

Effect of *Eucheuma spinosum* Carrageenan Flour Addition on the Chemical Quality and Sensory Acceptance of Milkfish (*Chanos Chanos*) Nuggets

Tasir^{1*}, Luthfiah², Rahmawati Saleh³, Mursida⁴, Sultan⁵

Fish Processing and Preservation Study Program, Department of Agricultural Technology, Politeknik Pertanian Negeri Pangkajene Kepulauan, South Sulawesi, Indonesia

Corresponding Author: Tasir tasirtappa47@gmail.com

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ABSTRACT

This study evaluated the effect of *Eucheuma spinosum* carrageenan flour on the chemical quality and sensory acceptance of milkfish nuggets. A completely randomized design with four carrageenan levels (0%, 5%, 10%, and 15%) and two replications was applied from January to April 2024 at Politeknik Pertanian Negeri Pangkajene Kepulauan. Moisture, protein, and fiber contents were analyzed, followed by sensory tests of aroma, taste, and texture. Increasing carrageenan reduced moisture content and increased fiber content. The 15% treatment produced the highest fiber level, whereas the 5% treatment showed the best sensory acceptance among the carrageenan formulations. Therefore, 5% carrageenan is recommended as the most balanced formulation in terms of product quality and consumer preference

INTRODUCTION

Fisheries encompass all activities related to the management and utilization of fishery resources, from pre-production, production, and processing to marketing within a fishery business system. One form of value-added development for fishery commodities is the processing of fish into practical ready-to-eat products that are readily accepted by consumers.

Fish nuggets are processed products made from minced fish meat mixed with seasonings and binding agents, then molded, coated with batter and breading, and finally fried or frozen before frying. This product has the potential to increase fish consumption among the public, including children, because it has a more familiar shape, taste, and texture.

Milkfish (*Chanos chanos*) is a fishery commodity widely cultivated in Pangkep Regency. In addition to its economic value, milkfish also has high nutritional content, especially protein and omega-3 fatty acids. Therefore, the development of milkfish nuggets can be a strategy to increase the added value of local fishery products while expanding consumer acceptance.

Carrageenan derived from *Eucheuma spinosum* is widely used as a thickening and stabilizing agent in food products. In nugget formulations, carrageenan can function as a filler as well as a source of water-soluble dietary fiber. This study was conducted to examine the effect of carrageenan flour addition on the chemical quality and panelist acceptance of milkfish nuggets, and to determine the most appropriate carrageenan concentration.

Milkfish is especially suitable for value-added processing because it contains a relatively high amount of protein and important micronutrients. Malle et al. (2019) reported that milkfish from Pangkep, South Sulawesi, contained 24.18% protein and also provided notable fatty acids, minerals, and vitamins, supporting its use as a nutritious raw material for further product development. In addition, recent work on milkfish surimi-based products showed that fish nuggets can be developed as ready-to-cook foods with appreciable protein content, indicating that milkfish processing into nugget-type products is a feasible diversification strategy for increasing both utilization and consumer accessibility (Molina et al., 2024).

From a product engineering perspective, the use of hydrocolloids is highly relevant in nugget formulation because these ingredients can modify viscosity, water retention, gel formation, and structural stability. A recent review emphasized that carrageenan derived from red algae is widely used in food systems as a gelling, thickening, stabilizing, emulsifying, and water-holding agent, while commercial *spinosum* is recognized as an important raw material for carrageenan production (Udo et al., 2023; Naseri et al., 2020). Studies on fish-based systems further indicate that carrageenan can improve texture-related quality attributes and product stability, although excessive addition may increase hardness and lower sensory acceptance; therefore, concentration optimization is required in restructured fish products (Cardoso et al., 2007; Meliana et al., 2022).

LITERATURE REVIEW

1. Milkfish Nuggets as a Value-Added Fishery Product

Fish nuggets are a restructured meat product that can enhance the diversification of fish-based foods. Processing milkfish into nuggets can extend the utility of the raw material, increase its economic value, and help raise the consumption of animal protein, especially among consumer groups that are less fond of fresh fish.

Evidence from recent milkfish research supports the role of nuggets as a practical value-added fishery product. Molina et al. (2024) demonstrated that milkfish surimi can be processed into fish nuggets, fish balls, and shrimp analogues, and concluded that this approach can help produce nutritious ready-to-cook and ready-to-eat products. This finding reinforces the idea that nugget processing is not only a diversification strategy, but also a practical way to convert locally abundant milkfish into more convenient foods while retaining its nutritional relevance.

2. Carrageenan as a Stabilizer and Dietary Fiber Source

Carrageenan is a polysaccharide extracted from red seaweed that is commonly used in the food industry because of its ability to form gels, increase viscosity, and stabilize emulsions. In nugget products, the addition of carrageenan is expected to improve the batter structure and increase dietary fiber content. However, excessive use may negatively affect the product's texture, taste, and aroma.

Carrageenan remains one of the most important hydrocolloids in food applications because of its ability to form gels, increase viscosity, retain water, and stabilize food matrices. Udo et al. (2023) described carrageenan as a multifunctional ingredient that has long been used in meat, dairy, and flour-based products, while Naseri et al. (2020) noted that commercial spinosum (*Eucheuma denticulatum*) is a major industrial source of carrageenan. These techno-functional properties explain why carrageenan is frequently considered for restructuring and stabilizing processed fish products.

In fish-based products, moderate carrageenan addition has been associated with improved product structure and quality. Cardoso et al. (2007) found that carrageenan increased hardness in restructured fish products containing dietary fibre, demonstrating its strong role in network formation. Likewise, Meliana et al. (2022) reported that 1% kappa-carrageenan improved emulsion stability, gel strength, water-holding capacity, and sensory quality in milkfish sausage. A more recent study by Shabanpour et al. (2024) also showed that shrimp nuggets containing 1% carrageenan had physical, chemical, and sensory characteristics closest to the control product. Together, these findings suggest that carrageenan can enhance fish nugget quality when used at appropriate levels, but an excessive concentration may produce a firmer texture that is less preferred by consumers.

METHODOLOGY

1. Time and Place

The study was conducted over four months, from January to April 2024, at the Fish Processing and Preservation Workshop and the Biochemistry Laboratory of the Department of Agricultural Technology, Politeknik Pertanian Negeri Pangkajene Kepulauan.

2. Materials and Equipment

The main materials used were fresh milkfish (*Chanos chanos*) and carrageenan flour as a source of dietary fiber. Supporting ingredients included cornstarch, wheat flour, water, breadcrumbs, cooking oil, salt, pepper, garlic, and shallots. Laboratory analyses used chemicals such as H₂SO₄, NaOH, ethanol, catalyst tablets, boric acid solution, H₂O₂, and HCl, along with appropriate processing equipment and proximate analysis instruments.

3. Experimental Design

The study employed a one-factor Completely Randomized Design (CRD), namely the carrageenan concentration in the milkfish nugget formulation. The treatments consisted of four levels: 0% (control), 5%, 10%, and 15%, each with two replications, resulting in eight experimental units.

4. Observed Parameters and Data Analysis

The observed parameters included protein content, moisture content, fiber content, and sensory tests of aroma, taste, and texture. The data were analyzed using SPSS version 27 with a univariate general linear model, followed by Tukey's test to determine differences among treatments.

RESEARCH RESULTS

The test results showed that carrageenan addition produced different responses in the chemical and sensory parameters of milkfish nuggets. In general, fiber content increased as carrageenan concentration increased, while moisture content tended to decrease. On the sensory side, the 5% formulation was the most preferred treatment among the nuggets containing carrageenan.

Table 1. The chemical and sensory parameters of milkfish nuggets

Parameter	Main findings from the manuscript
Protein content	The highest protein content was reported in the control (5.29%). Among the formulations containing carrageenan, the 5% treatment performed better than the higher-level treatments.
Moisture content	The highest moisture content was found in the control (72.26%) and the lowest in the 15% carrageenan treatment (67.00%). Analysis of variance showed no significant difference.
Fiber content	Fiber content increased from 0.46% in the control to 10.13% in the 15% treatment and differed significantly.

Sensory test	Among the formulations containing carrageenan, the 5% concentration was the most preferred for aroma, taste, and texture, whereas 15% tended to reduce panelist acceptance.
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Protein Content

Based on the study findings, the highest protein content was found in the control treatment. The 5% carrageenan addition was still able to maintain protein quality better than the 10% and 15% treatments. This indicates that increasing carrageenan concentration can affect the chemical composition of the product, mainly because of changes in the proportion of batter components.

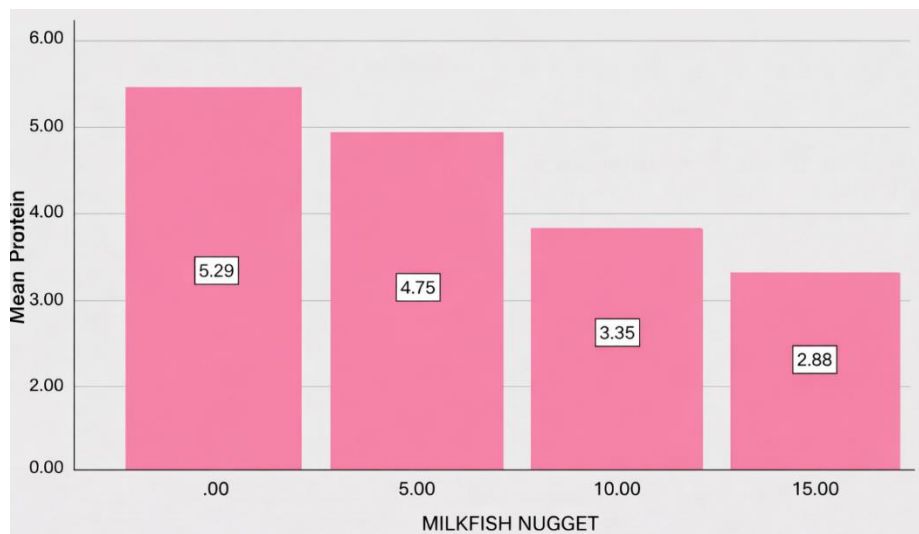


Figure 1. Simple Bar Chart of Mean Protein by Milkfish Nugget

Moisture Content

Moisture content tended to decrease as carrageenan concentration increased, from 72.26% in the control to 67.00% in the 15% treatment. However, based on the analysis of variance, carrageenan addition did not have a significant effect on the moisture content of milkfish nuggets.

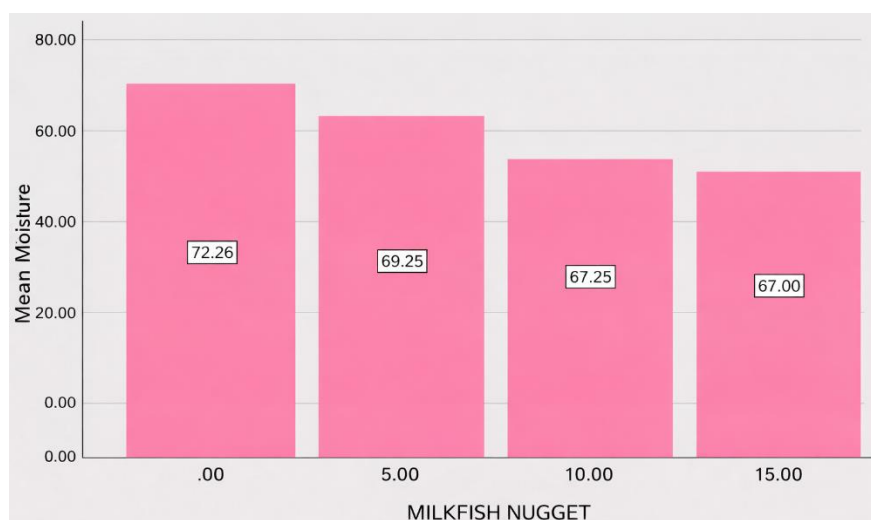


Figure 2. Simple Bar Chart of Mean Moisture by Milkfish Nugget

Fiber Content

The parameter most responsive to carrageenan addition was fiber content. Fiber content increased consistently from the control to the 15% treatment, reaching a highest value of 10.13%. These results confirm the role of carrageenan as a source of dietary fiber in processed fish products.

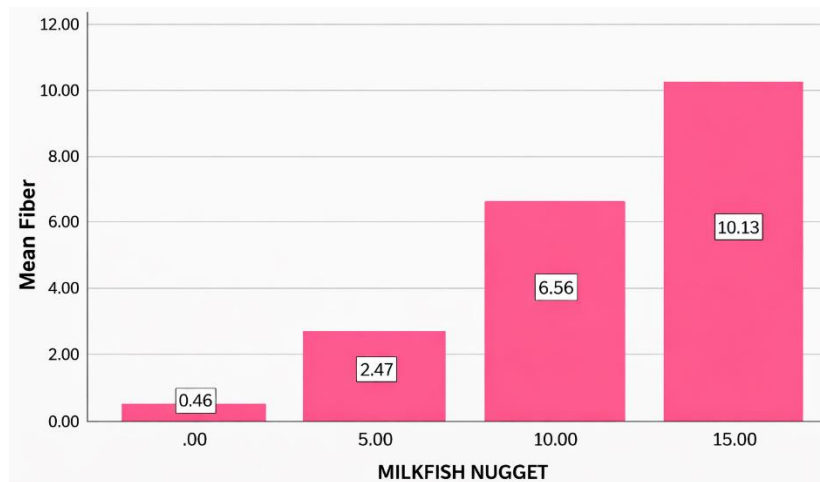


Figure 3. Simple Bar Chart of Mean Fiber by Milkfish Nugget

Sensory Evaluation

Sensory evaluation of aroma, taste, and texture was conducted using 10 untrained panelists. The 5% treatment produced the highest preference level among the carrageenan formulations, whereas increasing the concentration to 15% reduced panelist acceptance because the texture became firmer and the taste and aroma characteristics were less preferred.

The overall pattern of the results suggests that carrageenan modified the product matrix more strongly than it improved all quality attributes simultaneously. Although the control showed the highest protein content, the 5% carrageenan treatment still maintained protein performance better than the 10% and 15% treatments. This tendency may be related to a dilution effect caused by the increasing proportion of non-protein hydrocolloid material in the formulation. Ramírez et al. (2011) explained that hydrocolloids in restructured fish products primarily alter the mechanical and functional properties of the matrix, while Cardoso et al. (2007) showed that carrageenan is especially effective in modifying the structure and texture of fish products rather than increasing their intrinsic protein value.

The increase in fiber content up to 10.13% in the 15% treatment confirms that *Eucheuma spinosum* carrageenan flour can act as an effective source of dietary fiber in milkfish nuggets. However, the sensory data indicate that nutritional enhancement and consumer acceptance did not increase in parallel, because the highest preference among the carrageenan treatments remained at 5%. This result is relevant from a product development perspective, since excessive hydrocolloid addition may produce a denser structure, reduce juiciness, or leave a seaweed-like note that is less preferred by panelists. Comparable findings were reported in milkfish sausage and shrimp nugget

systems, where moderate carrageenan concentrations produced better sensory and structural balance than higher concentrations (Meliana et al., 2022; Shabanpour et al., 2024).

DISCUSSION

The findings indicate a trade-off between improved functional value and sensory acceptance. The addition of carrageenan at high concentrations was effective in increasing fiber content, but the resulting structural changes in the product also affected taste, aroma, and texture. This condition is consistent with the function of carrageenan as a hydrocolloid that can strengthen gels and alter the characteristics of food batter.

From a product development perspective, the 5% treatment can be regarded as the most balanced formulation. At this concentration, the nuggets still gained additional fiber, while the organoleptic quality remained well accepted by the panelists. Thus, increasing fiber content through carrageenan should take consumers' sensory tolerance thresholds into account.

These findings also show that the use of *Eucheuma spinosum* has the potential to be further developed in restructured fish products, particularly to support the diversification of fishery-based foods and to increase the added value of milkfish in producing areas such as Pangkep Regency.

The decrease in moisture content with increasing carrageenan concentration can be interpreted as a matrix effect during nugget formation. Carrageenan is widely recognized as a gelling, thickening, stabilizing, and water-holding agent, but in fish-based systems it also increases total solids and changes the distribution of free and bound water within the gel network (Udo et al., 2023; Ramírez et al., 2011). For that reason, a formulation may show lower measured moisture percentage while still forming a more compact and stable product structure. This interpretation is in line with the present study, where higher carrageenan levels were associated with lower moisture values and reduced sensory acceptance at the highest concentration.

From an application standpoint, the 5% treatment can be considered the most realistic formulation for further development because it provided a better compromise between functional enrichment and product acceptability. At this level, the nuggets still obtained additional fiber while maintaining more favorable protein performance and the highest aroma, taste, and texture scores among the carrageenan-added treatments. A moderate carrageenan level therefore appears sufficient to improve product functionality without causing excessive firmness or masking the typical sensory characteristics of milkfish nuggets. Similar tendencies have been reported in other fish-based systems, where intermediate carrageenan concentrations generated products with more desirable texture and sensory quality than higher concentrations (Cardoso et al., 2007; Meliana et al., 2022; Shabanpour et al., 2024).

CONCLUSIONS AND RECOMMENDATIONS

Carrageenan addition affected the chemical and sensory quality of milkfish nuggets. Higher carrageenan concentrations increased fiber content, while moisture content tended to decrease. The 15% treatment produced the highest fiber content, but sensory acceptance declined. Among the treatments containing carrageenan, the 5% formulation provided the best balance because it was still preferred by the panelists in terms of aroma, taste, and texture.

Based on these results, the use of 5% carrageenan is recommended as a more feasible formulation for the development of milkfish nuggets. This concentration may be considered at the production scale to obtain a product that is more acceptable to consumers without neglecting the improvement of functional value.

FUTURE RESEARCH

This study still had several limitations, including a relatively small number of replications, the use of a limited number of untrained panelists, and the absence of an evaluation of frozen-product storage stability. Further research is recommended to test the formulation at a larger production scale, add instrumental texture and shelf-life parameters, and compare other hydrocolloid sources as binding agents and fiber sources.

ADVANCED RESEARCH

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