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The Impact of Seaweed (*Eucheuma cottonii*) Fortification and Frozen Storage Conditions on the Chemical Composition of Tuna (*Thunnus albacare*) Sandwich

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tuna is an Indonesian fishery product that is one of the country's primary foreign exchange producers. This research aimed to determine the optimal addition of *Eucheuma cattonii* seaweed and duration of storage at -18^{o}C. (2) The second factor is storage duration at -18^{o}C, with three levels: B1: 0 days (control), B2: 10 days, and B3: 20 days. In the proximate test, the water content, protein content, and lipid content were observed. The analysis of data was performed using SPSS version 12. The addition of 20% seaweed with a 20-day storage period yielded the lowest water content, as determined by the results. The maximum water content was found in the 10% seaweed

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addition treatment. The addition of 30% seaweed and storage for 20 days resulted in the lowest protein content, while the addition of 10% seaweed and storage for 0 days resulted in the highest protein content. The average fat content ranged from 0.7% to 1.14 %, indicating that the maximum fat content of the sandwich product was obtained by storing it at -18°C for 20 days with 10% seaweed. While the treatment of 30% seaweed with extended storage at -18°C or the control had the lowest fat content. The results of the analysis of the effect of adding seaweed and storage time at -18°C on tuna sandwiches indicate that the combination of treatment with the addition of 30% seaweed and storage at -18°C for 20 days can maintain the nutritional value of sandwich products. The tuna sticks with the greatest score on the proximity test.

Keywords: Frozen; seaweed; storage; sandwich.

1. INTRODUCTION

Tuna is one of Indonesia's most important fishery products, not only due to its abundance in Indonesian waters, but also due to its high economic value, as it is one of Indonesia's most important exports to Japan, the United States, and Europe. According to [1], Indonesia ranked first globally in 2014 with 17.8% of the world's total catch of 1.156.480 tonnes of tuna. In 2016, Indonesia produced 525,238 tonnes of tuna, surpassing neighbouring nations such as Vietnam, which produced 123,076 tons, and the Philippines, which produced 143,557 tonnes.

According to Ministry of [2], the tuna commodity was able to generate US$ 659.99 million in export value in 2017 with a total production volume of 198,131 tons, or 16% of the global tuna production. South Sulawesi is one of the production centres for capture fisheries in Indonesia. In 2018, the harvest of commodities (tuna, skipjack, and cob) in South Sulawesi reached 56,292 tonnes and was worth $342,928.

Tuna is susceptible to quality deterioration because it contains protein and a high water content; therefore, efforts are required so that fish can last longer and increase product value; good processing is required in terms of nutrition, durability, and economic value; and making sandwiches is one of these efforts. Sandwiches are typically comprised of two slices of bread filled with meat, vegetables/fruit, and condiment. In fact, sandwiches resemble burgers, but burgers have round buns while sandwiches have square, triangular, and other configurations. Sandwiches, with their small size and portability, are ideal for those who don't want to be fussy about when and where they can consume.

Due to beef's distinct flavor, most sandwiches on the market are made from beef, whereas fish jerky has not been extensively distributed. Because tuna contains protein and other nutrients, it can be used as a raw material for pastrami and can also be processed into processed sandwich products. To make the texture of tuna pieces in sandwiches more elastic and resistant to crushing, it is necessary to add fillers, such as flour [3]

Seaweed is used as an additive in food products and has been reported as an additive used in the production of processed foods that improves their nutritional value and texture [4-8]. According to [9], seaweed is an abundant source of nutrients, including minerals, fatty acids, and free amino acids. *E. cottonii* seaweed is advantageous to the food industry because it generates a primary metabolite of the hydrocolloid compound carrageenan, which functions as a balance regulator, thickener, gelling agent, and emulsifier. No research has ever been conducted on tuna sandwiches with the addition of *Eucheuma cottonii* seaweed. The purpose of this investigation is to determine the characteristics of sandwich tuna (*Thunnus albacares*) with the addition of red seaweed flour (*E. cottonii*) during frozen storage.

2. MATERIALS AND METHODS

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2.1 Materials

Tuna (*Thunnus albacare*) from the waters of Sulawesi is the sandwich's primary ingredient. Tuna sandwiches are composed of seaweed (*Eucheuma cottonii*), plain bread, eggs, tomatoes, and mayonnaise condiment. Aquadest, H2SO4 (Merck), HCl 0.02 N (Merck), K2SO4 (Merck), HgO, NaOH 40% (Merck), and HCL 5 N were used for analysis (Merck).

Fry pans, analytical balances, Kjeldahl flasks, Soxhlet flasks, fat flasks, Erlenmeyer flasks, hot plates, spatulas, beakers, digital scales, dropper pipettes, and measuring containers were used.

2.2 Methods

According to the formulation, tuna is combined with seaweed, after which it is formed, sautéed, and shredded. After preparing the bread, the margarine is heated and the shallots and garlic are sautéed until fragrant. Add tuna, salt, and powdered black pepper. Mix well, then elevate. After the tuna stir fry has cooled, add the mayonnaise sauce and combine well. Make a loaf of wheat bread, Layer three cucumber slices, two tablespoons of tuna mayonnaise, and three tomato segments, then top with a slice of bread. Slice diagonally into 2 equal sections.

2.3 Analysis Data

The research treatment for adding seaweed to tuna sandwich sticks consisted of two levels, namely: The first variable was the production of tuna sandwich pieces containing seaweed, with three levels: A1 = 10%, A2 = 20%, and A3 = 30%. The duration of storage at -18°C comprises three levels: B1 = 0 days (control), B2 = 10 Days and B3 = 20 Days. The parameters to be observed in the proximate test are water content, protein content, and lipid content, which were gathered through data analysis. This investigation employed a completely randomised design (CRD) with three replications of a factorial design. SPSS version 12 was used to analyse the research design.

3. RESULTS AND DISCUSSION

3.1 Moisture of Tuna Sandwich

Extending product shelf life by protecting food from spoilage caused by microorganisms, one of which is inhibiting the growth of microorganisms by reducing the water content and thereby also reducing water activity (water activity) by means of drying, freezing (low temperature also inhibits the growth of microorganisms), adding salt, sugar, thickening, and others [10]. The average value obtained using the heated method (oven) for the analysis of the water content of Tuna Sandwich ranged from 22.86% to 58.55%. The addition of 20% seaweed with a 20-day storage period produced the lowest water content. The maximum water content was observed when 10% seaweed was added without storage (Fig. 1).

In addition to the drying process, the inclusion of seaweed flour can influence the water content of a tuna fish sandwich. The water content of food products is crucial because the higher the water content, the more readily the food product will be damaged and the shorter its shelf life will be. Due to the presence of hydrophilic groups, the capacity of food ingredients to bind water cannot be separated from the participation of proteins. Heating to a temperature of 80°C induces protein gelation, which traps water, thereby increasing the water-holding capacity [11]. The decrease in water content during storage resulted into the nutritional loss of frozen foods. Several factors, including fish species, initial product conditions, chilling speed, and storage conditions, reduce the nutritional value of food [12].

3.2 Protein of Tuna Sandwich

Protein is the primary source of nutrition, specifically as a source of essential amino acids. Protein also contributes significantly to the functional characteristics of dietary products. High biological value proteins have a high proportion of complete amino acid composition and are readily digestible. If one of the essential amino acids is present in the food in insufficient quantities to meet the body's needs, then the other essential amino acids present in the food cannot be used to meet the body's needs. These amino acids endure a deamination reaction, resulting in the excretion of nitrogen through the urine.

The average value of protein content determined using the Protein Content Determination of N-Total Semi Micro Method (Kjeldahl) ranged from 28.86% to 21.56 %; the lowest protein content was achieved by adding 30% sea grass and storing it for 20 days, while the highest protein content was achieved by adding 10% seaweed and storing it for 0 days. The treatment of 30% seaweed with extended storage at -18°C for 20 days contained the least amount of protein. The longer the Tuna Sandwich Stick is stored, the lower the protein content (Fig. 2). This is due to the degradation or hydrolysis of the protein in the Tuna Sandwich Stick, although the decrease in protein content is not excessive. According to [13] freezing has a minimal effect on the protein content. This is evident in the boiling of protein materials, particularly after repeated chilling and thawing. Although the biological value of denatured protein as a food ingredient for humans is not significantly different from that of native protein, the appearance and quality of the food product may be significantly altered by such processes. Animal tissues may undergo proteolysis during freezing storage if their enzymes are not inactivated.

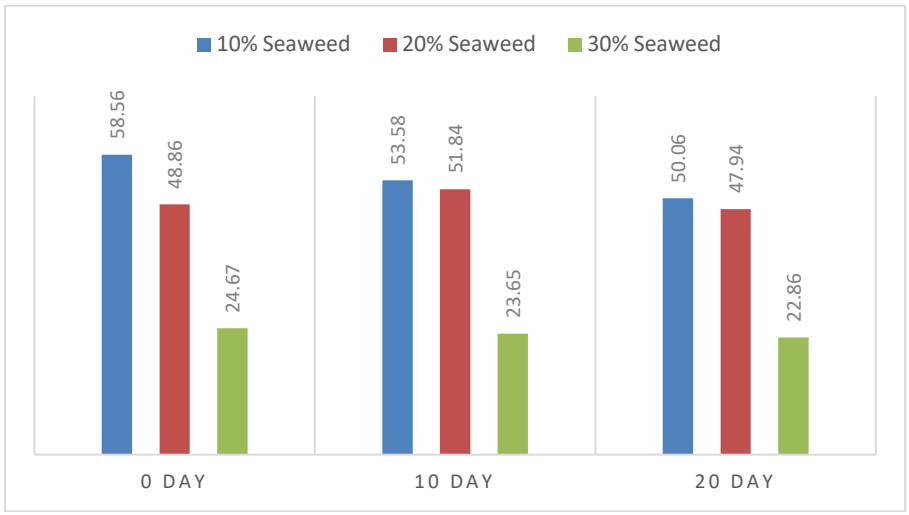

Fig. 1. Comparison of the Concentration of Seaweed (*Eucheuma cottonii*) and Long Storage Time at -18°C to the Moisture Content of Tuna Sandwich Sticks

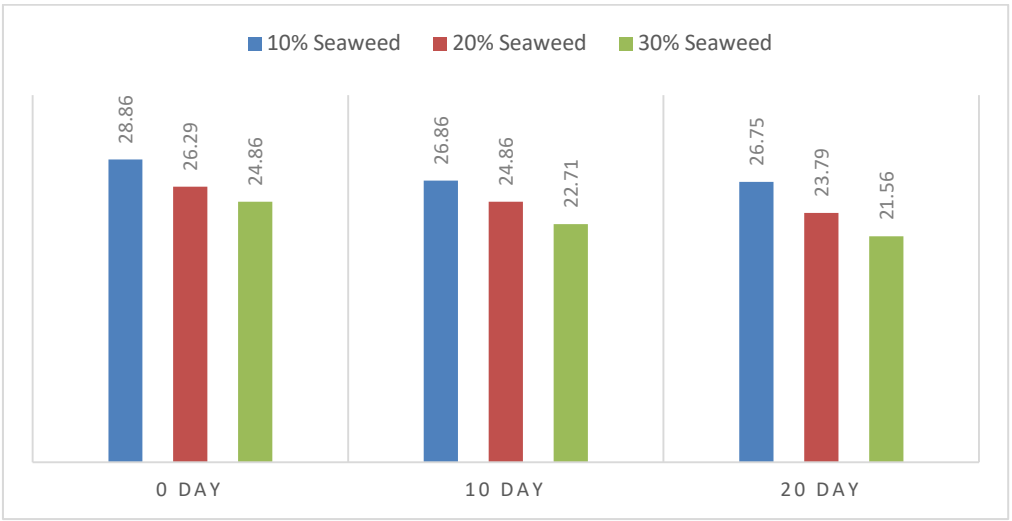

Fig. 2. Comparison of the effects of seaweed (*Eucheuma cattonii*) concentration and extended storage at -18 °C on the protein content of tuna sandwich

3.3 Fat of Tuna Sandwich

Animals store excess energy as fat, so the quantity of fat in animals consumed as food is determined by their energy balance. Additionally, fat is a source of essential fatty acids and vitamins (A, D, E, and K) (Bellitz *et al*., 2009). Fig. 3 depicts the results of measuring the fat content of the tuna's body regions. The average fat content ranges from 0.7% to 1.14%, indicating that the sandwich product with the maximum fat content was produced by administering 10% seaweed for an extended period of time. 20 days of storage at -18°C. While the treatment of 30% seaweed with extended storage at -18°C or the control had the lowest fat content.

Fish species, eating patterns, maturity, season, and feed availability are the primary factors influencing differences in fat content. Both moisture content and lipid content are highly variable. If meat's lipid content is higher, its water content will be lower, and vice versa [10]. The extraction method is an additional factor that contributes to fish's minimal fat content. In a previous investigation of fat levels, [14] used soxhletation extraction with chemical solvents such as methanol and chloroform to obtain a higher fat content, whereas in this study, rendering with boiling water was used for extraction [15].

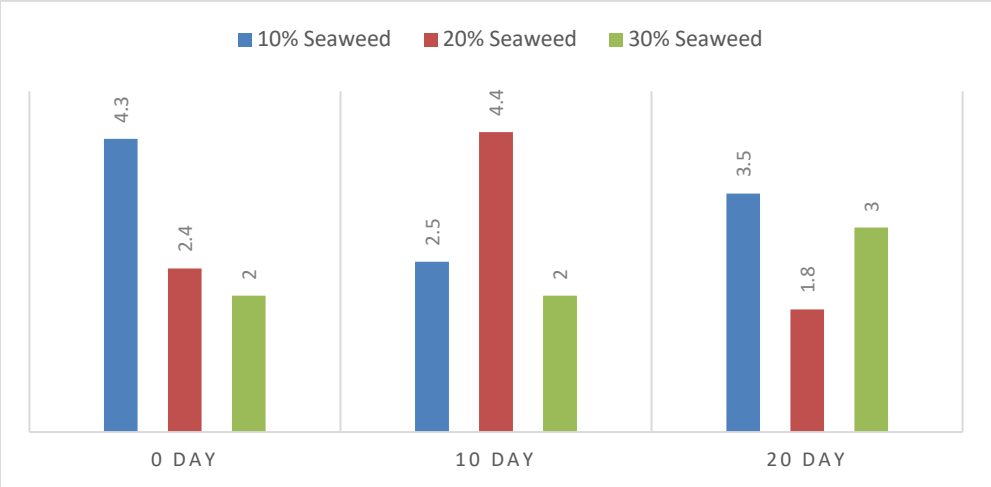

Fig. 3. Comparison of the Concentration of Seaweed (*Eucheuma cottonii*) and Length of Storage at -18°C on the Fat Content of Tuna Sandwiches Produced

4. CONCLUSION

The results of the analysis of the effect of adding seaweed and storage time at -18°C on tuna sandwiches indicate that the combination of treatment with the addition of 30% seaweed and storage at -18°C for 20 days can maintain the nutritional value of sandwich products. The tuna sticks with the greatest score on the proximity test.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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