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Characteristics of Jelly Candy Made from Eucheuma cottonii Seaweed

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A B S T R A C T

Jelly candy is a sweet confectionery product typically consumed as a snack. This study used whole Eucheuma cottonii seaweed without added carrageenan because it focuses on developing functional food-based jelly candy products. This study aims to determine how the proportions of E. cottonii seaweed puree and spirulina affect the characteristics of the resulting jelly candy. This study used a completely randomized design (CRD) with two factors: Factor I, the proportion of *E. cottonii* seaweed puree (50:50, 60:40, 70:30), and Factor II, spirulina (0.5 g; 1 g; 1.5 g). The data obtained were analyzed using ANOVA, followed by a DMRT post-hoc test at the 5% significance level. The optimal formulation was achieved with a 70:30 ratio of *E. cottonii* seaweed puree to *Spirulina platensis* (1.5 g). This treatment produced jelly candy with a moisture content of 35.41%, ash content of 2.45%, crude fiber content of 1.13%, reducing sugar content of 4.16%, and a chewiness value of 52.03 N.

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

1. INTRODUCTION

1.1. Research Background

Jelly candy is a semi-moist foods made from a mixture of sugar, fruit juice, and gelling agents, and have a clear and transparent appearance [1]. It is classified as functional food products that are popular among various groups due to their chewy texture, sweet taste, and attractive appearance, as well as their convenience [2]. It can be produced in a wide variety of colors, shapes, and flavors, which increases their appeal to the public [3].

Jelly candy is high in calories because it is made primarily from sugar, water, and fructose syrup [4]. Commercial candy made with artificial sweeteners or containing very high sugar levels can have adverse health effects [5]. Therefore, one approach to product innovation is to incorporate natural ingredients that provide health benefits. Through this approach, the functional value of jelly candy can be enhanced so the product serves not only as a sweet snack but also provides beneficial components.

In jelly candy manufacturing, hydrocolloid components such as gelatin, pectin, agar, gum, carrageenan, and starch are added to modify texture, resulting in a chewy jelly candy texture [6]. Both pectin and carrageenan are pure extracts; while effective, their manufacturing processes can reduce certain compounds. Therefore, this study utilized an alternative ingredient that not only functions as a gelling agent but also contributes to overall health: the seaweed species *Eucheuma cottonii*.

Seaweed is a leading commodity in aquaculture and has been utilized across various industries, ranging from food and pharmaceuticals to medicine and cosmetics [7]. One of the most common processed seaweed products is carrageenan, which uniquely regulates viscosity [8]. The carrageenan contained in seaweed can function as a stabilizer, thickener, and gelling agent, thereby influencing the characteristics of food products, particularly jelly candy [9].

Eucheuma cottonii seaweed is also a food source rich in nutrients, such as amino acids and pigments, but it contains a relatively high amount of crude fiber [10]. The dietary fiber content of *Eucheuma cottonii* seaweed reaches 65.5%, consisting of 39.47% insoluble dietary fiber and 26.03% soluble dietary fiber, making *E. cottonii* seaweed a promising candidate for a healthy food ingredient [11]. High-fiber jelly candy is beneficial for aiding digestion, helping maintain a healthy weight, are rich in vitamins, and help nourish the skin due to their high amino acid content [12]. Consumer demand for functional foods is currently growing rapidly. Most consumers believe the foods they eat can positively affect their health [13].

This study used whole Eucheuma cottonii seaweed without added commercial carrageenan because it focuses on developing functional food-based jelly candy products. Whole seaweed contains bioactive components such as fiber, polyphenols, and minerals that are no longer present in pure carrageenan due to the intensive purification process. In addition, whole seaweed also provides added value through the utilization of local commodities without the need for complex extraction processes. Although commercial carrageenan has stronger gelling properties, this study emphasizes the natural gelling characteristics of whole seaweed and its interaction with Spirulina; therefore, no additional gelling agents were used. This study utilized *E. cottonii* seaweed puree as a source of natural fiber and hydrocolloids that contribute to gel formation and can enhance the functional value of jelly candy.

Variations in the proportion of *E. cottonii* seaweed puree with added spirulina can affect the final characteristics and functional content of the resulting jelly candy. Therefore, this study developed jelly candy based on *Eucheuma cottonii* seaweed puree with added spirulina to produce jelly candy that are not only organoleptically appealing but also have functional value.

1.2. Literature Review

1.2.1 Jelly Candy

Jelly candy is a type of confectionery, also known as soft candy, that is consumed as a snack. Jelly candy is semi-solid and made from sugar or a mixture of sugar and sweeteners. They are food products with a chewy texture due to gelling agents [14]. Jelly candy is a convenient snack enjoyed by people of nearly all age groups [15]. Jelly candy is high in calories and made primarily from sugar, water, and fructose syrup. It has a soft texture and is processed with hydrocolloid components such as agar, gum arabic, pectin, starch, carrageenan, gelatin, and others to modify its texture, making it chewy and easy to mould before packaging [17].

Jelly candy has a soft texture and are made from fruit juice with the addition of gelatin, agar, gum, pectin, starch, or carrageenan. It is clear and transparent in color and has a chewy texture [18]. The main ingredients used in making jelly candy include pectin as a thickener, sugar as a sweetener, and organic acids as preservatives. In addition, jelly candy production typically uses a reversible gelling agent, meaning that when the gel is heated, it turns into a liquid and, when cooled, reforms into a gel. Gelatin is a commonly used gelling agent [12].

1.2.2 Eucheuma cottonii

Seaweed is Indonesia's primary non-fish fishery product, and the country ranks second in the world in seaweed production after China [18]. The utilization of seaweed as a raw material is supported by Indonesia's geographical conditions, as 70% of its territory consists of marine areas; consequently, the country's seaweed resources are abundant and readily accessible. One type of seaweed with great potential for development is *E. cottonii* [19]. In the food industry, seaweed is used as a thickener, stabilizer, and gelling agent in processed food products and as a nutritional supplement [20].

Eucheuma cottonii seaweed is a food source rich in nutrients, such as amino acids and pigments, but it contains a relatively high amount of crude fiber [10]. Research results show that *E. cottonii* contains 76.15% moisture, 5.62% ash, 2.32% protein, 0.11% fat, 15.8% carbohydrates; 83.2% total dietary fiber; and 65.7% carrageenan, along with bioactive compounds consisting of flavonoids, phenols, and triterpenoid hydroquinones [22]. *E. cottonii* contains 12.66 mg GAE/g of phenolics [23] and 35.1771 mg QE/g of flavonoids [24]. Meanwhile, according to [11], the dietary fiber content of the seaweed *Eucheuma cottonii* reaches 65.5%, consisting of 39.47% insoluble dietary fiber and 26.03% soluble dietary fiber. Seaweed has excellent nutritional value, including high levels of minerals and vitamins, making it very beneficial for the body.

1.2.3 Spirulina platensis

Spirulina platensis is a microalga with a bluish-green color [25], containing the pigment cyanophysin (bluish-green). Chemical analysis shows that *Spirulina platensis* contains 3–7% essential minerals. These minerals come from the growth medium and are influenced by the medium's concentration, pH, temperature, and salinity [26]. Spirulina's mineral content includes sodium, chloride, potassium, calcium, phosphorus, chromium, copper, iron, magnesium, manganese, selenium, and zinc. Amino acids commonly found in spirulina protein include essential amino acids such as methionine (1.3–2.75%), cysteine (0.5–0.75%), tryptophan (1–1.95%), and lysine (2.6–4.63%). These components offer great potential for spirulina to be utilized as a functional food product [27].

1.3 Research Objective

This study aims to analyze the effect of the proportion of *Eucheuma cottonii* seaweed puree and the addition of *Spirulina platensis* on the characteristics of jelly candy.

2 MATERIALS AND METHODS

2.2 Materials

This study used *Eucheuma cottonii* seaweed, water, *Spirulina platensis* powder, sugar, glucose syrup, and citric acid.

2.3 Jelly Candy Production Process

The process for making *E. cottonii* seaweed puree followed [28]. The seaweed was first cleaned of impurities, then blanched for 5 minutes. Researchers cut larger pieces of seaweed to make blending easier. Researchers added water to the seaweed according to the treatment variations—namely, 50:50, 60:40, and 70:30—and blended the mixture until a seaweed puree was obtained.

The jelly candy was made using a modified method from [28] and [29]. The seaweed puree was mixed with 20 g of granulated sugar and 15 g of glucose syrup, then heated and

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stirred in one direction for 5 minutes until thickened. Afterward, 0.5 g of citric acid and spirulina powder were added according to the treatment variations, namely 0.5 g, 1 g, and 1.5 g. The seaweed puree was left to stand at room temperature for 10 minutes and then stored in the refrigerator for 24 hours. The solidified seaweed puree was molded and dried using a food dehydrator at 60°C for 6 hours.

2.4 Treatment and Experimental Design

This study used a completely randomized design (CRD) with two factors: Factor I, the proportion of *E. cottonii* seaweed puree (50:50, 60:40, 70:30); and Factor II, spirulina (0.5 g; 1 g; 1.5 g).

2.5 Chemical Analysis

The analyses conducted in this study included moisture content analysis using the thermogravimetric method, ash content analysis using the oven-drying method, crude fiber content analysis using the enzymatic method, reducing sugar content analysis using the Nelson-Somogyi method, and texture (chewiness) analysis using a Lloyd Texture Analyzer.

2.6 Statistical Analysis

The data obtained were analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level for results showing significant differences.

3 RESULT AND DISCUSSION

The results of the chemical analysis of the jelly candy, including moisture content, ash content, crude fiber content, reducing sugar content, and texture, are presented in **Table 1.**

Notes:
A (Proportion of seaweed puree)
B (Spirulina concentration

Tabel 1. Results of the Chemical Analysis of Jelly Candy

Sample	Moisture (%)	Ash (%)	Crude Fiber (%)	Reducing Sugar (%)	Texture (N)
A1B1	$24.41^{a} \pm 0.33$	1.16±0.05	0.35±0.09	3.26 ± 0.88	38.38±0.64
A1B2	$30.14^{b} \pm 0.67$	1.14±0.21	0.44±0.13	3.36 ± 0.36	27.20±0.56
A1B3	$31.53^{c} \pm 0.38$	1.24±0.09	0.49±0.18	3.18 ± 0.22	31.49±0.46
A2B1	$35.83^{de} \pm 0.79$	1.47±0.27	0.34±0.15	3.49 ± 0.15	35.02±2.56
A2B2	$33.05^{ef} \pm 0.46$	1.55±0.24	0.44±0.24	3.87 ± 0.13	45.07±0.19
A2B3	$33.84^{f} \pm 0.08$	1.66±0.16	0.63±0.18	4.12 ± 0.37	43.08±0.00
A3B1	$36.16^{f} \pm 0.98$	1.95±0.08	0.76±0.04	3.46 ± 0.22	50.49±4.53
A3B2	$34.85^{f} \pm 0.05$	2.14±0.03	0.98±0.01	3.02 ± 0.03	58.11±4.34
A3B3	$35.41^{f} \pm 0.40$	2.45±0.23	1.13±0.17	4.16 ± 0.16	52.03±4.11

3.2.1 Moisture Content

The results of the analysis of variance (ANOVA) and post-hoc tests indicated a significant interaction ($p \leq 0.05$) between the combination of *Eucheuma cottonii* seaweed puree proportions and the addition of spirulina on the moisture content of the jelly candy product, as indicated by different letter codes. Based on **Table 1**, jelly candy moisture content ranged from 24.41% to 36.16%. The lowest moisture content was observed in the treatment with a 50:50 ratio of *E. cottonii* seaweed puree and 0.5 g of spirulina, at 24.41% (A1B1), while the highest moisture content was observed in the 70:30 seaweed ratio with the addition of 0.5 g of spirulina, at 36.16% (A3B1). Generally speaking, as the proportion of seaweed puree increases—especially when combined with added spirulina—the moisture content of the product also increases. Differences in the moisture content of these two ingredients affect how much water the product absorbs and retains, thereby influencing the final moisture content of the jelly candy.

Eucheuma cottonii contains carrageenan, which has the ability to bind and retain water (water-holding capacity) through the formation of a three-dimensional gel network. This three-dimensional structure traps water molecules, making it harder for water to be released during drying. Therefore, the higher the proportion of seaweed puree, the greater the product's ability to retain water, resulting in a tendency for the product's moisture content to increase [30]. Spirulina contains bioactive components and polysaccharides with hydroxyl (-OH) groups, enabling it to interact with water molecules through hydrogen bonds and improve its water-retention capacity.

All treatments resulted in higher moisture content compared to the standard moisture content for jelly candy according to SNI 3547.2:2008, which is a maximum of 20%. This high moisture content is due to the ability of carrageenan in seaweed to retain water during the drying process. The carrageenan content in seaweed can absorb more water than gelatin. The high moisture content in jelly candy is caused by ingredients containing too much water or too low a concentration of dissolved solids, resulting in a weak consistency. Insufficient gel-forming consistency prevents the structure from effectively retaining the sugar solution, leading to syneresis in the candy and high moisture content [31].

3.2.2 Ash Content

The results of the analysis of variance (ANOVA) showed no interaction effect on the ash content of the jelly candy; however, there were significant differences ($p \leq 0.05$) among the treatments involving the proportion of *E. cottonii* seaweed puree. Each treatment, rather than their combination, primarily influenced the increase in ash content. **Table 1** shows that as ash content increases, so does the product's mineral content [32]. The average ash content of the jelly candy ranged from 1.18% to 4.35%. The lowest ash content (1.14%) was observed in the jelly candy with a seaweed puree ratio of 50:50 and the addition of 1 g of spirulina (A1B2). The highest ash content, 2.45%, was observed in the treatment with a seaweed puree ratio of 70:30 and the addition of 1.5 g of spirulina (A3B3).

Treatments with varying proportions of *Eucheuma cottonii* seaweed puree showed a significant increase in ash content. This is because seaweed has a relatively high mineral content—including calcium, potassium, and magnesium—which contributes significantly to inorganic residue. Ash content reflects the concentration of inorganic substances, such as minerals, in a food product [21]. According to [33], variations in the ash content of jelly candy are caused by the inorganic compound content in the raw materials used. Seaweed is a food ingredient with a relatively high mineral content because it has the ability to absorb minerals from its environment.

Jelly candy with the highest proportion of seaweed puree tended to have high moisture and ash contents. This is because seaweed contains hydrocolloids that bind water along with the minerals present in it [28]. The average ash content of jelly candy products made with the highest proportion of seaweed puree and spirulina addition was lower than the SNI 3547.2:2008 quality requirement, which is a maximum of 3%.

3.2.3 Crude Fiber Content

The results of the analysis of variance (ANOVA) showed that there was no interaction ($p > 0.05$) between the two treatment factors—jelly candy—but there was a significant effect ($p \leq 0.05$) of the *Eucheuma cottonii* seaweed puree treatment and the addition of spirulina. The changes in crude fiber content were primarily influenced by each treatment individually, rather than by a combination of the two. The effects of each factor were independent—they did not directly influence one another—meaning that the increase in fiber content due to the addition of seaweed was not affected by the spirulina concentration, and vice versa. Thus, each factor acted independently in influencing the crude fiber content of the jelly candy.

The results of the crude fiber content analysis in **Table 1** show that as the proportion of seaweed used increases, so does the crude fiber content of the jelly candy. The lowest crude fiber content was observed in the treatment with a 60:40 puree ratio and the addition of 1 g of spirulina, equivalent to 0.34% (A2B1). Meanwhile, the highest crude fiber content was observed in the treatment with a 70:30 seaweed puree ratio and the addition of 1.5 g of spirulina, equivalent to 0.79% (A3B3). Crude fiber content increased with an increase in the seaweed puree proportion. This is because *Eucheuma cottonii* seaweed contains dietary fiber and hydrocolloids (carrageenan), which contribute to the increase in fiber content. [24] noted that seaweed is a marine product with a high fiber content.

3.2.4 Reducing Sugar Content

The analysis of variance (ANOVA) results showed no interaction ($p > 0.005$) and no significant difference between seaweed puree and spirulina proportions in the reducing sugar content of the jelly candy. Based on **Table 1**, reducing sugar values did not show an upward or downward trend with increasing treatment concentration, whether in seaweed puree proportions or spirulina addition. The lowest reducing sugar content was observed in the 70:30 seaweed puree treatment with 1 g of spirulina added, at 3.02% (A3B2), while the highest was observed in the 70:30 seaweed puree treatment with 1.5 g of spirulina added, at 4.16% (A3B3).

Reducing sugar content was more influenced by sweetener composition (glucose syrup) and jelly candy processing method than by seaweed proportion or spirulina addition. Furthermore, neither raw material is a primary source of simple sugars; therefore, increasing their concentrations did not significantly raise reducing sugar content. According to the literature in [34], reducing sugars are simple sugars that can react during heating; therefore, their amount is more influenced by processing conditions and the type of sugar used. Although values varied among treatments, these changes did not significantly affect quality.

The average reducing sugar content of the jelly candy products was higher than the quality standard specified in SNI 3547.2:2008—a maximum of 3%—and therefore did not meet the quality requirements for reducing sugar content in jelly candy. The reducing sugar content is largely influenced by the use of glucose syrup during manufacturing. In this study, 20 g of sucrose (granulated sugar) was used as a sweetener, and 15 g of glucose syrup was used to control the texture of the jelly candy.

3.2.5 Texture (Chewiness)

The results of the analysis of variance (ANOVA) showed that there was a significant interaction ($p \leq 0.05$) between the proportion of *E. cottonii* seaweed puree and the concentration of spirulina added on the texture of the jelly candy; however, there was a significant difference ($p \leq 0.05$) only in the treatment involving the proportion of *Eucheuma cottonii* seaweed puree on the texture of the jelly candy, while the addition of spirulina showed no significant difference.

Based on **Table 1**, the higher the proportion of *E. cottonii* seaweed puree, the higher the texture value. The lowest texture value was observed in the jelly candy with a 50:50 seaweed puree ratio and the addition of 1 g of spirulina, at 27.20 N (A1B2), while the highest value was observed in the 70:30 seaweed puree treatment with the addition of 1 g of spirulina, at 58.11 N (A3B2). In this study, the seaweed puree ratio largely influenced the chewiness of the jelly candy, whereas spirulina concentration alone did not have a significant effect. The results of a study by [35] showed that the use of *Eucheuma cottonii* can affect the textural characteristics of jelly candy because the gelling components in seaweed play a role in forming the gel structure.

Texture is a key attribute in determining the quality and acceptability of jelly candy. The chewiness value is used to determine the energy required to chew a jelly candy until it is ready to be swallowed. Chewiness is one of the secondary parameters in Texture Profile Analysis (TPA) related to the product's mechanical characteristics, namely hardness, cohesiveness, and springiness. Therefore, a higher chewiness value indicates that more energy is required to chew the product.

4 CONCLUSION

The results showed a significant interaction ($p \leq 0.05$) between the treatment of *E. cottonii* seaweed puree proportions and the addition of spirulina on moisture content and texture (chewiness). However, for the parameters of ash content, crude fiber content, and reducing sugar content, there was no significant interaction ($p \geq 0.05$).

The best treatment for the jelly candy was obtained in sample A3B3, where *E. cottonii* seaweed puree with the addition of 1.5 g of spirulina resulted in a moisture content of 35.41%, an ash content of 2.45%, a crude fiber content of 1.13%, a reducing sugar content of 4.16%, and a chewiness value of 52.03 N.

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