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THE EFFECT OF ADDITIONAL SEAWEED FLOUR (*Eucheuma cottonii*) ON THE QUALITY OF CATFISH (*Clarias* sp.) ROULADE

Pengaruh Penambahan Tepung Rumput Laut (*Eucheuma cottonii*) Terhadap Mutu Rolade Ikan Lele (*Clarias* sp.)

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ABSTRACT

Catfish (*Clarias* sp.) is a popular freshwater fish that contains higher protein than some types of animal meat. Seaweed (*Eucheuma cottonii*) has high nutritional content such as minerals and fiber. The high nutritional content of *Eucheuma cottonii* as a potential functional food source in the development of food products, one of which is processed into seaweed flour which is added to catfish rolade products. The objectives of this study were to analyze the quality of dried seaweed and fresh catfish, process seaweed flour and catfish rolade and analyze the quality of seaweed flour and catfish rolade, and determine the selected formula. The results of sensory tests of dried seaweed raw materials were 8, CAW 59,65%, and water content 34,19%, Organoleptic value of fresh catfish 9. The results of seaweed flour water content 6,39%, ash content 24,52%, fat content 0,24%, protein content 2,72%, carbohydrate 66,13%, crude fiber 22,21% and and around 360,27 mPa s. The results of catfish rolade with the addition of *E. cottonii* flour included water content 65,90%, ash content 2,90%, fat content 2,84%, protein content 17,79%, carbohydrate 10,57%, crude fiber 0,56%, ALT 5.21 x 10^1 kol/g, and physical test hardness 6562,99 gf. The selected formula is catfish roulade with the addition of 3,5% *E. cottonii* seaweed flour.

Keywords: Catfish Roulade, Crude Fiber, *Eucheuma cottonii*, Seaweed Flour

ABSTRAK

Ikan lele (*Clarias* sp.) merupakan salah satu ikan air tawar populer yang mengandung protein lebih tinggi daripada beberapa jenis daging hewan. Rumput laut (*Eucheuma cottonii*) memiliki kandungan gizi yang tinggi seperti mineral dan serat. Tingginya kandungan gizi *Eucheuma cottonii* sebagai sumber pangan fungsional yang potensial dalam pengembangan produk pangan, salah satunya diolah menjadi tepung rumput laut yang yang ditambahkan pada produk rolade ikan lele. Tujuan dari penelitian ini yaitu, melakukan analisis mutu rumput laut kering dan ikan lele segar, melakukan pengolahan tepung rumput laut dan rolade ikan lele dan menganalisis mutu tepung rumput laut dan rolade ikan lele, serta menentukan formula terpilih. Hasil uji sensori bahan baku rumput laut kering sebesar 8, CAW 59,65%, dan kadar air 34,19%, Nilai organoleptik ikan lele segar 9. Hasi kadar air tepung rumput laut 6,39%, kadar abu 24,52%, kadar lemak 0,24%, kadar protein 2,72%, karbohidrat 66,13%, serat kasar 22,21% dan dan viskositas 360,27 mPa·s. Hasil rolade ikan lele dengan penambahan tepung *E. cottonii* meliputi kadar air 65,90%, kadar abu 2,90%, kadar lemak 2,84%, kadar protein 17,79%, karbohidrat 10,57%, serat kasar 0,56%, ALT 5,21 x 10^1 kol/g, dan uji fisik kekerasan 6562,99 gf. Formula terpilih yaitu rolade ikan lele dengan penambahan tepung rumput laut *E. cottonii* 3,5%.

Kata Kunci: *Eucheuma cottonii*, Serat Kasar, Rolade Ikan, Tepung Rumput Laut

INTRODUCTION

Catfish (*Clarias* sp.) is a popular freshwater fish among Indonesians. Indonesians generally prefer catfish due to its soft texture and vitamin-rich meat (Christiand *et al*., 2022). According to Tarigan *et al*., (2023), catfish contain higher and better protein compared to animal meat. The nutritional value of catfish increases when processed properly, making catfish have high market demand. Based on statistical data from the Ministry of Marine Affairs and Fisheries (2023), the production volume of aquaculture for catfish farming in Indonesia reached 1,136,618.98 tons. Despite the high potential for sales and consumption of catfish, there are culled catfish, amounting to up to 10% in each production cycle, and these culled catfish are unsold in the market, thus harming farmers (Asriani *et al*., 2021). According to Norhayani *et al*., (2017), processing fish into various types of products is an effort to diversify fishery products. One example of a product resulting from fisheries diversification is fish roulade.

Fish roulade is a processed product made from ground fish meat mixed with flour or starch, with the addition of spices and other ingredients, wrapped in a thin omelet, rolled in aluminum foil or banana leaves, and then steamed (Sanditya *et al*., 2023). Currently, many beef or chicken roulades contain low or no fiber (Erti *et al*., 2025). Lifestyles, especially unbalanced and low-fiber diets, can lead to an unhealthy digestive system, thus seriously impacting our health (Hemawati, 2021). Therefore, one potential source of fiber to be developed is seaweed.

Seaweed produces hydrocolloids, for example, carrageenan, derived from the red seaweed species Eucheuma cottonii (Nurjanah *et al*., 2021). Hydrocolloids are water-soluble polymer components that can form colloids and gels from a solution. The characteristics of hydrocolloids can be utilized as gelling agents, thickeners, emulsifiers, adhesives, stabilizers, and film formers (Herawati, 2018). Given the many benefits of seaweed, it presents a good opportunity to combine it with fish roulade. Generally, all types of fish can be used as raw materials for making fish roulade, but considering that discarded catfish is an economical fish rich in nutrients, it makes it the primary choice as a raw material. The addition of seaweed is one effort to increase its utilization in the functional addition of fiber and gelling in fish roulade.

RESEARCH METHODS

Time and Place

This research was conducted from January to April 2025 at the AUP Jakarta Polytechnic Workshop for making catfish roulade and testing was carried out at the Sensory, Microbiology, and Chemistry Laboratory of AUP Jakarta Polytechnic, as well as the Research Center for Marine and Fisheries Product Processing and Biotechnology. The raw material of dried seaweed *E. cottonii* was taken from the Paria Laut area, Mappakasunggu District, Takalar

Regency-South Sulawesi. The culled catfish were taken from ponds in the Ciangsana area, Gunung Putri District, Bogor City-West Java.

Tools and Materials

The tools used for making fish roulade include, plastic containers, cutting boards, knives, Philips brand meat grinders, Philips brand spice blenders, steamer pans, Teflon (GM Bear Mini Frypan 16 cm), spoons, cake pans, spatulas, Vibra brand digital scales, Rinnai brand 2-burner stoves and LPG gas. The tools used for making seaweed flour include, Memmert brand water baths with bath dimensions of 350x290x140 mm, Iwaki brand beakers, plastic containers with holes, pH meters (Sanxin), cutting boards, knives, Mammert brand ovens and oven slings, grinder machines (Mill powder tech, 1200 W, 110-220V), spoons and 100 mesh sieves.

The ingredients used to make fish roulade include discarded catfish, dried seaweed (*Eucheuma cottonii*), tapioca flour, sago flour, garlic and shallots, chicken eggs, pepper, salt, water, cornstarch, cooking oil, banana leaves, and 7C mica plastic. The ingredients used to make seaweed flour include potassium hydroxide (KOH), distilled water, water, and baking paper.

Research Procedures

This study used a Completely Randomized Design (CRD) method, starting with organoleptic tests on raw catfish and dried seaweed, water content, and *Clean Anhydrous Weed*. Seaweed flour samples were tested for proximate, crude fiber content, and physical tests (viscosity). Next, fish roulade was made with the addition of seaweed flour at different concentrations and tested for proximate, crude fiber, physical tests (hardness), microbiological tests (ALT), and hedonic tests.

Making seaweed flour

The process of making seaweed flour using the ATC (*Alkali Treated Carrageenophyte*) or (*Alkali Treated* Cottonii) method refers to Andriani, (2007) begins by preparing 100 grams of dried seaweed raw material and then washing it first to remove salt and other dirt contained in the seaweed.

Then the seaweed is boiled in a 1000 mL KOH solution with a concentration of 6% that has been preheated to a temperature of 80°C, the seaweed is then soaked in the KOH solution for 2 hours. The seaweed is then neutralized again by repeated washing with clean water until neutral (pH 7). After the seaweed pH is neutral, the seaweed is then cut into pieces of 4-5 cm and dried for 2 days in an oven at a temperature of 50-60°C to obtain ATC in the form of chips. The ATC in the form of chips is then ground and filtered into ATC flour using a 100 mesh sieve. The process flow for making seaweed flour can be seen in Figure 1.

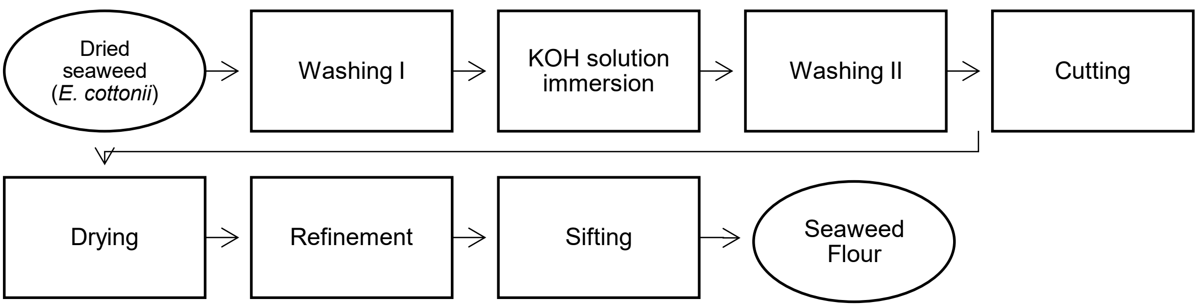

Figure 1. Process flow for making seaweed flour

Making fish roulade

The process of making fish roulade refers to Ayuningtyas *et al*., (2021) who made roulade from modified tilapia. The determination of the formulation of the addition of seaweed flour refers to Yudiastuti *et al*., (2022) who made seaweed vegetable meatballs with *E. cottonii* flour concentrations of 0.5%, 1.0%, 1.5%, 2.0% and 2.5%. The best concentration from this study was *Eucheuma cottonii* flour 1.5%. Further research from Widyastutik, (2020) who made milkfish tofu meatballs fortified with E. cottonii seaweed flour concentrations of 1%, 2%, 3%, 4% and 5%. The best concentration in this study was milkfish tofu meatballs fortified with E. cottonii seaweed flour concentration of 2%. This is the basis for this research to use formulations of 0%, 1.5%, 2.5% and 3.5% with the same type of seaweed but with different end products.

The formulation for catfish roulade with seaweed flour was determined by reducing the tapioca and sago flour compositions and substituting them with seaweed flour. The seaweed flour content was increased by 0, 1.5, 2.5, and 3.5%, calculated based on the weight of the catfish used. The modified seaweed flour formulation for catfish roulade is shown in Table 1.

Table 1 Formulation for making fish roulade

Material	Formulation (g)			
	F0	F1	F2	F3
1) Roll dough				
Catfish fillet	100	100	100	100
Tapioca flour	6	5,25	4,75	4,25
Sago flour	6	5,25	4,75	4,25
Seaweed flour	-	1,5	2,5	3,5
Red onion	5,6	5,6	5,6	5,6
Garlic	5,6	5,6	5,6	5,6
Chicken eggs	13	13	13	13
Ground pepper	1	1	1	1
Salt	1,5	1,5	1,5	1,5
2) Roll skin				
Chicken eggs	30	30	30	30
Cornstarch	7	7	7	7
Water	10	10	10	10

Organoleptic test of fresh catfish and sensory of dried seaweed

Organoleptic testing of raw materials was conducted in accordance with SNI 2729:2021 on Fresh Fish (BSN, 2021). Sensory testing was conducted using the senses to assess the quality of dried seaweed, which refers to SNI 2690:2023 on Dried Seaweed (BSN, 2023).

Chemical test

The quality standard of *Clean Anhydrous Weed* (CAW) *E. cottonii* refers to SNI 2690:2023, which is a minimum of 50%. The CAW testing procedure refers to SNI 8168:2015 concerning Determination of CAW in Dried Seaweed (BSN, 2015). The water content testing refers to SNI 2354.2:2015 concerning Testing of Water Content in Fishery Products (BSN, 2015). The ash content testing refers to SNI 2354.1:2010 concerning Determination of Ash and Acid-Insoluble Ash Content in Fishery Products (BSN, 2010). The fat content testing refers to SNI 2354.3:2017 concerning Determination of Total Fat Content in Fishery Products using the Soxhlet method (BSN, 2017). The protein content test refers to SNI 01-2354.4:2006 concerning

Determination of Protein Content Using the Total Nitrogen Method (BSN, 2006). Carbohydrate analysis uses the by-difference method. The fiber content test follows SNI 01-2891-1992 (BSN, 1992) which refers to (Widyastutik, 2020).

Physical test

The viscosity test refers to Pumpente & Palawe, (2020). Viscosity measurements were carried out using a Brookfield TV-10 viscometer using 33 Spindle No. 4 at a speed of 60 rpm.

The hardness test refers to SNI 2372.6:2009 Physical Test Methods – Part 6: Determination of Pasta Quality in Fishery Products (BSN, 2009). The cooled sample was cut into cubes measuring 2.5 cm in length, width, and height. The sample was placed on a testing plate so that it was directly under the probe. The probe was operated with Texture Analyzer software. The probe speed for pressing the sample was 1.1 mm/s.

Total Plate Count (TLC) Test

The ALT test refers to SNI 2332.3:2015 concerning Determination of Total Plate Number in Fishery Products (BSN, 2015).

Hedonic test/preference level

The hedonic test of catfish roulade with the addition of seaweed flour was carried out using the hedonic test parameters of SNI 8504-2018: Meat Rolade which includes color, aroma and taste using a 5-point hedonic scale (1 = very dislike, 2 = dislike, 3 = neutral, 4 = like, 5 = very like) which refers to Ananda et al., (2024). The test was carried out by 30 untrained panelists. The fish roulade tested hedonically was fish roulade with 4 different formulations, namely, F0 = 0%, F1 = 1.5%, F2 = 2.5% and F3 = 3.5%.

RESULTS

Quality of Raw Materials

Dried seaweed sensory

Sensory testing was conducted on dried seaweed raw materials visually using a dried seaweed sensory test scoresheet based on SNI 2690:2023. The results of the dried seaweed sensory test can be seen in Table 2.

Table 2 Results of sensory tests of dried seaweed

Observation	Sensory Value	SNI 2690:2023
1	8	
2	8	Min. 7
3	8	

Clean Anhydrous Weed (CAW*) rumput laut kering*

CAW testing was conducted on dried seaweed raw materials based on SNI 8168:2015. The CAW test results can be seen in Table 3.

Table 3 Results of CAW test of dried seaweed

Observation	CAW (%)	SNI 2690:2023
1	59,11	
2	60,48	Min. 50%
3	59,37	
Average	59,65 ± 0,73	

Water content of dried seaweed

Moisture content is the amount of water contained in a material expressed as a percentage (Saraswati *et al*., 2022). Moisture content testing was conducted on dried seaweed raw materials based on SNI 2354.2:2015. The results of the dried seaweed moisture content can be seen in Table 4.

Table 4 Results of the water content test of dried seaweed

Observation	Water content (%)	SNI 2690:2023
1	34,45	Maks. 38%
2	33,99	
3	34,24	
Aaverage	34,19 ± 0,18	

Organoleptic of fresh catfish

Organoleptic testing was conducted visually on fresh catfish raw materials using a fresh fish organoleptic test scoresheet based on SNI 2729:2021. The results of the organoleptic test of fresh catfish can be seen in Table 5.

Table 5 Results of organoleptic tests of fresh catfish

Observation	Organoleptic value	SNI 2729:2021
1	9	Min. 7
2	9	
3	9	

Seaweed flour quality

According to Dwijayanti *et al*., (2023), proximate analysis is an analysis conducted to determine the chemical composition of a material, including analysis of water content, ash content, protein content, fat content, carbohydrate by difference, and crude fiber content. The results of the chemical analysis of seaweed flour can be seen in Table 6.

Table 6 Results of chemical analysis of seaweed flour

Chemical quality	Results (%)	FAO JECFA, (2014)	SNI 7688:2022
Water content	6,39 ± 0,09	-	Maks. 12%
Ash content	24,52 ± 0,22	15-40%	-
Fat content	0,24 ± 0,02	-	-
Protein content	2,72 ± 0,18	-	-
Carbohydrate	66,13 ± 0,32	-	-
Crude Fiber	22,21 ± 0,52	-	-

Viscosity of seaweed flour

A viscosity test is performed to determine the viscosity of a preparation, expressed in centipoises (cP). The higher the viscosity value of a preparation, the higher its viscosity level (Magi, 2020). The results of the seaweed flour viscosity test can be seen in Table 7.

Table 7 Seaweed flour viscosity results

Viscosity (mPa·s)	SNI 7688:2022	(FAO JECFA, 2014)
360,27	Min. 5,0 cP	Min. 5 cP

Information:
100 cP = 100 mPa·s (Hariyadi & Kusnandar, 2018)

The quality of catfish roulade with the addition of seaweed flour

The chemical quality tests conducted included moisture content, ash content, protein content, fat content, carbohydrate by difference, and crude fiber content. The results of the chemical quality test for catfish roulade with seaweed flour addition can be seen in Table 8.

Table 8 Results of chemical quality tests on fish roulade

Formula	Chemical Quality (%)					
	Water content	Ash content	Fat content	Protein content	Carbohydrate	Crude Fiber
F0	68,64±0,48[b]	1,75±0,09[a]	4,20±0,12[d]	17,52±0,06[a]	7,89±0,40[a]	0,09 ± 0,02[a]
F1	67,84±0,9[ab]	2,20± 0,10[b]	3,80±0,05[c]	17,61±0,09[ab]	8,55±0,92[ab]	0,35 ± 0,03[b]
F2	66,95±0,77[ab]	2,45±0,11[c]	3,36±0,09[b]	17,71±0,05[bc]	9,53±0,87[ab]	0,46 ± 0,03[c]
F3	65,90± 0,96[a]	2,90±0,03[d]	2,84±0,10[a]	17,79±0,04[c]	10,57±1,08[b]	0,56 ± 0,02[d]

Information:
The same letters after numbers in the same column indicate no significant difference. (value $p>0,05$)

Hardness test of catfish roulade with added seaweed flour

The principle of measuring food texture with a texture analyzer is to apply a force to the material with a certain magnitude so that the texture profile of the food can be measured (Huidobro *et al*., 2005). The results of the hardness test of catfish roulade with the addition of seaweed flour can be seen in Table 9.

Table 9 Results of the hardness test of fish roulade

Formulas	Violence (g.force)
F0	1588,93[a]
F1	3511,26[b]
F2	5240,30[c]
F3	6562,99[d]

Information:
Different letters after numbers in the same column indicate a significant difference. (value $p<0,05$)

ALT test of fish roll

According to Sukmawati *et al*., (2020), the Total Plate Count (TPL) test is conducted to determine the number of aerobic mesophilic bacteria that may contaminate a product, be it food, beverages, or other products. The results of the TPL test on catfish roulade with the addition of seaweed flour can be seen in Table 10.

Table 10 ALT test results for fish roulade

Formulation	ALT (kol/g)	SNI 8504:2018
F0	$1,52 \times 10^2$	Maks. 1×10^4
F1	$1,22 \times 10^2$	
F2	$7,80 \times 10^1$	
F3	$5,66 \times 10^1$	

Selected products based on hedonic tests

The hedonic test is a widely used instrument to measure consumer preference for food products (Yang & Lee, 2019). The results of the hedonic test for catfish roulade with the addition of seaweed flour can be seen in Table 11.

Table 11 Results of the hedonic test of fish roulade

Formula	Appearance	Aroma	Flavor	Texture	Overall Likes
F0	$4{,}08 \pm 0{,}51^{a}$	$3{,}80 \pm 0{,}48^{a}$	$3{,}53 \pm 0{,}48^{a}$	$3{,}35 \pm 0{,}63^{a}$	$3{,}55 \pm 0{,}49^{a}$
F1	$4{,}14 \pm 0{,}38^{a}$	$3{,}95 \pm 0{,}43^{a}$	$3{,}83 \pm 0{,}37^{b}$	$3{,}85 \pm 0{,}48^{b}$	$3{,}93 \pm 0{,}33^{b}$
F2	$4{,}09 \pm 0{,}30^{a}$	$3{,}98 \pm 0{,}36^{a}$	$3{,}85 \pm 0{,}35^{b}$	$4{,}18 \pm 0{,}41^{c}$	$4{,}15 \pm 0{,}33^{c}$
F3	$3{,}95 \pm 0{,}41^{a}$	$4{,}02 \pm 0{,}43^{a}$	$3{,}84 \pm 0{,}47^{b}$	$4{,}01 \pm 0{,}51^{bc}$	$3{,}94 \pm 0{,}43^{bc}$

Information:
The same letters after numbers in the same column indicate no significant difference (value p>0,05)

DISCUSSION

The sensory test results of dried seaweed obtained a value of 8 in Table 2. This is in accordance with SNI 2690:2023 with a minimum standard value of 7, which means it has met the quality requirements. In the study of Muhammad *et al*., (2024) who used Eucheuma cottonii seaweed with a harvest age of 40 days obtained a value of 8. The sensory value of 8 was obtained from the texture of the thallus which was dry, tough and not easily broken.

The CAW test results of dried seaweed in Table 3, obtained an average of 59.65%, where the results are higher than the minimum CAW standard of 50% in dried seaweed Kappaphycus spp. or Eucheuma cottonii based on SNI 2690:2023. According to Utomo & Satriyana, (2006) CAW or Clean Anhydrous Weed is the percentage of the weight of clean dry seaweed to the original material. This Eucheuma cottonii seaweed has a purity range of 59.11% - 60.48%, while the rest is water and other impurities such as sand, salt, other seaweed and other materials attached to the seaweed.

Based on Table 4, the average moisture content of dried seaweed was 34.19%, which still meets the maximum standard of 38% for dried E. cottonii seaweed. However, this moisture content is higher than the research results of Safia *et al*. (2020) of 23.22% - 38%. According to Safia *et al*. (2020), these differences in seaweed moisture content are partly due to the drying method used.

The organoleptic test results in Table 5 obtained a value of 9, where the standard organoleptic test value in SNI is a minimum of 7, the discarded catfish observed were catfish that had just been killed using ice cubes. This is in accordance with Deni's research, (2015) which stated that the high organoleptic value (9) was caused by the fish having just been caught and had just died, so that all of its organs were still in very good condition (prime). The fresh discarded catfish used in this study had a convex eyeball appearance, clear corneas and pupils, and were shiny, the gills were reddish brown with a little mucus. The mucus on the body surface, the mucus layer was clear, transparent, and shiny. With a very bright meat cut, and strong meat tissue, with a very fresh smell, and a dense and compact texture.

Based on Table 6, the water content of seaweed flour is 6.39%, where the result is in accordance with the maximum standard of 12% for semi-pure carrageenan / Semi Refined Carrageenan (SRC) in SNI 7688:2022 (BSN, 2022). In the study of Dumondor *et al*., (2019) obtained a water content of 6.75% in SRC chips with 8% KOH soaking for 2-3 hours at a temperature of 70°C and drying for 24 hours at a temperature of 50-60°C. Several factors that cause differences in water content are caused by differences in time and the drying process carried out (Masduqi *et al*., 2014). According to Hutasoit *et al*., (2021) the longer the drying, the lower the water content in the material because during the drying process water evaporation occurs which reduces the water content of the material.

The ash content of seaweed flour was 24.52%, which is in accordance with the standard limit of 15-40% set by the FAO. According to Gadore & Ahmaruzzaman (2021), the high ash content is caused by the excessively high salt content in seaweed, which causes an increase in ash content. The longer the seaweed is in the water, the more mineral salts it absorbs. Harun *et al*. (2013) stated that ash content is influenced by the amount of mineral content at the cultivation location and the level of salinity in the waters.

The resulting seaweed flour fat content was 0.24%. This low fat content is due to seaweed being relatively low in fat (Safia *et al*., 2020). The low fat content is due to the fact that seaweed and plants generally store food reserves in the form of carbohydrates, particularly polysaccharides (Yanuarti *et al*., 2017).

The protein content of seaweed flour was 2.72%. During the exponential growth period, algae synthesize more protein for cell wall formation, reducing protein levels and food reserves (Safia *et al*., 2020). Protein levels in a material can vary depending on the species, geographic area, season, or aquatic environmental conditions (Balboa *et al*., 2016).

The carbohydrate content of seaweed flour was 66.13%. According to Safia *et al*. (2020), seaweed carbohydrates are generally found in the form of fiber that cannot be digested by digestive enzymes, thus resulting in low calorie intake, making seaweed suitable for use as a diet food.

Crude fiber is a compound that cannot be hydrolyzed by acids or bases (Korompot *et al*., 2018). The crude fiber test results obtained a result of 22.21%. This result is higher than the research of Lestari, (2019) who obtained crude fiber of 8.75% in E. cottonii seaweed flour by soaking for 3 days in water, and drying in the sun for ± 3 hours. The chemical composition of seaweed depends on the species, growing location, growth stage, and growing conditions of the seaweed (Widyastutik, 2020). The nutritional content of seaweed is influenced by temperature, salinity, and sunlight intensity (Nurjanah *et al*., 2018).

The viscosity test results of seaweed flour in Table 7 obtained a result of 360.27 mPa·s which is still in accordance with the SNI which is a minimum of 5.0 cP and also in accordance with the standards set by FAO which is a minimum of 5 cP. Research by Pratiwi *et al*., (2022) stated that the higher the viscosity value, the higher the gel strength value because the thicker the seaweed flour, the greater the repulsion provided will be the resistance of the gel strength. The high gel strength value in seaweed flour can improve the texture of fish roulade to be more chewy and dense. The viscosity value can be influenced by particle size. The larger the particle size, the lower the viscosity (Sumarni & Sulastri, 2017). This is in accordance with the statement of Feng *et al*., (2017) which states that the viscosity of a polysaccharide is influenced by the molecular weight of the polysaccharide.

Based on Table 8, the results of the water content of catfish roulade with each addition of seaweed flour showed a decrease. It is suspected that the decrease in water content was caused by the ability of seaweed flour to bind water and changes in the form of water in the dough (from free water to water bound in a gel or the phenomenon of syneresis). This is in accordance with the research of Fitriasholikah *et al*., (2022) which stated that carrageenan can bind with proteins in catfish meat to bind water. Safitri *et al*., (2017) also stated that carrageenan in fish meat can increase the ability to bind water. In the study of Saputro *et al*., (2018) who analyzed the effect of carrageenan on dumbo catfish otak-otak, the water content decreased due to the phenomenon of syneresis where water is released from the gel matrix, because carrageenan gel is more prone to syneresis.

The ash content of catfish rolade increased with each addition of seaweed flour. This increase is suspected to be due to the high mineral content in seaweed. According to Tumaya *et al*. (2022), seaweed flour has a high mineral content, which can be in the form of organic and inorganic salts.

The results of the fat content of catfish rolade with each addition of seaweed flour showed a decrease. The decrease in fat content was caused by the low fat content in seaweed flour, which was 0.24%. These results are in accordance with the research of Hastuti, (2019) who analyzed the addition of seaweed flour to dumbo catfish kamoboko which experienced a decrease in fat content because the percentage of seaweed flour added also increased. Research by Afriyanti *et al*., (2017) who analyzed the addition of seaweed flour to patin fish empek-empek showed that the more seaweed flour added, the lower the fat content of empek-empek, this is due to the low fat content of seaweed flour.

The protein content of catfish roulade increased with each addition of seaweed flour. This increase was due to the 2.42% protein content in seaweed flour. These results align with research by Hastuti (2019), who analyzed the addition of seaweed flour to dumbo catfish kamoboko, which found that protein content increased due to the increased percentage of seaweed flour added.

The carbohydrate content of fish roulade increased with the addition of seaweed concentration. This is in accordance with Lekahena's (2015) research, which analyzed yellowfin tuna fish balls with seaweed porridge as a substitute, showing that the substitution of fish meat with seaweed increased the carbohydrate content of the fish balls. The carbohydrate content of yellowfin tuna fish balls increased with the increase in the concentration of seaweed used to replace fish meat in making fish balls. In addition, the carbohydrate content of fish roulade also comes from tapioca flour and sago flour used as binding agents.

Table 8 shows an increase in the crude fiber content of catfish roulade with each addition of seaweed flour. This increase in crude fiber is due to the 22.21% crude fiber content in seaweed flour. These results align with research by Hastuti (2019) which analyzed the addition of seaweed flour to dumbo catfish kamoboko, which found an increase in crude fiber due to the increased percentage of seaweed flour added.

Data from Table 9 shows that the hardness test results for catfish roulade with each addition of seaweed flour showed an increase. This may be due to the increase in hardness caused by the content of seaweed flour such as carrageenan which is able to form a gel. In a study by Hastuti, (2019) who analyzed the effect of adding seaweed flour to catfish kamaboko, it stated that the addition of seaweed flour was able to form a gel. According to Safitri *et al*., (2017) the formation of carrageenan gel is due to its interaction with charged macromolecules such as proteins, so that it can produce various effects such as formation. Carrageenan can improve the bond and texture of the meat binding system, both raw and cooked, with proteins that form complex bonds.

Table 10 shows a decrease in the ALT of catfish rolade with each addition of seaweed flour. This decrease in ALT values may be due to the natural antimicrobial compounds in E. cottonii seaweed, which can inhibit the growth of microorganisms. According to Susanti *et al*. (2024), antibacterials are compounds that can inhibit the growth of certain bacteria. Antibacterials are compounds used to inhibit bacteria. Antibacterials are usually found in organisms as secondary metabolites.

The results in Table 11 show that the appearance of catfish roulade with the addition of seaweed flour has a smooth and flat surface with a pale color with a yellow roulade skin. According to Putri *et al*., (2024) the neutral or pale color is almost the same as the color of the fish meat so it does not greatly affect the final product. The aroma of catfish roulade with the addition of seaweed flour has a dominant aroma of spices or herbs such as shallots and garlic so that the fishy smell of the fish is not strong. The taste of catfish roulade with the addition of seaweed flour has an umami taste, the taste is also influenced by texture. According to Arziyah *et al*., (2022) taste can be determined by taste and mouth stimulation. The texture and consistency of an ingredient will affect the taste produced by the ingredient. For texture, panelists preferred roulade with the addition of a higher concentration of seaweed flour. The results of the hedonic test of fish roulade, seen from the overall preference parameters, obtained an average result of F0 of 3.55, F1 of 3.93, F2 of 4.15 and F3 of 3.94. The selected formula from the hedonic test was F3, seen from the overall preference parameters and by considering the results of chemical and microbiological quality tests.

CONCLUSION

The sensory quality of dried seaweed *E. cottonii* was 8, CAW 59.65% and water content 34.19% and the organolpetic quality of fresh catfish was 9. The quality of seaweed flour included water content 6.39%, ash content 24.52%, fat content 0.24%, protein content 2.72%, carbohydrate 66.13%, crude fiber content 22.21%, viscosity 360.27 mPa·s. The quality of catfish roulade with the addition of seaweed flour includes water content of 65.90 – 68.64%, ash content of 1.75 – 2.90%, fat content of 2.84 – 4.20%, protein content of 17.52 – 17.79%, carbohydrate 7.89 – 10.57%, crude fiber content of 0.09 – 0.56%, hardness test of 1588.93 – 6562.99 gf, and ALT <1 x 104 colonies/g. The selected product of catfish roulade was obtained in F3 with the addition of 3.5% seaweed flour through a hedonic test with an overall preference value of 3.94 ± 0.43 with a protein content of 17.79% and crude fiber of 0.56%.

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