The effect addition of kappa carrageenan flour to the level of gel strength and acceptability of dumpling from threadfin bream fish (Nemipterus nematophorus) surimi

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Abstract. Surimi is an intermediate product (semi-finished product) that has an ability to be processed into various products through a cooking process. Dumpling is a steam product and categorized as a product that requires a specification of compact and not have hard gel formation. To improve texture, the formulation used was added kappa carrageenan flour due to it was able to absorb excessive water level which caused by protein denaturation process. The purpose of this study was to determine the effect of adding kappa carrageenan flour on dumpling from threadfin bream fish surimi on the level of gel strength and acceptability product. This study used a completely randomized design which consists of 4 treatments with kappa carrageenan flour concentrations of 0.00%, 0.55%, 1.50%, and 2.45% and 5 replications. The result showed that the addition of kappa carrageenan flour had significant effect (P <0.05) on the value of the texture and acceptability of dumplings from threadfin bream fish surimi, as well as the proximate content. Kappa carrageenan flour with a concentration of 1.50 % produced the moisture and protein content of 50.14% and 8.16%, respectively and showed the best characteristic of compact and moist gel strength.

1. Introduction

The Indonesian fisheries sector in the global era has very potential development prospects, especially in capture fisheries production. The realization of capture fisheries production in Indonesia has increased from 6.58 million tons in 2014 to 6.83 million tons in 2016 [1]. One of the result of capture fisheries in Indonesia is threadfin bream fish (Nemipterus nematophorus) [2]. Threadfin bream fish (Nemipterus nematophorus) has a protein content of 19.66% and a fat content of 0.94%. Threadfin bream fish has white meat, abundant catches, and the price is relatively cheap so that it can be used as raw material for making surimi [3].

Surimi is an intermediate product (semi-finished product) that has the ability to be processed into various kinds of products through the cooking process. The main focus in making surimi is to maintain the functional properties of the protein from the denaturation process and increase the ability of gel formation [4]. Surimi used in this study has a gel strength level of 750 g/cm² so that it can be used as raw material for making fish dumplings.

Fish dumplings are steam products derived from fish meat or surimi with the addition of several additional ingredients and wrapped in dumpling skin [5]. Fish dumpling is very popular among the people because its processing is easy and the price is relatively cheap so it is widely sold in Chinese restaurants and street vendors in Indonesia. Usually dumplings are added as a complement in serving meatballs or noodles, fried rice, and various soups [6]. The number of dumpling producers in
Indonesia does not pay attention to quality and is only concerned with business competition. Types of fish dumplings are susceptible to spoilage because they are made by steaming. The steaming process is able to increase the amount of water content in the product so that the product expands. The amount of water content can increase the growth of microbes, causing the quality of the product to be low [7]. Efforts are made to maintain the quality of fish dumplings by adding an ingredient that functions as a flocculating agent which is a material that can cause a particle to come together to form an aggregate or floc such as kappa carrageenan flour. Kappa carrageenan is hydrophilic so that it is able to absorb water content in the product and convert it into Hydrocolloid form [8]. Kappa carrageenan has a strong gel because it is formed from 3,6 anhydro D-galactose bonds that combine to form 3-dimensional networks in the polymer so that it provides better tissue chain organization [9]. The addition of kappa carrageenan flour to threadfin bream fish dumplings is expected to be able to be an alternative for healthy food additives, especially for processed fishery products in Indonesia.

2. Materials and method

2.1. Process of making surimi

The threadfin bream fish fillet that has been obtained is weighed in advance to determine the initial weight that will be used to calculate the yield. The curry fish fillet is then ground using a food processor for 3 minutes and the leaching process is immersed using ice water for 15 minutes at 5-10℃. Washing the meat was done 3 times. In the washing process 0.3% salt is added to the water and meat mixture which has a 1:4 mixture. Washing the meat with cold water and adding salt are the most important steps in making surimi. In this washing process the component of dissolved nitrogen, blood, pigment and fat is also wasted, while the protein myofibril joins with actin to form actomiosin so that the ability to form a gel increases. Next, the pressing process is carried out using filter cloth and surimi is formed. Fish meat that has been pressed is weighed to determine the amount of cryoprotectant addition that will be added to surimi. Cryoprotectant added was 3% sugar and 0.2% salt by weight of meat after pressing. For further processing of surimi products, surimi raw materials are wrapped in plastic and stored at -20℃.

2.2. Process of making dumpling

The making of threadfin bream fish dumplings is carried out in accordance with the provisions of the Indonesian National Standardization. Surimi thawed at 0-5℃ for 15 minutes mixed with tapioca flour, egg, ice water as much as 16%, 6%, 20%, respectively and spices that have been crushed such as garlic, carrots, pepper, MSG, salt, sugar, leeks as much as 2.4%, 1.4%, 0.1%, 0.1%, 1.6%, 0.4%, 2%, respectively and kappa carrageenan flour treated by P0 0%, P1 0.55%, P2 1.5% and P3 2.45%. The addition of herbs aims to improve taste. The ingredients that have been mixed then stirred or kneaded until evenly distributed until the dough is formed. The dough that has been smooth is then shaped to taste 20 pcs of dumplings according to 4 treatments and 5 replications, then wrap them in dumpling skin neatly and sanitary. The next process is steaming dumplings at a temperature of 60-90℃ for 10-15 minutes with the condition of the lid covered with a clean cloth to reduce the amount of water content during the steaming process.

The cooked dumpling then cooled by draining or assisted with a fan carefully and sanitary for 5-10 minutes. The ingredients for making fish dumplings by adding kappa carrageenan flour can be seen in Table 1
Table 1. Formulation of fish dumpling

| No. | Raw materials       | P0     | P1     | P2     | P3     |
|-----|---------------------|--------|--------|--------|--------|
| 1.  | Kappa carrageenan   | 0%     | 0.55%  | 1.50%  | 2.45%  |
| 2.  | Surimi              | 50%    | 50%    | 50%    | 50%    |
| 3.  | Tapioca flour       | 16%    | 16%    | 16%    | 16%    |
| 4.  | Egg                 | 6%     | 6%     | 6%     | 6%     |
| 5.  | Ice water           | 20%    | 20%    | 20%    | 20%    |
| 6.  | Salt                | 1.60%  | 1.60%  | 1.60%  | 1.60%  |
| 7.  | Sugar               | 0.40%  | 0.40%  | 0.40%  | 0.40%  |
| 8.  | Pepper              | 0.10%  | 0.10%  | 0.10%  | 0.10%  |
| 9.  | MSG                 | 0.10%  | 0.10%  | 0.10%  | 0.10%  |
| 10. | Garlic              | 2.40%  | 2.40%  | 2.40%  | 2.40%  |
| 11. | Carrot              | 1.40%  | 1.40%  | 1.40%  | 1.40%  |
| 12. | Leek                | 2%     | 2%     | 2%     | 2%     |

The main parameters in this study were gel strength included the level of hardness, gumminess, chewiness, springiness, cohesiveness and resilience as well as the organoleptic value of threadfin bream fish dumpling. The method used to determine the level of product acceptance to consumers is to do organoleptic analysis by scoring the quality levels such as appearance, texture, aroma, and taste, while the gel strength level is tested with the instrument LLOYD Texture Analyzer, TA-TX type 1 plus. Supporting parameters in this study were the value of the water holding capacity, water and protein content. Data were analyzed using analyze of variance (ANOVA) and if there was significant results then the calculation continues with Duncan Multiple Range Method [10]. Non-parametric data such as organoleptic test results were analyzed by the Kruskal Wallis method.

3. Results

3.1. Texture analysis

Texture analysis aims to determine the physical characteristics of materials related to the durability or strength of a material to pressure. The parameters observed included hardness, springiness, cohesiveness, gumminess, chewiness and resilience. The results of the texture parameters of threadfin bream fish dumplings added with kappa carrageenan flour can be seen in Table 2.
The results of statistical analysis showed that the parameters of hardness, springiness, cohesiveness, gumminess, chewiness, and resilience significantly affected the curry fish dumplings by adding kappa carrageenan flour (P <0.05). Hardness testing aims to determine the level of hardness of fish siomay products with the addition of carrageenan kappa flour. The average results of the lowest hardness value is 1,721.21 ± 12.72 in the treatment of 0.55% (P1), while the highest average is obtained in the treatment of 2.45% (P3) which is 3,125.93 ± 13.99. According to Tiwo et al [11] surimi-based gel products have a hardness value of 2,583.21 g / cm² so that the best hardness texture parameter values in this study were obtained in the addition of carrageenan kappa flour with a concentration of 1.50% (P2). Hardness statistical test shows that there is a significant difference between treatments (P <0.05), it means that the addition of carrageenan kappa flour has an effect on the hardness value of cured fish dumplings.

Springiness testing aims to determine the ability of the product to return to its original form after suppression. The lowest average springiness value is 0.85 ± 0.027 at 0.55% (P1) treatment, while the highest average is 1.44 ± 0.15 obtained at 1.50% treatment (P2). Surimi-based gel products have a springiness value of 0.93 mm so that the best springiness texture parameter values in this study were obtained in the addition of carrageenan kappa flour with a concentration of 1.50% (P2). Springiness statistical test showed that there is a significant difference between P0 and P1, but it is significantly different from P2 and P3, it means that the addition of carrageenan kappa flour influences the springiness value of cured fish dumplings, especially in P2 and P3. Cohesiveness testing aims to determine the cohesiveness of the product texture between the constituent components. The lowest average cohesiveness value obtained in the control treatment (P0) is 0.74 ± 0.025, while the highest average is obtained at P2 (1.50%), 0.85 ± 0.028. The cohesiveness statistical test showed that P0 has a significant difference to P1, P2, and P3, but between P1, P2 and P3.
does not have a very significant difference, it means that the addition of carrageenan kappa flour influences the cohesiveness value of curried fish in cows P1, P2 and P3.

The gumminess test aims to determine the level of flexibility of the product after it is added with carrageenan kappa flour in each treatment. The lowest average value of gumminess texture parameters is shown in P1 (0.55%), which is 1,939.73 ± 25.34, while the highest average is obtained in P2 (1.50%), namely 3,235.50 ± 23.10. Chewiness testing aims to determine the level of plasticity of cured fish siomay products added with carrageenan kappa flour. The lowest average value of the chewiness test was obtained at P1 (0.55%), namely 1,431.96 ± 15.28, while the highest average was obtained at P3 (2.45%), namely 3,669.18 ± 20.74. According to Hu et al [12] surimi-based gel products have a chewiness value of 3,220.24 so that the best chewiness texture parameter values in this study were obtained in the addition of carrageenan kappa flour with a concentration of 1.50% (P2). Chewiness statistical test shows that there is a very significant difference between treatments (P <0.05), it means that the addition of carrageenan kappa flour has an effect on the level of elasticity of the resulting threadfin bream fish.

Resilience testing aims to determine the level of product durability or the recovery rate of material samples in terms of speed. The lowest average results of resilience in this study were obtained in the control treatment that was 0.42 ± 0.037, while the highest average value was obtained at P2 (1.50%) which was 0.51 ± 0.026. Statistical test of resilience value showed that the control treatment with P1 did not have a real difference but it was very significantly different from P2, whereas between P2 and P3 also did not have a real difference but it was very significantly different from the control treatment, it meant that the addition of kappa carrageenan flour affected the value of fish curry resilience between control treatments with P2.

3.2. Water holding capacity

Analysis of water holding capacity aims to determine the ability of meat to hold water absorbed by the product so that it produces cured fish dumplings with a chewy texture quality. The value of water holding capacity in fish dumplings can be seen in Figure 1.

![Figure 1. Water holding capacity of fish dumpling](image)
The lowest average value in the water holding capacity was obtained at P1 (0.55%) as many as 1.96 ± 0.23, while the highest average value was obtained at P3 (2.45%) which was 3.30 ± 0.20. Statistical test of water holding capacity showed that between P0 and P1 did not have very significant differences, but differed significantly from P2 and P3.

3.3. Proximate analysis
Proximate testing in this study includes testing the water content and protein content in the product. Protein content was tested to determine the percentage of protein content in cured fish siomay with the addition of kappa carrageenan flour, while the water content was tested to determine the amount of water content in it. According to Nugroho [13] water content is one of the most important characteristics in food because water in the product can affect the appearance, texture, and taste of food.

Water is one of the media that can increase microbial growth so that if the water content in the product is too much it can cause spoilage in the product, besides the water content contained in food can affect the strength of the gel [14]. Data on the average test results of water and protein content on cured fish dumplings can be seen in Table 3.

Table 3. Protein and water analysis of fish dumpling

| Parameters       | Treatments (%) | Value (%) ± SD | Standard (%)          |
|------------------|----------------|----------------|-----------------------|
| Protein          | P0 (0.00)      | 7.30 ± 0.17    | Min. 5.00 (SNI-7756-2013) |
|                  | P1 (0.55)      | 7.32 ± 0.13    |                       |
|                  | P2 (1.50)      | 8.16 ± 0.11    |                       |
|                  | P3 (2.45)      | 8.27 ± 0.18    |                       |
| Water            | P0 (0.00)      | 58.16 ± 0.11   | Maks. 60.00 (SNI-7756-2013) |
|                  | P1 (0.55)      | 54.19 ± 0.14   |                       |
|                  | P2 (1.50)      | 50.14 ± 0.09   |                       |
|                  | P3 (2.45)      | 48.30 ± 0.16   |                       |

The lowest average value in the water content test was obtained at P3 (2.45%) which was 48.30 ± 0.16, while the highest average value of water content was obtained at the control treatment amounted to 58.16 ± 0.11. Statistical test of water content shows that there is a very significant difference between treatments (P <0.05), it shows that the addition of kappa carrageenan flour has an effect on the amount of moisture content of threadfin bream fish produced. The lowest average value of the protein content test results obtained in the control treatment was 7.30 ± 0.17, while the highest average value was obtained at P3 (2.45%) which was 8.27 ± 0.18. Statistical tests showed that the control treatment and P1 were not significantly different, but significantly different from P2 and P3, whereas between P2 and P3 did not have significant differences in the value of dumpling fish protein levels. The statistical test means that the addition of kappa carrageenan flour does not affect the value of protein content between treatments given.

Organoleptic test in this study aims to determine the level of product acceptance by panelists. The parameters tested in organoleptic testing according to SNI-7756-2006 concerning fish dumplings are appearance, aroma, taste, and texture of the product. Organoleptic test in this study was tested by 30 untrained panelists. The fish dumplings tested will be assessed according to a randomly generated sample code to produce an even distribution of assessments and the tests are carried out based on organoleptic test instructions according to the Indonesian National Standard on fish dumplings. The average organoleptic value of threadfin bream fish dumplings can be seen in Table 4.
Table 4. Organoleptic value of fish dumpling

| Parameters | Treatments (%) | Value (%) ± SD | Standard |
|------------|----------------|----------------|----------|
| Appearance | P0 (0.00)      | 7.13 ± 1.16    | Min. 7   |
|            | P1 (0.55)      | 7.33 ± 0.92    |          |
|            | P2 (1.50)      | 7.47 ± 1.13    |          |
|            | P3 (2.45)      | 6.73 ± 0.69    |          |
| Aroma      | P0 (0.00)      | 6.33 ± 1.09    | Min. 7   |
|            | P1 (0.55)      | 6.27 ± 1.23    |          |
|            | P2 (1.50)      | 7.20 ± 1.21    |          |
|            | P3 (2.45)      | 6.73 ± 1.25    |          |
| Taste      | P0 (0.00)      | 7.40 ± 0.81    | Min. 7   |
|            | P1 (0.55)      | 7.07 ± 0.98    |          |
|            | P2 (1.50)      | 7.80 ± 1.24    |          |
|            | P3 (2.45)      | 7.40 ± 0.96    |          |
| Texture    | P0 (0.00)      | 7.47 ± 0.86    | Min. 7   |
|            | P1 (0.55)      | 7.33 ± 0.75    |          |
|            | P2 (1.50)      | 7.87 ± 1.00    |          |
|            | P3 (2.45)      | 7.13 ± 0.50    |          |

The results of statistical analysis on the appearance parameters showed that the P value was significantly different from the whole treatment (P <0.05), this meant that the addition of carrageenan kappa flour to cured fish dumplings had a significant effect on the appearance value. The best treatment of the appearance value of curried fish dumplings was obtained in P2.

In the aroma parameter, the highest average yield was obtained at P2, 7.20 ± 1.21, while the lowest average value was obtained at P1, 6.27 ± 1.23. The results of statistical analysis on the aroma parameters showed that the P value was significantly different from the whole treatment (P <0.05), this meant that the addition of carrageenan kappa flour to curd fish dumplings had a significant effect on the aroma value. The best treatment of aroma value of cured fish dumplings was obtained in P2.

In the taste parameter the highest average yield was obtained at P2, 7.80 ± 1.24, while the lowest average value was obtained at P1, 7.07 ± 0.98. The results of statistical analysis on the taste parameters showed that the P value was significantly different from the whole treatment (P <0.05), it meant that the addition of carrageenan kappa flour to curd fish dumplings had a significant effect on the taste value. The best treatment of flavor value of curried fish dumplings was obtained in P2.

In the texture parameters the highest average results obtained at P2 is 7.87 ± 1.00, while the lowest average values obtained at P3 is 7.13 ± 0.50. The results of statistical analysis on the texture parameters showed that the P value was significantly different from the whole treatment (P <0.05), it means that the addition of carrageenan kappa flour to curd fish dumplings had a significant effect on the texture value. The best treatment of the texture value of curd fish siomay products was obtained at P2.

3.4. Discussion

Texture is an important aspect for evaluating the quality of food products, especially in products that have a soft and hard texture because they can affect consumer acceptance of the products produced. The assessment of the texture of a product can be determined from the value of hardness, springiness, cohesiveness, gumminess, chewiness and resilience. Dumpling is a steam product (a product that is processed by steaming) and is classified as a product that requires a gel formation specification that is compact, not soft, non-aqueous, and not too hard so that in improving its texture, the formulation used is added with kappa carrageenan flour.

Kappa carrageenan is able to absorb too much water content due to the protein denaturation process which causes the weak binding capacity of myofibril in meat during the steaming process [8]. The
results showed that the increase in the addition of carrageenan kappa flour caused the formation of fish dumpling gel that was too strong. The formation of strong gels by kappa carrageenan is caused by the joining of polymer chains through hydrogen bonds in hydroxyl groups along the carrageenan kappa polymer chains to form a strong and rigid three-dimensional mesh. The three-dimensional polymer structure will function to capture or immobilize water into a colloidal form, causing a strong gel to form.

The formation of a strong gel is supported by the low amount of water content and the high value of the water holding capacity in the product. The lower water content in the sample indicates that the product produced has a better water holding capacity. The higher the water holding capacity means the greater the strengthening of the gel. Low water content in the product will produce a dumpling gel texture that is getting harder because there is an unbalanced comparison between carrageenan kappa flour and water available in fish meat [15]. Temperature and cooking time can also affect the hardness value of fish dumplings.

The compact texture of the product is also caused by the addition of eggs in the formulation of cured fish dumplings which causes the interaction between the components in the product to be strong and stable so as to form a dough gel matrix [16]. Protein and starch in fish dumplings are the main factors in determining the quality of processing food products. The gumminess texture test results show that the resulting fish dumplings have a high stickiness. Amylopectin plays more role in increasing the resilience and firmness value of fish dumplings because it can form amorphous or less compact areas so that it will be more easily penetrated by water, enzymes, and other chemicals. The structure of kappa carrageenan has larger pores so that under these conditions the recovery time of the sample becomes faster when under pressure.

In the food industry, product acceptance is very important because it can affect consumers' interest in the product. Organoleptic test results (texture, appearance, aroma, taste) show that the average panelist prefers the texture of fish dumplings that are not too hard and not too sticky compared to the fish dumplings texture which is very hard and very sticky because it is easy to crush and swallow. Consumers will also prefer products with a neat, good, and intact form compared to less neat and incomplete products [17]. Generally consumers will like a distinctive aroma that does not deviate from the normal aroma. Taste assessment is very important for consumers to determine whether to accept or reject a product. Although other parameters are considered quite good, but if the taste is not liked then the product will be rejected. Taste parameter values in this study have almost the same taste, namely the specific characteristics of the types of fish used as raw materials, besides the taste of the spices added are also sufficient and not excessive. The use of spices such as garlic will affect the flavor produced because it has bioactive components such as alisin. Just like other phenolic compounds, this compound can increase the taste in food ingredients [18].

4. Conclusion

The conclusion in this study is the difference in the concentration of carrageenan kappa flour influences the value of the strength of the gel and the acceptability of cured fish dumplings produced. Fish dumplings with 1.50% carrageenan kappa concentration have a gel strength that is in accordance with consumer acceptance and produces a gel texture that is compact and not too hard.

5. References

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