutter to produce noodle strands. The noodles were steamed over boiling water for 2 min, transferred to a tray, and air-cooled for approximately 15 min.

Macronutrient Analysis

The second stage consisted of laboratory analyses of carbohydrate, protein, and fat contents. Carbohydrate content was determined using the Anthrone method. A 1-g sample was hydrolyzed with 3 mL of HCl for 3 h and subsequently neutralized with

Na_2CO_3. The solution volume was adjusted to 100 mL and filtered. A 1-mL aliquot of the filtrate was mixed with 3 mL of Anthrone reagent, heated for 10 min, and its absorbance was measured at a wavelength of 630 nm.

Protein content was determined using the Biuret method. A 1-g sample was mixed with 25 mL of distilled water and 5 mL of 1 M NaOH. The mixture was heated for 15 min, agitated for 2–3 h, and centrifuged at 5,000 rpm for 45 min. A 1-mL aliquot of the resulting filtrate was mixed with 3 mL of Biuret reagent, incubated for 30 min, and subsequently subjected to absorbance measurement.

Fat content was determined using the Soxhlet extraction method. A 5-g sample was dried, placed in a paper extraction thimble, and extracted with *n*-hexane for 6 h. The solvent was removed using a rotary evaporator, after which the residue was dried in an oven at 105°C for 1 h and weighed until a constant mass was obtained (Laenggeng, 2024).

Development and Validation of the Learning Poster

The third stage involved the development and validation of a poster as a learning medium. The poster development and validation procedures followed the media-development approach described by Arikunto (2014). The poster was evaluated by three university lecturers serving as expert validators in content, design, and media.

Data Analysis

Two analytical approaches were applied: quantitative analysis for the macronutrient data and quantitative descriptive analysis for the feasibility assessment of the learning poster. For the macronutrient data, laboratory measurements were first converted into percentage values using parameter-specific equations. Carbohydrate content was calculated as follows:

$$\textbf{Carbohydrate content (\%)} = \frac{X \times Y \times fp}{W \times 1000} \times 100\%$$

where (X) is the glucose concentration (mg/L), (Y) is the total volume (L), (fp) is the dilution factor, and (W) is the sample weight (g).

Protein content was calculated using the following equation:

$$\textbf{Protein content (\%)} = \frac{(X/1000) \times Y \times fp}{W} \times 100\%$$

where (X) is the bovine serum albumin (BSA) concentration of the sample (ppm), (Y) is the total volume, (fp) is the dilution factor, and (W) is the sample weight (g).

Fat content was calculated as follows:

$$\textbf{Fat content (\%)} = \frac{W1 - W2}{W} \times 100\%$$

where (W_1) is the weight of the flask plus the extracted sample residue (g), (W_2) is the weight of the empty flask (g), and (W) is the initial sample weight (g).

The macronutrient data were subsequently analyzed using parametric statistical procedures in SPSS version 26. A one-way analysis of variance (ANOVA) was performed to determine the effect of seaweed flour substitution on the macronutrient composition of the noodles at a significance level of $\alpha = 0.05$. The statistical hypotheses were defined as follows: H_0, the addition of seaweed flour has no significant effect on the macronutrient composition of the noodles; and H_1, the addition of seaweed flour has a significant effect on the macronutrient composition of the noodles.

H_0 was rejected when the calculated F-value exceeded the critical F-value or when the significance value (p) was < 0.05 (Steel & Torrie, 2001). When ANOVA indicated a significant treatment effect, a Least Significant Difference (LSD) post hoc test at the 5% significance level was performed to identify differences among treatments.

Feasibility Assessment of the Learning Poster

The feasibility of the learning poster was evaluated using validation sheets completed by three expert validators representing content, design, and media expertise. The feasibility percentage was calculated according to Arikunto (2014) using the following equation:

$$\textbf{Mean feasibility (\%)} = \frac{\textbf{Sum of all percentage scores}}{\textbf{Number of assessment items}} \times 100$$

The resulting percentages were classified according to the feasibility criteria presented in Table 2. All feasibility data were interpreted descriptively. The overall findings were subsequently discussed in relation to relevant food and nutrition theories and previous studies.

Table 2. Feasibility criteria for the learning media

Percentage	Feasibility Category
81–100%	Highly feasible
61–80%	Feasible
41–60%	Moderately feasible
21–40%	Not feasible
<21%	Highly infeasible

RESULTS AND DISCUSSION

Macronutrient Composition of Seaweed Noodles

The macronutrient composition of *Eucheuma cottonii* seaweed noodles varied significantly according to the proportion of seaweed flour incorporated into the formulation. Overall, the 90:10 wheat flour-to-seaweed flour formulation (P1) produced the highest carbohydrate, protein, and fat contents. Increasing the proportion of seaweed flour beyond 10% resulted in gradual decreases in all three macronutrients. This pattern indicates that the nutritional response to seaweed substitution was non-linear and depended on the proportion of seaweed flour used.

Carbohydrate Content of Seaweed Noodles

The carbohydrate content differed significantly among the four formulations. The control treatment, P0 (100% wheat flour), contained 56.278% carbohydrate. Carbohydrate content increased markedly to 71.631% in P1 (90% wheat flour:10% seaweed flour), then decreased to 68.402% in P2 (80:20) and 65.490% in P3 (70:30). Thus, P1 had the highest carbohydrate content, whereas the control formulation showed the lowest value.

One-way ANOVA demonstrated that seaweed flour substitution significantly affected the carbohydrate content of the noodles ($F = 21.727$; $p < 0.05$). The subsequent LSD test indicated significant differences among treatments ($p < 0.05$). These findings demonstrate that changes in the proportion of seaweed flour significantly altered the carbohydrate composition of the noodles.

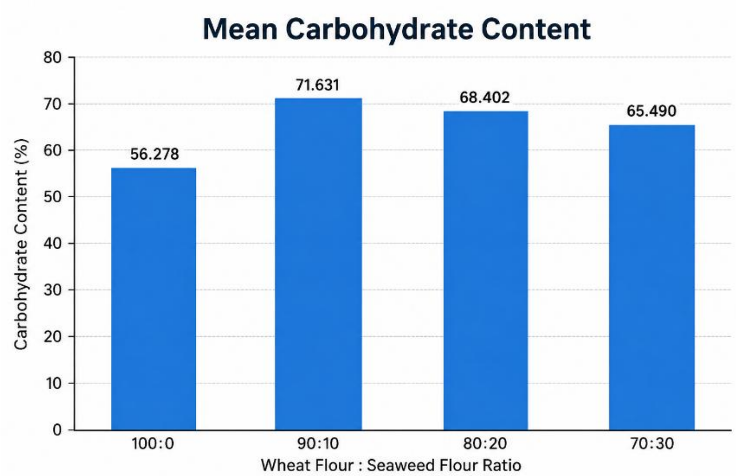

Figure 1. Mean carbohydrate content of seaweed noodles at different wheat flour : seaweed flour ratios

The increase observed at 10% seaweed substitution may be associated with the contribution of complex carbohydrates from *E. cottonii* in combination with starch from wheat flour. As a carrageenan-producing red seaweed, *E. cottonii* contains structural polysaccharides that may contribute to the carbohydrate fraction measured in the product. At a relatively low substitution level, these polysaccharides may increase the measured carbohydrate fraction without substantially reducing the contribution of wheat-derived starch.

In contrast, the gradual reduction in carbohydrate content at substitution levels of 20% and 30% may be related to the decreasing proportion of wheat flour, which is a major source of starch. At higher seaweed concentrations, dietary fiber, minerals, and other non-starch constituents represent a greater proportion of the product, which may reduce the relative concentration of measurable carbohydrate per unit weight. However, this interpretation should be considered cautiously because starch, dietary fiber, and individual polysaccharide fractions were not quantified separately in the present study.

The present results are broadly consistent with Windara et al. (2014), who reported that incorporation of *Eucheuma cottonii* into wet noodles at concentrations of up to 15% altered the chemical composition of the product, although their study focused primarily on physical characteristics rather than carbohydrate content. Billina et al. (2014) similarly reported that seaweed substitution affected the physicochemical properties of wet noodles, including moisture content and water absorption capacity.

Within the macronutrient parameters examined in this study, the 10% seaweed formulation produced the most favorable carbohydrate value. Nevertheless, this formulation should not yet be regarded as the overall optimal noodle formulation because other important characteristics, including dietary fiber, starch digestibility, sensory acceptability, texture, and consumer preference, were not evaluated.

Protein Content of Seaweed Noodles

The protein content exhibited a pattern similar to that observed for carbohydrate content. The control formulation P0 had the lowest protein content at 4.355%, whereas P1 showed the highest value at 7.441%. Protein content subsequently declined to 6.458% in P2 and 5.337% in P3. Compared with the control, the protein content of P1 was approximately 70.9% higher.

ANOVA confirmed a significant effect of seaweed flour substitution on protein content ($F = 53.370$; $p < 0.05$). The LSD post hoc test further indicated significant differences among treatments ($p < 0.05$).

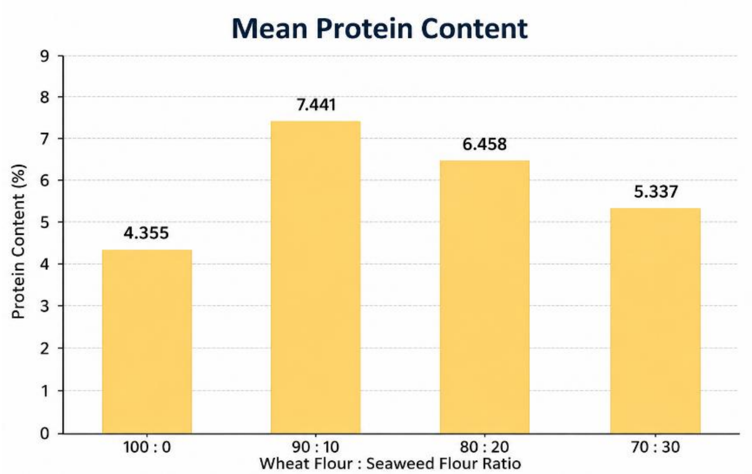

Figure 2. Mean protein content of seaweed noodles at different wheat flour : seaweed flour ratios

The increase in protein content at 10% substitution suggests that incorporation of a relatively small proportion of *E. cottonii* altered the measured protein composition of the noodles. Seaweeds contain proteins and amino acids that can contribute to the overall protein fraction of food products. Protein concentration in seaweeds varies considerably among species and environmental conditions, and red seaweeds generally contain appreciable amounts of protein and essential amino acids (Černá, 2011; López-Pedrouso et al., 2022). Safia et al. (2020) reported that the protein content of *E. cottonii* cultivated in Indonesian waters varied according to cultivation depth and cultivation conditions. Thus, the incorporation of *E. cottonii* flour may have contributed additional protein to the noodle matrix, although the magnitude of this contribution depends on the composition of the raw material.

However, the magnitude of the increase observed in P1 cannot necessarily be attributed solely to the intrinsic protein content of the seaweed. Protein percentages in formulated foods may also be influenced by differences in moisture content, dry-matter concentration, ingredient proportions, sample preparation, and analytical procedures. Consequently, an apparent increase in protein concentration may partly reflect changes in the relative proportions of water and other macronutrients rather than a proportional increase in absolute protein mass. Further analyses of moisture content, amino acid composition, and protein digestibility would therefore be required to explain this increase more comprehensively.

The subsequent reduction in protein content in P2 and P3 may be associated with the progressive replacement of wheat flour by seaweed flour. Wheat flour is an important source of gluten proteins, particularly gliadin and glutenin, which constitute the major protein fraction responsible for the structural properties of wheat dough (Zang et al., 2022). As the proportion of wheat flour decreases, the contribution of wheat-derived protein to the formulation may also decline. At the same time, increasing levels of seaweed introduce greater proportions of non-protein constituents, including polysaccharides, dietary fiber, and minerals, which may reduce the relative protein concentration of the final product.

Similar changes in nutritional composition have been observed in noodles containing seaweed-based flour substitutions. Hasanah et al. (2021), for example, evaluated dried noodles containing 0–25% *Kappaphycus alvarezii* flour and reported that substitution level affected the chemical composition of the product, with the 5% formulation showing favorable nutritional and sensory characteristics. Similarly, Khanza et al. (2023) found that substitution of wheat flour with a combination of banana blossom flour and *E. cottonii* flour significantly affected the nutritional quality of wet noodles, including protein content. These findings indicate that the effect of seaweed incorporation on noodle protein content is formulation-dependent and may not follow a simple linear pattern.

This interpretation is also supported by studies showing that the incorporation of seaweed powder alters the physicochemical properties of noodle systems. In instant noodles containing *Eucheuma denticulatum*, increasing seaweed incorporation affected water absorption, cooking yield, cooking loss, texture, and other physicochemical characteristics, demonstrating that seaweed addition modifies the overall food matrix rather than contributing nutrients in isolation (Matanjun et al., 2022). Such matrix effects may also influence the relative concentration and analytical recovery of protein in formulated noodles.

Although the 10% seaweed formulation showed the highest measured protein content, the present findings indicate an increase in protein concentration rather than direct evidence of improved protein quality or nutritional efficacy. Protein quantity alone does not establish nutritional quality, which also depends on amino acid composition, digestibility, and bioavailability. Seaweed proteins may contain nutritionally relevant essential amino acids, but their nutritional value varies among species and processing conditions (Černá, 2011; López-Pedrouso et al., 2022). Therefore, broader claims regarding the prevention of protein deficiency or malnutrition require additional evidence from amino acid profiling, protein digestibility assessment, and nutritional intervention studies.

Fat Content of Seaweed Noodles

The fat content remained relatively low across all formulations but differed significantly among treatments. P0 contained 1.117% fat, whereas P1 showed the highest fat content at 1.262%. The value decreased to 1.097% in P2 and reached the lowest level of 0.896% in P3.

ANOVA showed that seaweed flour substitution significantly affected fat content ($F = 683.451$; $p < 0.05$), and the LSD test indicated significant differences among treatments ($p < 0.05$). Unlike carbohydrate and protein, the fat content of P3 was lower than that of the control.

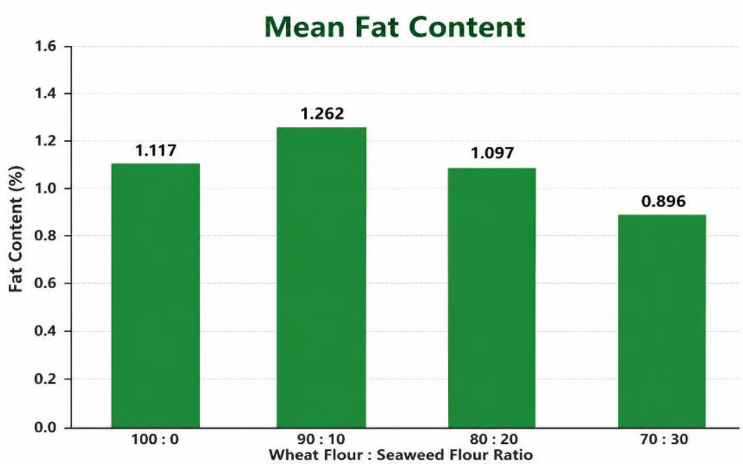

Figure 3. Mean fat content of seaweed noodles at different wheat flour : seaweed flour ratios

The slight increase in fat content in P1 may be associated with the contribution of naturally occurring lipids in seaweed. Although seaweeds are generally considered low-fat food ingredients, their lipid fractions contain fatty acids, glycolipids, phospholipids, sterols, and other lipid-associated compounds. Total lipid concentrations in macroalgae are generally low and vary considerably among species and environmental conditions (Kumari et al., 2013; Lopes et al., 2023). In *Kappaphycus alvarezii*—commercially known as *Eucheuma cottonii*—fatty acids have also been identified, confirming that this seaweed contributes a small but measurable lipid fraction to food formulations. Therefore, at a low substitution level, these naturally occurring lipid components may make a modest contribution to total extractable lipids while the proportion of wheat flour remains relatively high.

The reduction in fat content observed at higher seaweed substitution levels may be associated with the naturally low lipid content of seaweed and the progressive reduction in wheat flour. Seaweed is also rich in soluble dietary fiber and hydrocolloid-forming polysaccharides, including carrageenan, which exhibit high water-holding capacity, viscosity, and gel-forming properties (Jiménez-Escrig & Sánchez-Muniz, 2000). These characteristics may modify the physical organization of the noodle matrix and, consequently, influence the distribution or extractability of lipid components. Because fiber–lipid interactions and lipid recovery were not directly measured in the present study, however, this mechanism should be regarded as a plausible explanation rather than a demonstrated causal relationship.

The decreasing fat content at higher seaweed substitution levels observed in the present study is also consistent with findings from seaweed-enriched noodle products. Hasanah et al. (2021), for example, reported relatively low fat levels in dried noodles containing *Kappaphycus alvarezii* flour, supporting the general characterization of this seaweed as a low-lipid ingredient. More recent work on *K. alvarezii*-enriched dried noodles similarly showed that seaweed incorporation did not increase fat content relative to the control formulation. Such differences in the magnitude and direction of changes in fat content among seaweed-based food products may reflect variation in seaweed species, ingredient composition, substitution level, processing conditions, product moisture, and analytical procedures. Seaweed lipid composition itself is also affected by species, geographical origin, season, temperature, and other environmental factors (Lopes et al., 2023).

The P3 formulation contained less than 1% fat (0.896%), indicating that higher levels of seaweed substitution may be useful for producing noodle formulations with relatively low fat content. Nevertheless, a low measured fat concentration alone does not justify classifying the product as healthier or lower in calories. Such claims would require additional information on total energy content, carbohydrate digestibility, portion size, sensory characteristics, consumer acceptance, and potentially other nutritional attributes. Therefore, the present results should be interpreted specifically as evidence of reduced measured fat content rather than as direct evidence of an overall health benefit.

Table 3. Macronutrient content of seaweed noodles at different formulation ratios

Treatment	Wheat Flour : Seaweed Flour	Carbohydrate (%)	Protein (%)	Fat (%)
P0	100:0	56.28	4.35	1.12
P1	90:10	71.63	7.44	1.26
P2	80:20	68.40	6.46	1.10
P3	70:30	65.49	5.34	0.90

Table 3 shows that P1 consistently produced the highest values for all three measured macronutrients. In contrast, P3 showed lower carbohydrate and protein contents than P1 and the lowest fat content among the formulations. The results therefore indicate that increasing seaweed substitution did not produce a linear increase in macronutrient content.

Table 4. Summary of statistical effects of seaweed flour substitution on macronutrient content

Nutritional Parameter	F-value	Statistical Significance	LSD Interpretation
Carbohydrate content	21.727	$p < 0.05$	Significant differences among treatments
Protein content	53.370	$p < 0.05$	Significant differences among treatments
Fat content	683.451	$p < 0.05$	Significant differences among treatments

For greater statistical transparency, future presentation of these results should include the mean ± standard deviation for each treatment and superscript letters derived from the LSD test to indicate statistically homogeneous groups. Exact p-values should also be reported when available.

Feasibility of the Poster as a Learning Medium
Expert validation

The feasibility of the research-based poster was evaluated by content, design, and media experts. To avoid repetitive presentation of individual validation items, the expert assessments are summarized in Table 5.

The content expert evaluated title appropriateness, consistency between the title and content, image clarity, image labeling, presentation of research findings, and supporting references. The highest scores were assigned to title appropriateness and consistency between the title and content. The design expert evaluated typography, sentence clarity, organization, visual presentation, image quality, and caption design. The strongest design ratings were recorded for font size, sentence clarity, and systematic organization, whereas image attractiveness and overall visual presentation received comparatively lower scores.

The media expert evaluated image quality and placement, title-text quality, consistency between the material and the learning medium, image size, textual clarity, and font consistency. Overall, the three expert assessments classified the poster as highly feasible, with a reported feasibility score of 85% for each validation domain.

Table 5. Summary of expert validation of the poster learning medium

Validator	Main Assessment Aspects	Total Score	Reported Feasibility (%)	Category
Content expert	Title appropriateness, consistency between title and content, image clarity, image labels, clarity of research findings, and supporting references	30	85	Highly feasible
Design expert	Font size, sentence clarity, organization, material presentation, image quality, image placement, and caption design	45	85	Highly feasible
Media expert	Image quality and placement, title-text quality, consistency between material and medium, image size, text quality, and font consistency	47	85	Highly feasible

The expert validation results indicate that the poster was generally perceived as clear, relevant, and suitable for instructional use. Nevertheless, the comparatively lower scores assigned to image attractiveness and visual presentation indicate that these elements remain the main areas for further improvement. Enhancing image quality, visual hierarchy, and the balance between text and graphics may increase the overall communication effectiveness of the poster.

Student Feasibility Trial

The poster was subsequently evaluated by 20 students from the Biology Education Program, Department of Mathematics and Natural Sciences Education, Faculty of Teacher Training and Education, Tadulako University. Student responses were favorable across all assessment indicators, with percentage scores ranging from 83% to 94% and an overall reported mean of 90%.

Table 6. Summary of student feasibility trial of the poster learning medium

Assessment Aspect	Percentage (%)	Interpretation
Attractiveness of poster content	92	Highly feasible
Ease of understanding the poster content	90	Highly feasible
Clarity of images	87	Highly feasible
Clarity of written text	94	Highly feasible
Attractiveness of images	83	Highly feasible
Overall attractiveness of the poster	91	Highly feasible
Usefulness in facilitating understanding of the macronutrient content of *Eucheuma cottonii* seaweed noodles	94	Highly feasible
Accuracy of Latin terminology	92	Highly feasible
Mean	90	Highly feasible

The highest ratings were recorded for written-text clarity and the usefulness of the poster in facilitating understanding of the macronutrient content of *E. cottonii* seaweed noodles, both at 94%. The lowest score was obtained for image attractiveness (83%), although this value remained within the highly feasible category.

The lower score for image attractiveness is consistent with the design expert's assessment. This convergence between expert and student evaluations suggests that visual presentation, rather than content clarity, represents the principal aspect requiring further improvement. Future revisions should therefore prioritize image quality, visual consistency, graphic hierarchy, and the balance between textual and visual information.

The findings are consistent with Darung et al. (2020), who developed an infographic poster for geography education and obtained an expert feasibility score of 87%. Siregar et al. (2022) similarly reported high validity for a three-dimensional poster developed using a scientific approach, with scores ranging from 85% to 90% from media and subject-matter experts. Putri et al. (2022) reported that posters used as instructional media can support a more engaging and efficient learning environment and may increase students' interest in learning. Utami et al. (2021) also demonstrated that well-designed posters may support students' motivation and facilitate the retention of concepts presented during learning.

Differences from the lower validation results reported by Rohani (2019) may be associated with variations in material complexity, visual design, evaluation criteria, and target audience characteristics. In the present study, the poster was specifically designed to transform experimental findings on carbohydrate, protein, and fat contents into a concise visual format using bar charts, supporting images, and brief explanatory text. This presentation may have contributed to the favorable assessments obtained from both experts and students.

Importantly, the expert validation and student trial results should be interpreted as evidence of feasibility and perceived quality rather than instructional effectiveness. The present study did not employ an experimental learning design, such as pre-test and post-test comparisons or a control group, to determine whether use of the poster improves learning outcomes. Therefore, although the poster can be considered highly feasible as a medium for communicating research findings, further studies are required to evaluate its effectiveness in improving conceptual understanding, knowledge retention, and student learning outcomes.

CONCLUSION

The addition of *Eucheuma cottonii* significantly affected the macronutrient composition of seaweed noodles. Among the tested formulations, the 90:10 wheat flour-to-seaweed flour ratio showed the most favorable macronutrient profile, with carbohydrate, protein, and fat contents of 71.63%, 7.44%, and 1.26%, respectively. Increasing the seaweed proportion to 30% tended to reduce the measured macronutrient contents but resulted in a relatively low fat content of 0.90%.

These findings indicate the potential of *E. cottonii* as a locally available ingredient for the development of seaweed-based noodle products. However, the 90:10 formulation should be considered a promising formulation based on the macronutrient parameters evaluated in this study, as organoleptic properties, consumer acceptance, and storage stability were not assessed. The research findings were also successfully incorporated into an educational poster, which was classified as highly feasible with an average validation score of 86.25%. The poster may serve as a supporting learning medium for biology education, particularly for topics related to macronutrients and the utilization of marine biological resources.

RECOMMENDATION

Future studies should evaluate other nutritional components of *E. cottonii*-based noodles, including dietary fiber, minerals, carrageenan, and antioxidant compounds. Organoleptic properties, consumer acceptance, and shelf life should also be assessed to determine the practical potential of the product.

Further research should include samples from different cultivation areas and harvesting periods to account for variations in seaweed quality. Increasing experimental replication and using more advanced analytical methods may also improve the robustness of the findings. The educational poster should be tested directly with school students to determine its effectiveness in improving learning outcomes. Further development into digital or interactive learning media may also broaden its educational application.

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REFERENCES

Arikunto, S. (2014). *Prosedur penelitian: Suatu pendekatan praktik*. PT Rineka Cipta.
Billina, A., Waluyo, S., & Suhandy, D. D. (2014). Kajian sifat fisik mie basah dengan

penambahan rumput laut. *Jurnal Teknik Pertanian Lampung, 4*(2), 109–116.

Černá, M. (2011). Seaweed proteins and amino acids as nutraceuticals. *Advances in Food and Nutrition Research, 64*, 297–312. https://doi.org/10.1016/B978-0-12-387669-0.00024-7

Darung, A., Setyasih, I., & Ningrum, M. V. R. (2020). Pengembangan pembelajaran media geografi menggunakan poster infografis. *Geoedusains: Jurnal Pendidikan Geografi, 1*(1), 27–41.

Hasanah, A. N., Munandar, A., Surilayani, D., Haryati, S., Aditia, R. P., Sumantri, M. H., Pratama, G., & Meata, B. A. (2021). Characterization of dried noodles from seaweed (*Kappaphycus alvarezii*) as potential substitute for wheat flour. *Food ScienTech Journal, 3*(2), 113–122. https://doi.org/10.33512/fsj.v3i2.13001

Jiménez-Escrig, A., & Sánchez-Muniz, F. J. (2000). Dietary fibre from edible seaweeds: Chemical structure, physicochemical properties and effects on cholesterol metabolism. *Nutrition Research, 20*(4), 585–598. https://doi.org/10.1016/S0271-5317(00)00149-4

Kementerian Kelautan dan Perikanan Republik Indonesia. (2023, November 25). *KKP optimis tingkatkan produksi dan kesejahteraan pembudidaya rumput laut*.

Khanza, N., Yasa, I. W. S., & Paramartha, D. N. A. (2023). Pengaruh substitusi tepung terigu dengan kombinasi tepung jantung pisang (*Musa paradisiaca*) dan tepung rumput laut (*Eucheuma cottonii*) terhadap mutu gizi mi basah. *Jurnal Teknologi dan Mutu Pangan, 1*(2), 65–76. https://doi.org/10.30812/jtmp.v1i2.2586

Kumari, P., Kumar, M., Reddy, C. R. K., & Jha, B. (2013). Fatty acid profiling of tropical marine macroalgae: An analysis from chemotaxonomic and nutritional perspectives. *Phytochemistry, 86*, 44–56. https://doi.org/10.1016/j.phytochem.2012.10.015

Laenggeng, A. H. (2024). *Komplementasi kedelai (Glycine max L. Merr) dan rumput laut (Eucheuma cottonii) dalam pembuatan tempe sebagai pangan fungsional* [Doctoral dissertation, Universitas Tadulako].

Manurung, H., Simanjuntak, R., Pakpahan, Y. A., & Pandiangan, S. (2019). Pembuatan mie kering komposit tepung rumput laut (*E. cottonii*) dan labu kuning (*Cucurbita moschata*) sebagai pangan fungsional. *Rona Teknik Pertanian, 12*(2), 1–10.

Muchtadi, D. (2014). *Pengantar ilmu gizi*. Alfabeta.

Pamungkas, A., Sedayu, B. B., Hakim, A. R., Wullandari, P., Fauzi, A., & Novianto, T. D. (2023). Perkembangan penelitian aplikasi rumput laut sebagai bahan pangan di Indonesia: Tinjauan literatur. *Agrointek: Jurnal Teknologi Industri Pertanian, 17*(3), 557–570. https://doi.org/10.21107/agrointek.v17i3.1648

Putri, C. F., & Saputra, E. R. (2022). Penggunaan media poster dalam pembelajaran PPKn di kelas tinggi. *Jurnal Riset Pendidikan Dasar (JRPD), 3*(2), 127.

Radiati, A., & Sumarto. (2016). Analisis sifat fisik, sifat organoleptik, dan kandungan gizi pada produk tempe dari kacang non-kedelai. *Jurnal Aplikasi Teknologi Pangan, 5*(1). https://doi.org/10.17728/jatp.v5i1.32

Ridwan, M., Tantu, G., & Zainuddin, H. (2019). Analisis kualitas karaginan rumput laut jenis *Eucheuma spinosum* pada ekosistem yang berbeda di perairan Tomia, Kabupaten Wakatobi, Provinsi Sulawesi Tenggara. *Journal of Aquaculture and Environment, 1*(2), 1–7.

Safia, W., Budiyanti, & Musrif. (2020). Kandungan nutrisi dan senyawa bioaktif rumput laut (*Eucheuma cottonii*) dengan metode rakit gantung pada kedalaman berbeda. *Jurnal Pengolahan Hasil Perikanan Indonesia, 23*(2), 261–271.

Sari, N. I., Diharmi, A., Sidauruk, S. W., & Sinurat, F. M. (2022). Identifikasi komponen bioaktif dan aktivitas ekstrak rumput laut merah (*Eucheuma spinosum*). *Jurnal Teknologi dan Industri Pertanian Indonesia, 14*(1), 9–15. https://doi.org/10.17969/jtipi.v14i1.18862

Siregar, R., & Nurjannah. (2022). Pengembangan media pembelajaran poster 3 dimensi berbasis pendekatan saintifik pada tema energi dan perubahannya di kelas III SD. *Edu Global: Jurnal Penelitian Pendidikan, 1*(3), 258–271.

Soejarwo, P. A., & Yusuf, R. (2018). Saluran pemasaran rumput laut (*Eucheuma cottonii*) di Sumba Timur, Nusa Tenggara Timur. *Buletin Ilmiah Marina Sosial Ekonomi Kelautan dan Perikanan, 4*(2), 45–51. https://doi.org/10.15578/marina.v4i2.7399

Steel, R. G. D., & Torrie, J. H. (1989). *Prinsip dan prosedur statistika: Suatu pendekatan biometrik* (B. Sumantri, Trans.; 2nd ed.). Gramedia. (Original work published in English)

Tan, A. (2021). Profil protein dan karbohidrat dari spesies rumput laut di perairan Indonesia. *Jurnal Gizi Kelautan, 4*(1), 56–70.

Windara, Suardi, & Sumarto. (2014). Pengaruh penambahan rumput laut (*Eucheuma cottonii*) terhadap mutu mie basah. *Jurnal Sains & Teknologi, 3*(3), 1–13.

World Instant Noodles Association. (2025). *Demand rankings*.

Yani, I. E., Habibi, N. A., Sary, R. Y., & Darningsih, S. (2023). Pengaruh penambahan rumput laut terhadap kandungan serat dan mutu sensori snack tradisional serabi. *Teknologi Pangan: Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian, 14*(1), 90–97. https://doi.org/10.35891/tp.v14i1.3448

Zang, P., Gao, Y., Chen, P., Lv, C., & Zhao, G. (2022). Recent advances in the study of wheat protein and other food components affecting the gluten network and the properties of noodles. *Foods, 11*(23), 3824. https://doi.org/10.3390/foods11233824