



PHYSICAL AND CHEMICAL CHARACTERIZATION OF SCRUB SOAP ENRICHED WITH *Sargassum polycystum* POWDER

Elfrida Juliana Nababan¹, Amir Husni^{1,2*}

¹Fishery Product Technology Study Program, Department of Fisheries, Faculty of Agriculture,
Universitas Gadjah Mada

Flora st. Fisheries Building A4 Bulaksumur Yogyakarta Indonesia 55281

²Department of Fisheries, Faculty of Agriculture, Universitas Gadjah Mada

Flora st. Fisheries Building A4 Bulaksumur Yogyakarta Indonesia 55281

Submitted: 15 January 2026/Accepted: 17 April 2026

*Correspondence: a-husni@ugm.ac.id

How to cite (APA Style 7th): Nababan, E. J., & Husni, A. (2026). Physical and chemical characterization of scrub soap enriched with *Sargassum polycystum* powder. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 29(6), 582-595. <http://dx.doi.org/10.17844/scdvhk06>

Abstract

The brown seaweed *Sargassum polycystum* is abundant in Indonesian waters and is rich in bioactive compounds with antioxidant properties. This study aimed to determine the effect of adding *S. polycystum* powder on the physical and chemical characteristics of scrub soap. Soap was produced using the cold saponification method with four treatments: addition of *S. polycystum* powder at concentrations of 0, 2, 4, and 6%. The physical characteristics observed included hardness, foam stability, and color, while the chemical characteristics included pH, water content, ethanol-insoluble materials, free fatty acids, and antioxidant activity. Data were analyzed using analysis of variance, followed by DMRT. The results showed that the addition of *S. polycystum* powder significantly affected the color, pH, water content, ethanol-insoluble substances, free fatty acids, and antioxidant activity, but did not significantly affect the foam stability and soap hardness. The hardness values ranged from 16.38 to 20.99 N, foam stability from 80.46 to 82.75%, lightness (L^*) from 44.74 to 76.27, pH from 10.62 to 10.66, water content from 7.01 to 10.62%, ethanol-insoluble matter from 1.21 to 8.36%, and free fatty acids from 1.11 to 1.35%. The best antioxidant activity was achieved with the addition of 6% *S. polycystum* powder, yielding an IC_{50} value of 17,383.47 ppm, which was identified as the best overall formulation based on its functional antioxidant properties.

Keywords: antioxidants, characteristics, foam stability, saponification, seaweed

Karakteristik Fisik dan Kimia Sabun Scrub dengan Penambahan Serbuk *Sargassum polycystum*

Abstrak

Rumput laut *Sargassum polycystum* banyak terdapat di perairan Indonesia dan kaya senyawa bioaktif sebagai antioksidan. Penelitian ini bertujuan untuk menentukan pengaruh penambahan serbuk *S. polycystum* terhadap karakteristik fisik dan kimia sabun scrub padat. Sabun dibuat dengan metode saponifikasi dingin dengan empat perlakuan, yaitu penambahan serbuk *S. polycystum* dengan konsentrasi 0, 2, 4, dan 6%. Karakteristik fisik yang diamati terdiri dari kekerasan, stabilitas busa, dan warna, sedangkan karakteristik kimia meliputi pH, kadar air, bahan tak larut dalam etanol, asam lemak bebas, dan aktivitas antioksidan. Data dianalisis menggunakan ANOVA dan uji DMRT. Hasil penelitian menunjukkan bahwa penambahan serbuk *S. polycystum*

berpengaruh secara signifikan terhadap warna, pH, kadar air, bahan tak larut dalam etanol, asam lemak bebas, dan aktivitas antioksidan, namun tidak berpengaruh secara signifikan terhadap stabilitas busa dan kekerasan sabun. Nilai kekerasan sabun berkisar 16,38–20,99 N; stabilitas busa 80,46–82,75%; *lightness* (L^*) 44,74–76,27; pH 10,62–10,66; kadar air 7,01–10,62%; bahan tak larut dalam etanol 1,21–8,36%; dan asam lemak bebas 1,11–1,35%. Aktivitas antioksidan terbaik diperoleh pada penambahan 6% serbuk *S. polycystum* dengan nilai IC_{50} sebesar 17.383,47 ppm, yang juga merupakan formula terbaik secara keseluruhan berdasarkan nilai fungsional antioksidannya.

Kata kunci: antioksidan, rumput laut, sabun mandi, saponifikasi, stabilitas busa

INTRODUCTION

Indonesia is an archipelagic nation with abundant marine resource potential, and seaweed is a leading commodity with a significant contribution to the national economy (KKP, 2024). According to the latest data from the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia, Indonesia's total seaweed production in 2023 reached approximately 10.6 million tons, reflecting its crucial role as a raw material in various industrial sectors, such as food, feed, fertilizers, cosmetics, and pharmaceuticals (KKP, 2024). The increasing global demand for seaweed is driving diversification and innovation in its utilization. One type of seaweed with significant potential but is underutilized is brown seaweed of the genus *Sargassum*, which grows abundantly in Indonesian waters (Akbar *et al.*, 2022).

The brown seaweed *Sargassum polycystum*, a species of the genus *Sargassum*, is rich in nutrients and bioactive compounds (Nazarudin *et al.*, 2021; Husni *et al.*, 2022). This seaweed contains various secondary metabolites, including steroids, phenols, tannins, saponins, flavonoids, and terpenoids (Aznury *et al.*, 2022). The phenolic compounds in *S. polycystum* have antioxidant activity that can potentially protect the skin from free radical damage (Mahardani & Yuanita, 2021), while saponins can function as natural surfactants in soap-making. The saponins found in *S. polycystum* are known to have various biological activities, such as anticancer, anti-inflammatory, antimicrobial, and antioxidant properties, which play a role in supporting the bioactive potential of seaweed (Sidana *et al.*, 2016), making it a

promising candidate for functional skin care products (Michalak *et al.*, 2021).

Among the various cosmetic dosage forms, solid scrub soap offers distinct advantages over conventional creams, lotions, or serums in terms of ease of use, longer shelf life without preservatives, and dual functionality of cleansing and physical exfoliation in a single application step. Scrub soap with the addition of natural particles (exfoliants) can help remove dead skin cells and increase the cleansing efficiency (Nurhidayati *et al.*, 2024). Unlike leave-on cosmetics, such as creams or serums, rinse-off products, such as soap, are generally regarded as safer for consumers with sensitive skin, as the active ingredients are not retained on the skin surface for extended periods (Michalak *et al.*, 2021). These advantages make solid scrub soap a strategically important product for delivering bioactive ingredients derived from natural sources, such as seaweed.

The use of *S. polycystum* powder as a natural scrub agent in scrub soap has the potential to provide a mechanical exfoliating effect and facilitate the transfer of its bioactive compounds into the skin. This transfer mechanism occurs through two pathways: (1) mechanical abrasion of the scrub particles disrupts the outermost layer of the stratum corneum, temporarily increasing skin permeability and enabling passive diffusion of bioactive compounds such as phenolics and fucoxanthin into the deeper epidermal layers; and (2) the amphiphilic nature of saponins present in *S. polycystum* allows them to interact with skin lipids, acting as natural penetration enhancers that facilitate the transdermal delivery of polar bioactive molecules (Michalak



et al., 2021; Paputungan *et al.*, 2023). Studies on scrub soaps formulated with other seaweed species, such as *Eucheuma spinosum*, have demonstrated that incorporating seaweed powder can enhance antioxidant activity and improve the functional quality of the final product (Paputungan *et al.*, 2023).

Although cosmetic applications of *Sargassum* have been explored in previous studies, the novelty of this research lies in its comprehensive evaluation of a functional scrub soap formulated specifically with *S. polycystum* powder, combining physical, chemical, and antioxidant analyses, and discussing its regulatory implications under Indonesian National Standards (SNI), thereby providing a holistic view of the potential of *S. polycystum* in functional cosmetics. Given this potential, the objective of this study was to determine the effect of adding *S. polycystum* powder on the physical and chemical characteristics of scrub soap.

MATERIALS AND METHODS

Research Methods

This study used a completely randomized design (CRD) with one factor, namely the concentration of *S. polycystum* powder, consisting of four levels: 0, 2, 4, and 6% of the total oil weight (Paputungan *et al.*, 2023). Each treatment was performed in triplicate. The concentrations were selected based on preliminary trials, which indicated that concentrations above 6% resulted in a soap texture that was too coarse and brittle,

while concentrations below 2% did not show a significant exfoliating effect.

Sargassum polycystum Powder

Fresh seaweed was cleaned of dirt, washed, and dried in an oven at 45°C for approximately 6 h until the moisture content was below 12% (Maulina *et al.*, 2018). The dried seaweed was then ground using a blender (MKS-ML300) for 90 s and sieved through a 60-mesh sieve to obtain a homogeneous powder (Paputungan *et al.*, 2023).

Production of Scrub Soap

The process of making solid scrub soap was carried out using the cold saponification method, with reference to the research of Muti'ah *et al.* (2022) and Paputungan *et al.* (2023), with modifications. The detailed formulations are presented in Table 1. The study began by carefully dissolving 10 g of NaOH flakes (99% concentration) in 22 g of distilled water using a heat-resistant beaker. This solution was then cooled to a temperature equivalent to the temperature of palm oil (30-40°C). The NaOH solution was then poured into 8 g of palm oil while stirring and homogenized with a hand blender until a soap mixture (base soap) was formed. The powder was then added to the soap mixture as an additional ingredient in the form of a scrub according to the treatment, namely 0, 2, 4, and 6% of the total weight of the soap mixture (base soap) that had been prepared, and then stirred until evenly mixed. The scrub soap was

Table 1 Formulation of *Sargassum polycystum* scrub soap

Ingredients	F0 (0%)	F1 (2%)	F2 (4%)	F3 (6%)
Palm oil (g)	68	68	68	68
NaOH (g)	10	10	10	10
Aquadest (g)	22	22	22	22
<i>S. polycystum</i> powder (g)	0	2	4	6
Total base soap (g)	100	100	100	100
<i>S. polycystum</i> powder added (% of base soap)	0%	2%	4%	6%

Note: The base soap formulation (palm oil + NaOH + aquadest) made up 100% of the soap matrix. *S. polycystum* powder was added as an additional functional ingredient at 2%, 4%, and 6% of the total base soap weight (100 g), resulting in total batch weights of 102 g, 104 g, and 106 g, respectively.

poured into a silicone mold and allowed to harden at room temperature for 2'24 h. After hardening, the scrub soap was removed from the mold and stored for 3-4 weeks (curing period) to maximize the saponification process in the soap (Febriani *et al.*, 2020).

Hardness Analysis

The hardness test on soap was conducted based on the research conducted by Astuti (2018) using a universal testing machine (UTM; Stable Micro Systems TA.XT Plus, Surrey, UK) that measures the sample's resistance to the applied compressive force. The soap sample used had a diameter of 12.7 mm and was placed between the pressure plates of the UTM, and then subjected to a load at a speed of 10 mm/min until cracking or deformation occurred. The compressive strength was recorded in Newtons.

Foam Stability Analysis

Foam stability was calculated by weighing 1 g of the ground soap sample into a test tube and adding distilled water to a volume of 10 mL (Jalaluddin *et al.*, 2023). The soap mixture was shaken by inverting the test tube for 30 s, and the initial foam height was measured (Fanani *et al.*, 2020). The soap mixture was allowed to stand for 5 min, and the final foam height was immediately measured. The foam stability was calculated using the formula described by Pangestika *et al.* (2021) as follows:

$$\text{Foam stability} = 100\% - \% \text{ of foam lost}$$

$$\% \text{ of foam lost} = \frac{\text{initial foam (mm)} - \text{final foam (mm)}}{\text{initial foam (mm)}} \times 100$$

Color Measurement

Color measurements of the soap samples were performed using a color reader (Hawa *et al.*, 2022). The color reader used was a color reader CR-20 (Konica Minolta). The instrument was turned on by pressing the power button, and an initial calibration was performed using a white calibration plate by selecting the "calibration" menu and pressing the enter key until the notification "calibration complete" appeared. After calibrating the instrument, the soap sample was covered

with a thin, clear plastic film to prevent direct contact with the sensor without compromising the reading accuracy. The instrument was then placed perpendicularly and tightly against the soap surface, and the "measure" button was pressed to initiate color reading. Measurements were performed three times at different points on each sample to obtain the representative values. The measurement results were in the form of an L* value indicating brightness (0=black, 100=white), an a value indicating red-green color (a+=red, a-=green), and a b value indicating yellow-blue color (b+=yellow, b-=blue). The L*, a*, and b* values were recorded and subjected to further analysis.

pH Measurement

The pH of the scrub soap samples was measured using the method described by Yansen and Humaira (2022). The test was conducted using a previously calibrated digital pH meter. One gram of the sample was dissolved in 10 mL of distilled water. The cathode indicator tip of the pH meter was then dipped into the soap sample, and the pH reading was recorded after it stabilized.

Moisture Content Analysis

The moisture content of the soap samples was determined using the method described by Rejeki *et al.* (2025), using a moisture analyzer (Ohaus MB120, Parsippany, NJ, USA). The device was activated, and the appropriate operating mode was selected. The lid was opened, an aluminum pan was placed, the lid was closed, and the tare process was performed. A total of 0.5 g of the ground soap sample was placed in the tare pan, which was then closed. The moisture content calculation process was declared complete when the indicator on the screen turned green, and the results were recorded accordingly.

Ethanol-Insoluble Substances Analysis

The calculation of ethanol-insoluble substances in the scrub soap samples was based on SNI 3532:2021 (Badan Standardisasi Nasional [BSN], 2021). A total of 5 g of finely chopped soap was weighed and added to 200



mL boiling ethanol. The mixture was then heated on a hot plate until the soap sample was completely dissolved. The heated soap solution was then filtered using a previously prepared filter paper. The filter paper was dried in an oven at 105°C for 30 min, cooled in a desiccator, and weighed. The remaining insoluble substances on the filter paper were rinsed with hot ethanol until the filtrate was clear and foam-free. The resulting filtrate was stored for testing free alkali/free fatty acids. The filter paper and residue were then dried in an oven at 103°C for 3 h, cooled in a desiccator, and weighed. The value of insoluble substances in ethanol was calculated using the following formula:

$$\text{Ethanol insoluble substances (\%)} = \frac{b_2 - b_0}{b_1} \times 100$$

where:

b₀ = initial weight of filter paper (g)

b₁ = sample weight (g)

b₂ = weight of filter paper and residue (g)

Free Fatty Acids Analysis

The free fatty acids in the scrub soaps were calculated according to SNI 3532:2021 (BSN, 2021). A 0.1 N alcoholic KOH solution was prepared by dissolving 5.6 g of KOH in ethanol in a 1000 mL volumetric flask. A 0.1 N alcoholic HCl solution was prepared by dissolving 8.3 mL of HCl in ethanol in a 1000 mL volumetric flask. The filtrate from the ethanol-insoluble material test was heated on a hot plate until boiling, and 0.5 mL of 1% phenolphthalein indicator was added to it. If the solution was acidic (the phenolphthalein indicator did not produce a red color), it was titrated with a 0.1 N alcoholic KOH solution until a stable pink color appeared in the solution. If the solution was alkaline (the phenolphthalein indicator produced a red color), it was titrated with a 0.1 N alcoholic HCl solution until the red color disappeared. Alkaline solutions were calculated as NaOH and acidic solutions as oleic acid. The free fatty acid content was calculated using the following equation:

$$\text{Free fatty acid (\%)} = \frac{282 \times V \times N}{b} \times 100$$

where:

282 = oleic acid equivalent weight

V = KOH volume used for titration (mL)

N = KOH normality

b = sample weight used (mg)

Antioxidant Activity Analysis

The antioxidant activity test using the DPPH method was based on the research conducted by Mahendran *et al.* (2021), with modifications to the sample solution concentrations. A 0.1 mM DPPH solution was prepared by dissolving 3.94 mg of DPPH powder in 100 mL of 96% ethanol and incubating it at 4°C for 30 min. A control solution was prepared by mixing 3 mL of 96% ethanol with 1 mL of DPPH solution and homogenized using a vortex. The soap sample was dissolved in 96% ethanol at five serial dilutions: 5, 10, 15, 20, and 25 mg/mL. *Sargassum polycystum* powder was dissolved at five concentrations: 1, 2, 3, 4, and 5 mg/mL. The soap solution and powder were centrifuged at 3000 rpm for 10 min each. Three milliliters of each filtrate was added to 1 mL of DPPH solution and homogenized by vortexing. The control and sample solutions were incubated for 30 min in the dark to determine their free radical-scavenging efficiency. The absorbance of the samples was measured using a UV-Vis spectrophotometer at a wavelength of 517 nm. The absorbance values of each solution were recorded, and the percentage inhibition was calculated using the following formula:

$$\text{DPPH inhibition activity (\%)} = \frac{A_0 - A_1}{A_0} \times 100$$

where:

A₀ = absorbance of control

A₁ = absorbance of sample

The percent inhibition data from various sample concentrations were used to construct a linear regression curve between the sample concentration (x-axis) and percent inhibition (y-axis). The resulting linear regression equation was used to determine the antioxidant value, expressed as the IC₅₀ value, which is the sample concentration required to scavenge 50% of the DPPH free radicals.

Data Analysis

The research data were analyzed using one-way analysis of variance (ANOVA) at a 95% confidence level. Prior to ANOVA, the data were tested for normality using the Shapiro-Wilk test and for homogeneity of variances using Levene's test. All data met the assumptions of ANOVA. If significant differences were found between treatments, Duncan's multiple range test (DMRT) was used using SPSS Statistics 25 software (IBM Corp., Armonk, NY, USA), under a licensed copy provided by the Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia.

RESULTS AND DISCUSSION

Physical Characteristics of Scrub Soap

Physical characteristics are essential indicators of soap quality and consumer acceptability of the product. This study evaluated three key physical parameters: hardness, foam stability, and color of the samples. The addition of *S. polycystum* powder is expected to influence these physical properties in different ways. The physical characteristics of the scrub soap in terms of hardness value, foam stability, and the color parameter are shown in Table 2.

The results showed that the addition of *S. polycystum* powder had varying effects on the soap's physical characteristics. The soap hardness value ranged from 16.38 to 20.99 N, while the foam stability was in the range of 80.46–82.75%. Contrary to the lack of a significant effect on foam stability, the hardness values progressively increased

with increasing *S. polycystum* powder concentration. Although the DMRT analysis indicated no statistically significant difference ($p>0.05$) between treatments, the numerical trend suggests that the powder particles may have contributed to a denser soap matrix. This observation is noteworthy and warrants further investigation. Saputri *et al.* (2022) studied transparent soap with salak skin extract and reported hardness values ranging from 1.47–2.01 N, which is substantially lower than that observed in the present study. This indicates that the cold saponification method with palm oil as the primary oil base in this study produced inherently harder soaps. Similarly, Widyasanti and Hasna (2016) reported hardness values of 0.45–0.75 N for coconut oil-based transparent soap, which is again much lower than our findings. The higher hardness values in the present study (16–21 N) reflect the formulation's use of a higher proportion of palm oil and the cold saponification method, which typically produces denser and harder soaps compared to hot process methods. The slight increase in hardness with *S. polycystum* powder addition, although not statistically significant, may be attributed to the physical reinforcement provided by the powder particles, which could increase the density and compactness of the soap matrix. This mechanism is consistent with the findings of Nandani *et al.* (2021), who observed that solid particles can influence the physical structure of the soap. To date, there are no specific provisions or standards for assessing the hardness of soap.

An important observation from the hardness data is the non-linear response at

Table 2 Effect of *Sargassum polycystum* powder on the hardness, foam stability, and color characteristics (L, a*, b*) of scrub soap

Addition of <i>S. polycystum</i> (%)	Hardness (N)	Foam stability in 5 minutes (%)	Color characteristics		
			L	a*	b*
0	16.41±2.99 ^a	82.35±1.13 ^a	76.27±0.84 ^d	1.13±0.03 ^a	14.25±0.73 ^c
2	16.38±2.06 ^a	82.75±0.48 ^a	61.79±0.19 ^c	2.21±0.02 ^b	15.22±0.65 ^c
4	17.35±0.28 ^a	81.56±1.56 ^a	52.39±0.53 ^b	2.92±0.05 ^c	12.17±0.50 ^b
6	20.99±2.93 ^a	80.46±1.38 ^a	44.74±0.86 ^a	3.46±0.04 ^d	9.64±0.54 ^a

Note: numbers followed by different letters in the same column indicate a significant difference ($p<0.05$)



the 2% treatment level. The hardness at 2% (16.38 ± 2.06 N) was nearly identical to that of the control (16.41 ± 2.99 N), suggesting that a low concentration of *S. polycystum* powder (2%) was insufficient to induce a measurable change in soap hardness. This plateau effect at low powder concentrations is common in formulation studies. This phenomenon can be explained by the concept of a 'threshold concentration,' below which the added material does not significantly alter the physical properties of the matrix. At 2%, the powder particles may have been too dispersed within the large soap matrix to create a significant reinforcement effect.

Only at higher concentrations (4% and 6%) did the cumulative effect of the powder particles sufficiently increase the soap density and hardness. This observation is supported by Nandani *et al.* (2021), who noted that the effect of solid additives on soap properties is concentration-dependent and may exhibit a threshold response. Similarly, Viani *et al.* (2024) reported that the incorporation of stabilizers in soap formulations exhibited a nonlinear dose-response relationship, with minimal effects at low concentrations and more pronounced effects at higher concentrations. Additionally, the variability in the 2% treatment (standard deviation of ± 2.06 N) was comparable to that in the control (± 2.99 N), suggesting that at this low concentration, the natural variation inherent in the cold saponification process may have masked any subtle effects of the powder addition. These findings underscore the importance of testing multiple concentration levels in formulation studies, as the relationship between additive concentration and product properties is not always linear.

Although there are no specific Indonesian national standards (SNI) that prescribe a mandatory hardness range for solid soap, the hardness values obtained in this study are comparable to those reported in similar studies. Saputri *et al.* (2022) reported hardness values of 14.5–22.3 N for transparent soap formulations, whereas Widyasanti & Hasna (2016) noted that solid coconut oil-based soaps typically exhibit hardness values

between 15 and 25 N. Soaps with a harder texture are generally more resistant to damage and deformation than those with softer textures (Saputri *et al.*, 2022). Hard and dense soaps have a longer shelf life than softer soaps (Widyasanti & Hasna, 2016). The hardness values obtained in this study fell within the acceptable range reported in the literature, indicating that the scrub soap formulations possessed adequate structural integrity for practical use.

The addition of *S. polycystum* powder up to 6% tended to reduce the stability of the soap foam. This phenomenon was also reported by Baehaki *et al.* (2019) in soap making with the addition of *Eucheuma cottonii*, with a foam stability of 42.77–74.41%, and by Papatungan *et al.* (2023) in scrub soap with *Eucheuma spinosum* powder, which showed foam stability values of 73.33–82.22%. The decrease in foam stability is attributed to the fiber content in seaweed. This is also supported by Haryanto *et al.* (2023), who found that solid particles in the form of coffee can reduce the thickness of the thin layer on the foam, resulting in a decrease in the stability of the surfactant foam. These results are consistent with the opinion of Nandani *et al.* (2021), who stated that increasing the concentration of solid materials will cause the resulting foam stability to decrease. Regarding standard benchmarks, the Indonesian National Standard SNI 3532:2021 does not specify a minimum requirement for foam stability in solid soap; however, a foam stability value above 60% is generally considered acceptable in the cosmetic industry (Pangestika *et al.*, 2021). All formulations in this study exceeded this threshold value.

The addition of *S. polycystum* powder had no significant effect ($p > 0.05$) on foam hardness and stability (Table 2). The absence of significant differences in these two parameters indicates that the addition of powder up to a concentration of 6% was insufficient to structurally change the soap matrix. The powder particles dispersed in the soap did not disrupt the interactions between surfactant molecules that play a role in foam formation and stabilization and did not drastically change the soap density (Viani *et al.*, 2024).

In contrast, the addition of *S. polycystum* powder significantly affected soap color (Table 2). The data showed a decrease in brightness (L) and an increase in redness (a) with increasing the powder concentration. This may be due to the natural pigments in brown seaweed, such as fucoxanthin and phaeophytin, which impart a dark brownish color to the final product (Jesumani *et al.*, 2019). The higher the concentration of the powder, the more dominant the pigment in influencing the soap color. To date, no standard has determined the ideal color value range for soap. Arifiani (2022) reported the best color value for *Sargassum* sp. liquid scrub soap with L^* of -59.39, a^* , and b^* values of -59.39, 1.40, and 1.81, respectively. Soap color is subjective and depends on the formulation and consumer preference for the desired product type. In the industry, measuring color values can be used to maintain consistency between production batches so that the resulting product color is uniform and in accordance with established standards. The colors of the soap for each formula are shown in Figure 1.

The decrease in the L^* values (from 76.27 for the control to 44.74 for the 6% treatment) indicates the progressive darkening of the soap with increasing powder concentration, reflecting the accumulation of brown pigments from *S. polycystum*. Simultaneously, the increase in a^* values (from approximately 1.40 for the control to higher values at 6% treatment) indicates a shift toward the red spectrum, consistent with the brownish coloration imparted by fucoxanthin and phaeophytin. This linear trend in L^* and a^* is well documented for seaweed-based cosmetic products. Paputungan *et al.* (2023) reported

that scrub soap with *E. spinosum* showed similar progressive darkening with increasing seaweed powder concentration, confirming that this is a characteristic response of seaweed-based formulations. Similarly, Wadu *et al.* (2023) reported consistent darkening patterns in solid soap made from *E. spinosum* at different concentrations.

Notably, the b^* parameter showed a non-linear response, with values at 2% treatment higher than the control, followed by a decrease at 4 and 6% treatments. This fluctuating pattern warrants careful interpretation. The initial increase in b^* at 2% (indicating a shift toward yellow) may reflect the early stage of pigment incorporation, where yellow-toned compounds, such as carotenoids, become more prominent relative to the darker brown pigments. However, as powder concentration increased to 4 and 6%, the b^* values decreased, suggesting that the darker brown pigments (fucoxanthin and phaeophytin) became increasingly dominant, shifting the overall color perception away from yellow toward brown. This phenomenon can be explained by the differential solubility and distribution of various pigment classes within the soap matrix. Brown algae contain multiple pigment types, with fucoxanthin (a xanthophyll) being the most prominent, masking other pigments such as chlorophyll-a and carotenoids (Micó-Vicent *et al.*, 2021). At low concentrations (2%), yellow-toned carotenoids may be more evenly distributed and visible. At higher concentrations (4-6%), the accumulation of darker pigments created a masking effect, reducing the perception of yellow tones and resulting in lower b^* values. This masking phenomenon is well documented

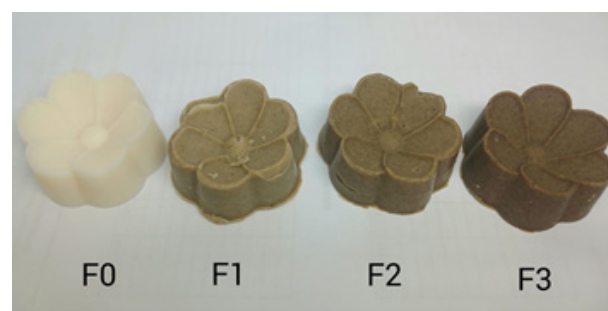


Figure 1 The color of the scrub soap for each formula



in natural colorant research, where pigment concentration and composition can create nonlinear color responses (Faulkner, 2021). The b^* parameter is particularly important in this study, as it reflects the balance between yellow pigments (carotenoids) and brown pigments (fucoxanthin and phaeophytin) in the final product. The decrease in b^* at higher concentrations indicates that the brown pigments progressively dominated the color profile, which is desirable for creating a visually appealing, uniformly colored scrub soap product.

The progressive darkening of the soap color with increasing *S. polycystum* powder concentration is consistent with observations from other seaweed-based soap formulations. Paputungan *et al.* (2023) reported similar trends in their study on scrub bath soap with the addition of *E. spinosum* algae powder, where the incorporation of seaweed powder resulted in darker, more brownish-colored products compared to the control soaps. Similarly, Wadu *et al.* (2023), in their study on the quality of solid bath soap made from *E. spinosum* at different concentrations, observed that increasing seaweed powder concentration led to progressive darkening of the soap product. These consistent findings across different seaweed species (*Sargassum* and *Eucheuma*) and research groups suggest that the darkening effect is a general characteristic of seaweed-based soap formulations. The mechanism underlying this color change is the natural pigment content of the seaweed, which includes carotenoids, chlorophyll derivatives, and other chromophoric compounds that accumulate as the powder concentration

increases. This consistency with other seaweed soap studies strengthens the validity of the color results obtained in the present study and demonstrates that the color change is a predictable and reproducible effect of seaweed powder addition to soap formulations.

Chemical Characteristics of Scrub Soap

The chemical characteristics of soap are critical determinants of its quality, safety, and efficacy in personal care applications. These parameters provide insights into the composition, stability, and functional properties of the formulated products. The following section presents the chemical analysis results, including free fatty acid (FFA) content, pH, water content, and ethanol-insoluble matter, which were systematically evaluated across all the treatment groups. The addition of *S. polycystum* powder significantly affected all the tested chemical parameters (Table 3).

The pH of the resulting soap was 10.62 ± 0.00 to 10.64 ± 0.01 , with a control soap pH of 10.66 ± 0.00 . This pH value is still included in the range set by SNI 3532-2021, namely 6-11 (BSN, 2021). Increasing the concentration of *S. polycystum* powder tended to decrease the pH of the scrub soap. This is consistent with the results of Wadu *et al.* (2023), who studied solid scrub soap with the addition of *E. spinosum* seaweed. The decrease in pH can occur because seaweed contains acidic phenolic compounds (Baehaki *et al.*, 2019; Sobuj *et al.*, 2024). The moisture content of the scrub soap with the addition of *S. polycystum* powder ranged from 7.78 ± 0.47

Table 3 Effect of *Sargassum polycystum* powder addition on pH, moisture content, ethanol-insoluble substances, free fatty acids, and antioxidant activity of scrub soap

Addition of <i>S. polycystum</i> (%)	pH	Moisture content (%)	Ethanol-insoluble substances (%)	Free fatty acid (%)	IC ₅₀ of DPPH (ppm)
0	10.66 ± 0.00^c	7.01 ± 0.49^a	1.21 ± 0.06^a	1.11 ± 0.03^a	$25,104.07 \pm 2,334.74^c$
2	10.64 ± 0.01^b	7.78 ± 0.47^a	4.30 ± 0.14^b	1.19 ± 0.10^{ab}	$20,759.08 \pm 1,885.57^b$
4	10.63 ± 0.01^{ab}	10.20 ± 0.38^b	5.80 ± 0.25^c	1.33 ± 0.03^{bc}	$18,010.15 \pm 965.43^{ab}$
6	10.62 ± 0.00^a	10.62 ± 0.78^b	8.36 ± 0.19^d	1.35 ± 0.12^c	$17,383.47 \pm 1,274.24^a$

Note: numbers followed by different letters in the same column indicate a significant difference ($p < 0.05$)

to $10.62 \pm 0.78\%$. This moisture content still meets the maximum water content criteria set by SNI 3532-2021, which is 23% (BSN, 2021). The addition of *S. polycystum* powder increased the water content of soap. Baehaki et al. (2019) reported similar results for solid scrub soap with added seaweed. The increase in water content can occur because the polysaccharides in *Sargassum* absorb and retain water (Jesumani et al., 2019). The hydroxyl and sulfate ester groups in polysaccharides can form hydrogen bonds with water molecules and maintain water content (Li et al., 2017).

Soap with the addition of 2% *S. polycystum* powder had the lowest value of insoluble substances in ethanol (4.30 ± 0.14), while the highest value was with the addition of 6% *S. polycystum* powder (8.36 ± 0.19). This value still meets the criteria set by SNI 3532-2021, which is 10% (BSN, 2021). The higher the concentration of *S. polycystum* powder, the higher the value of insoluble substances in ethanol in the soap. Papatungan et al. (2023) reported the same phenomenon when *E. spinosum* powder was added. This is thought to be influenced by two categories of compounds in seaweed powder that are poorly soluble in ethanol: (1) non-polar compounds such as chlorophyll a and carotenoids, which are hydrophobic and therefore insoluble in the polar ethanol solvent; and (2) the ionic compound NaCl (naturally present in seaweed), which, despite being polar, has limited solubility in ethanol because of the low dielectric constant of ethanol compared to that of water (Papatungan et al., 2023).

The lowest free fatty acid value of the scrub soap was found with the addition of 2% *S. polycystum* ($1.19 \pm 0.10\%$), and the highest with the addition of 6% *S. polycystum* powder ($1.35 \pm 0.12\%$). This value is still within the safe limit of free fatty acids for solid soap set by SNI 3532-2021, which is a maximum of 2.5% (BSN, 2021). Increasing the concentration of *S. polycystum* powder increased the free fatty acid value in the scrub soap. These results are consistent with those of Papatungan et al. (2023), who reported that the fatty acid content in soap with the addition of *E. spinosum* powder was higher than that in soap

without the addition of *E. spinosum* powder. High water content can increase free fatty acid levels due to the hydrolysis of triglycerides with water (Pambayun & Broto, 2023). The presence of water can trigger a hydrolysis reaction, in which the water breaks down triglycerides into free fatty acids and glycerol, increasing the acid number and accelerating the oil degradation process (Utami et al., 2025). According to the results of measuring the water content in *S. polycystum* scrub soap, the higher the powder concentration, the higher the water content. Therefore, to prevent triglyceride hydrolysis, it is necessary to control the water content in soap, for example, by selecting materials with low water content and storing the soap in dry conditions.

This study revealed a significant increase in the antioxidant activity of scrub soap with the addition of *S. polycystum* powder (Table 4). The IC_{50} value decreased from 25,104.07 ppm (control) to 17,383.47 ppm (6% treatment), indicating a progressive improvement in antioxidant activity with increasing powder concentrations. According to conventional classification, these IC_{50} values indicate weak antioxidant activity. However, it is crucial to interpret these results within the context of a finished cosmetic product rather than a pure extract. The antioxidant activity of *S. polycystum* powder alone was much stronger, with an IC_{50} value of 354.21 ppm.

The significant reduction in the antioxidant potency of the final soap product compared to that of the raw powder can be attributed to several interrelated factors. First, the alkaline conditions of the cold saponification process ($pH > 12$ during NaOH reaction) can cause the degradation of phenolic compounds and other antioxidant molecules through oxidation and structural modification in high-pH environments (Mahardani & Yuanita, 2021). Second, the dilution effect of the soap matrix, comprising oils, water, and NaOH, substantially reduces the concentration of active compounds per unit mass of the final product. Third, the DPPH assay measures the antioxidant activity of compounds that are soluble and accessible in the test medium. In the soap matrix, some bioactive compounds may be physically



entrapped within the soap structure and are therefore not fully accessible to DPPH radicals during the assay. Fourth, the interaction between phenolic compounds and fatty acids or glycerol produced during saponification may form complexes that reduce the effective antioxidant capacity of the product (Sobuj *et al.*, 2024). Despite this reduction, the fact that *S. polycystum* bioactives remain functional after the harsh alkaline conditions of saponification is a significant finding, highlighting its robustness as a cosmetic ingredient.

It is important to note that the antioxidants in *S. polycystum* powder are not chemically extracted in the traditional sense before soap incorporation. Instead, the powder is directly added to the soap matrix, and the bioactive compounds—primarily phenolics, fucoxanthin, and other polyphenols—are released from the powder matrix during use via mechanical abrasion and contact with water. During the DPPH assay, the soap samples were dissolved in 96% ethanol, which served as a solvent to extract and solubilize the antioxidant compounds from the soap matrix for measurement. This ethanol-based dissolution effectively releases polar phenolic compounds from the powder embedded in the soap, allowing their antioxidant capacity to be quantified (Mahendran *et al.*, 2021).

Although the contact time of soap with the skin is brief, the presence of these antioxidants can provide a protective barrier against oxidative stressors during washing. Research suggests that topical antioxidants can neutralize free radicals on the skin surface, potentially mitigating damage even with short exposure (Pillai *et al.*, 2005). Compared to other natural scrub soaps, such as coffee scrub soap, which has reported IC_{50} values of approximately 30,000 ppm (Sari *et al.*, 2022) and solid soap enriched with *Eucheuma cottonii* extract with IC_{50} values of approximately 45,000 ppm (Trilaksani *et al.*, 2023), the antioxidant performance of the *S. polycystum* soap is promising.

However, the incorporation of *S. polycystum* powder presents regulatory challenges. The ethanol-insoluble matter for treatments with 2%, 4%, and 6% powder (4.30%, 5.80%, and 8.36%, respectively) were

all within the maximum limit of 10% set by SNI 3532:2021 (BSN, 2021), as was the control treatment (1.21%). Therefore, all formulations comply with the SNI standard. In scrub soap formulations, insoluble particles serve a dual purpose: they function as mechanical exfoliants while remaining within regulatory compliance. This demonstrates that functional scrub soaps enriched with seaweed powder can be developed while maintaining full compliance with the Indonesian national standards.

Considering all the evaluated parameters, the formulation with 6% *S. polycystum* powder (F3) was identified as the best overall formulation. This formulation yielded the highest antioxidant activity ($IC_{50}=17,383.47$ ppm), the most pronounced color change indicative of higher pigment content, and all chemical parameters (pH, water content, free fatty acids) were within the limits prescribed by SNI 3532:2021. Although the ethanol-insoluble substance content of F3 (8.36%) exceeded the SNI limit for conventional soap, this was attributable to the intentionally added functional exfoliant particles, which are not impurities. The hardness and foam stability of F3 were comparable to those of the control and other treatments, confirming that the addition of 6% powder did not compromise the physical integrity of the soap. Therefore, F3 represents an optimal balance between functional antioxidant performance and acceptable physical and chemical quality.

CONCLUSION

The addition of *S. polycystum* powder significantly enhanced the antioxidant activity and affected the color, pH, water content, ethanol-insoluble substances, and free fatty acid content of the scrub soap, while maintaining compliance with SNI 3532:2021. The 6% formulation exhibited the highest antioxidant activity ($IC_{50}=17,383.47$ ppm) and was identified as the best overall formulation. These findings demonstrate the potential of *S. polycystum* as a functional ingredient in cosmetic products, suggesting that seaweed-based scrub soaps can be developed with enhanced bioactivity and regulatory compliance.

ACKNOWLEDGMENT

The author would like to express his gratitude to the Department of Fisheries, Faculty of Agriculture, Universitas Gadjah Mada for providing the facilities necessary for this research. This paper is part of the first author's thesis.

REFERENCES

- Akbar, D. S., Sunarwidhi, A. L., & Muliastari, H. (2022). Aktivitas antibakteri ekstrak *Sargassum polycystum* dari pantai Batu Layar, Nusa Tenggara Barat. *Indonesia Natural Research Pharmaceutical Journal*, 7(2), 97–107. <https://doi.org/10.31771/inrpj.v7i2.295>
- Arifiani, A. (2022). Pengaruh penambahan ekstrak *Sargassum* sp. dengan konsentrasi berbeda terhadap kualitas mutu sabun cair. [Skripsi]. Universitas Diponegoro.
- Astuti, I. (2018). Pengaruh penambahan lemak biji kakao (*Theobroma cacao* L.) apkir pada karakteristik sabun padat aroma kayu manis. [Skripsi]. Universitas Gadjah Mada.
- Aznury, M., Zikri, A., Ningsih, A. S., Margaretty, E., Agriani, L., Indriani, I., & Rachmadona, N. (2022). Production of solid soap with addition of green betel leaf (*Piper betle* L.) extract and left lemon extract (*Cymbopogon nardus* L. rendle) as antioxidants. *Atlantis Highlights in Engineering*, 5(1), 148–157. <https://doi.org/10.2991/ahe.k.220205.026>
- Baehaki, A., Lestari, S. D., & Hildianti, D. F. (2019). The utilization of seaweed *Eucheuma cottonii* in the production of antiseptic soap. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 22(1), 143–154. <https://doi.org/10.17844/jphpi.v22i1.25891>
- [BSN] Badan Standardisasi Nasional. (2021). SNI 3532:2021. Sabun mandi padat. Jakarta: Badan Standardisasi Nasional.
- Fanani, Z., Panagan, A. T., & Apriyani, N. (2020). Uji kualitas sabun padat transparan dari minyak kelapa dan minyak kelapa sawit dengan antioksidan ekstrak likopen buah tomat. *Jurnal Penelitian Sains*, 22(3), 108–118. <https://doi.org/10.56064/jps.v22i3.600>
- Febriani, A., Syafriana, V., Afriyanto, H., & Djuhariah, Y. S. (2020, October 28–29). The utilization of oil palm leaves (*Elaeis guineensis* Jacq.) waste as an antibacterial solid bar soap [Conference session]. The 9th International Symposium for Sustainable Humanosphere, Bogor, Indonesia. IOP Conference Series: Earth And Environmental Science, 572(1), 1–10. <https://doi.org/10.1088/1755-1315/572/1/012038>
- Faulkner, E. B. (2021). Coloring the cosmetic world: Using pigments in decorative cosmetic formulations. Springer Publishing.
- Haryanto, B., Tambun, R., Sinulingga, E. P., Bukit, R. B., Tarigan, K., & Gulo, N. (2023). Foam stability of local surfactant on the presence contaminant Cd ions, coffee and oil in solution. *ARPJ Journal of Engineering and Applied Sciences*, 18(1), 35–40.
- Hawa, L. C., Bahari, A. N., & Lastryanto, A. (2022). Characterization of physicochemical properties of solid laundry soap based on lerak (*Sapindus rarak* Dc.). *Jurnal Teknologi Pertanian*, 23(2), 139–150. <https://doi.org/10.21776/ub.jtp.2022.023.02.5>
- Husni, A., Izmi, N., Ayunani, F. Z., Kartini, A., Husnayain, N., & Isnansetyo, A. (2022). Characteristics and antioxidant activity of fucoidan from *Sargassum hystrix*: effect of extraction method. *International Journal of Food Science*, 3689724, 1–9 <https://doi.org/10.1155/2022/3689724>
- Jalaluddin, Zulnazri, Ibrahim, I., Hakim, L., & Daulay, S. H. (2023). Proses pembuatan sabun padat dengan proses saponifikasi melalui reaksi minyak jarak dan vco dengan NAOH dan menambahkan bubuk coklat (*Theobroma cacao* L.). *Jurnal Teknologi Kimia Unimal*, 12(1), 23–33. <https://doi.org/10.29103/jtku.v12i1.11611>
- Jesumani, V., Du, H., Pei, P., Zheng, C., Cheong, K. L., & Huang, N. (2019). Unravelling property of polysaccharides from *Sargassum* sp. as an anti-wrinkle and skin whitening property. *International*



- Journal of Biological Macromolecules*, 140, 216-224. <https://doi.org/10.1016/j.ijbiomac.2019.08.027>
- [KKP] Kementerian Kelautan dan Perikanan. (2024). Profil pasar rumput laut. Kementerian Kelautan dan Perikanan.
- Li, J., Chi, Z., Yu, L., Jiang, F., & Liu, C. (2017). Sulfated modification, characterization, and antioxidant and moisture absorption/retention activities of a soluble neutral polysaccharide from *Enteromorpha prolifera*. *International Journal of Biological Macromolecules*, 105, 1544-1553. <https://doi.org/10.1016/j.ijbiomac.2017.03.157>
- Mahardani, O. T., & Yuanita, L. (2021). Efek metode pengolahan dan penyimpanan terhadap kadar senyawa fenolik dan aktivitas antioksidan. *Unesa Journal of Chemistry*, 10(1), 64-78. <https://doi.org/10.26740/ujc.v10n1.p64-78>
- Mahendran, S., Maheswari, P., Sasikala, V., Rubika, J. J., & Pandiarajan, J. (2021). In vitro antioxidant study of polyphenol from red seaweeds dichotomously branched *Gracilaria edulis* and robust sea moss *Hypnea valentiae*. *Toxicology Reports*, 8, 1404-1411. <https://doi.org/10.1016/j.toxrep.2021.07.006>
- Maulina, S., Suhendra, L., & Gunam, W. B. I. (2018). Karakteristik bubuk alga coklat (*Sargassum polycystum*) pada perlakuan ukuran bahan dan suhu pengeringan. *Jurnal Rekayasa Manajemen Agroindustri*, 6(1), 1-10. <https://doi.org/10.24843/JRMA.2018.v06.i01.p01>
- Michalak, M., Pierzak, M., Kręcis, B., & Suliga, E. (2021). Bioactive compounds for skin health: a review. *Nutrient*, 13(1), 203. <https://doi.org/10.3390/nu13010203>
- Micó-Vicent, B., Perales Romero, E., Bermejo, R., & Martínez-Verdú, F. (2021). Using laminar nanoclays for phycocyanin and phycoerythrin stabilization as new natural hybrid pigments from microalgae extraction. *Applied Sciences*, 11(24), 1-23. <https://doi.org/10.3390/app112411992>
- Muti'ah, N., Muliawati, E. S., & Suryaningrum, D. A. (2022). Produksi sabun alami dari lidah buaya dan temu giring dengan metode cold process. *Journal of Applied Agriculture, Health, and Technology*, 1(2), 43-53. <https://doi.org/10.20961/jaht.v1i2.481>
- Nandani, R., Arif, M. R., Purwati, E., & Safitri, C. I. N. H. (2021, 27 Mei). Formulasi dan uji mutu fisik sediaan sabun padat herbal ekstrak daun ubi jalar ungu (*Ipomea batatas* L) dengan penambahan madu. Seminar Nasional Pendidikan Biologi dan Saintek VI, Surakarta. Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek), 453-459.
- Nazarudin, M. F., Alias, N. H., Balakrishnan, S., Hasnan, W. N. I., Mazli, W. N. A. I., Ahmad, M. I., & Aliyu-Paiko, V. (2021). Chemical, nutrient and physicochemical properties of brown seaweed, *Sargassum polycystum* C. Agardh (phaeophyceae) collected from Port Dickson, Peninsular Malaysia. *Molecules*. 26(5216), 1-16. <https://doi.org/10.3390/molecules26175216>
- Nurhidayati, L. G., Rejeki, D. S., & Fauziah, S. N. N. (2024). Formulasi dan evaluasi sediaan body scrub bunga telang (*Clitoria ternatea* L.) dan sabut kelapa (*Cocos nucifera* L.) sebagai antioksidan. *Jurnal Mandala Pharmacon Indonesia*, 10(2), 697-706. <https://doi.org/10.35311/jmpi.v10i2.573>
- Pambayun, F., & Broto, R. W. (2023). The effect of moisture content on reducing the free fatty acid content of nyamplung seed oil (*Callophylum inophyllum*) using factorial design method. *Journal of Vocational Studies on Applied Research*, 5(1), 31-35. <https://doi.org/10.14710/jvsar.v5i1.17619>
- Pangestika, W., Abrian, S., & Adauwiyah, R. (2021). Pembuatan sabun mandi padat dengan penambahan ekstrak daun *Avicennia marina*. *Jurnal Teknologi Agro-Industri*, 8(2), 135-153. <https://doi.org/10.34128/jtai.v8i2.146>
- Paputungan, F., Momuat, L. I., & Suryanto, E. (2023). Quality and antioxidant activity of scrub bath soap with addition of *Eucheuma spinosum* algae powder. *Jurnal Ilmiah Sains*, 23(1), 55-64. <https://doi.org/10.35799/jis.v23i1.48540>

- Pillai, S., Oresajo, C., & Hayward, J. (2005). Ultraviolet radiation and skin aging: roles of reactive oxygen species, inflammation and protease activation, and strategies for prevention of inflammation-induced matrix degradation - a review. *International Journal of Cosmetic Science*, 27(1), 17-34. <https://doi.org/10.1111/j.1467-2494.2004.00241.x>
- Rejeki, D. S., Istriningsih, E., & Wulandari, P. S. (2025). Physical characteristics and antibacterial activity of solid soap containing banana peel extract (*Musa acuminata* Colla) against *Staphylococcus aureus*. *Journal of Chemistry Sciences and Education*, 2(01), 10-20. <https://doi.org/10.69606/jcse.v2i01.171>
- Saputri, R. K., Al-Bari, A., & Nisak, S. C. (2022). Pengaruh basis minyak terhadap karakteristik dan daya bersih sabun transparan ekstrak kulit salak (*Salacca zalacca*). *Medical Sains: Jurnal Ilmiah Kefarmasian*, 7(2), 245-254. <https://doi.org/10.37874/ms.v7i2.311>
- Sari, L. P., Swastawati, F., & Rianingsih, L. (2022). Karakteristik fisikokimia dan aktivitas antioksidan sabun mandi padat dengan penambahan bubuk kopi robusta (*Coffea canephora*). *Jurnal Pengolahan Hasil Perikanan Indonesia*, 25(2), 235-245. <https://doi.org/10.17844/jphpi.v25i2.41321>
- Sidana, J., Singh, B., & Sharma, O. P. (2016). Saponins of agave: chemistry and bioactivity. *Phytochemistry*, 130, 22-46. <https://doi.org/10.1016/j.phytochem.2016.06.010>
- Sobuj, M. K. A., Shemul, M. S., Islam, M. S., Islam, M. A., Mely, S. S., Ayon, M. H., & Rafiquzzaman, S. M. (2024). Qualitative and quantitative phytochemical analysis of brown seaweed *Sargassum polycystum* collected from Bangladesh with its antioxidant activity determination. *Food Chemistry Advances*, 4(100565), 1-9. <https://doi.org/10.1016/j.focha.2023.100565>
- Trilaksani, W., Salamah, E., & Nurjanah, N. (2023). Antioxidant activity of solid soap enriched with crude *Eucheuma cottonii* extract. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 26(1), 45-56. <https://doi.org/10.17844/jphpi.v26i1.42150>
- Utami, E. A., Nizar, U. K., & Etika, V. (2025). Peningkatan pemurnian minyak jelantah melalui sistem adsorben ganda: bleaching earth dan karbon dari kulit buah kakao (*Theobroma cacao* L.). *Jurnal Pendidikan dan Sains*, 5(3), 1368-1392. <https://doi.org/10.58578/masaliq.v5i3.6039>
- Viani, S. C., Putranti, J. A., Jelau, K., & Wrsiati, L. P. (2024). Characteristics of solid soap in the treatment of adding tween 80 stabilizer. *Jurnal Rekayasa dan Manajemen Agroindustri*, 12(2), 263-272. <https://doi.org/10.24843/JRMA.2024.v12.i02.p10>
- Wadu, L. G., Meiyasa, F., & Ndahawali, S. (2023). Kajian mutu sabun mandi padat rumput laut *Eucheuma spinosum* dengan konsentrasi yang berbeda. *Marinade*, 6(02), 1-10. <https://doi.org/10.31629/marinade.v5i02.4949>
- Widyasanti, A., & Hasna, A. H. (2016). Kajian pembuatan sabun padat transparan basis minyak kelapa murni dengan penambahan bahan aktif ekstrak teh putih. *Jurnal Penelitian Teh dan Kina*, 19(2), 179-195. <https://doi.org/10.22302/pptk.jur.jptk.v19i2.102>
- Yansen, F., & Humaira, V. (2022). Uji mutu sediaan sabun padat dari ekstrak lidah buaya (*Aloe vera*). *Jurnal Kesehatan Perintis*, 9(2), 82-88. <https://doi.org/10.33653/jkp.v9i2.883>