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The Effect of Carrageenan on the Textural and Sensory Characteristics of Mackerel Tuna Fishballs

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ABSTRACT-- *Mackerel tuna is one of the marines catches with a high production amount in Indonesia, but lacking in its utilization. Diversification of Mackerel tuna can be made with processed into fishballs. The used of Mackerel tuna surimi as raw material and the addition of carrageenan is expected to improve the texture so it can be accepted sensory. Arrowroot flour as substitution of tapioca starch is useful to increased the nutritional and functional content of fishballs. This research aims to determine the effect of the addition of carrageenan to the characteristics of texture and sensory fishballs. This research used completely randomizes design (CDR) with one factor of carrageenan addition variations i.e. 0.5%; 1% and 1.5%. Data were analyzed statistically by the method of one-way Analysis of Variance (ANOVA). The result of this study showed that the addition of carrageenan gave significant different effect on the physical characteristics such as water holding capacity, cohesiveness, chewiness, and springiness, while not significantly different to the color of fishballs. Sensory test results showed that overall, fishballs with 0.5% addition of carrageenan.*

Keywords-- *arrowroot, carrageenan, fishball*

I. INTRODUCTION

Mackerel tuna is one of the marines catches with a high production volume in Indonesia. Production of Mackerel tuna 552,410 tons in Indonesia in 2015 [1]. However, the utilization of Mackerel tuna as the main ingredient of food products is still limited, therefore product diversifications such as fishballs, nugget, and shredded fish made of Mackerel tuna are needed. A good quality fishballs is influenced by some factors such as appearance, texture, taste, and nutritional value [2]. The use of surimi in the making of fishballs gives the advantage of better gel formation [3] Surimi is fish fillet which has been washed and its water content has been reduced that it is called a wet concentrate protein. Surimi has some superiorities, one of them can be processed into various food products such as kamaboko, meatballs, and nugget [4].

Kappa carrageenan has the ability to form a gel which will increase the springiness that it will create chewy fishballs texture. Carrageenan can also be used to increase the dietary fiber content in the fishballs. Carrageenan has a total dietary of 68.55%, which consists of 32.85% soluble fiber and 35.60% insoluble fiber [5]. This research will study the textural and sensory characteristics of the Mackerel tuna fishballs with arrowroot flour and carrageenan substitution.

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II. MATERIALS AND METHODS

2.1. Materials

The ingredients of surimi are Mackerel tuna (Surakarta, Indonesia), arrowroot (*Maranta arundinacea*) flour (Yogyakarta, Indonesia), tapioca, carrageenan (Surabaya Indonesia), salt, pepper, ice cubes, silica gel, concentrated H_2SO_4, K_2SO_4, $CuSO_3$, NaOH 45%, H_3BO_3 4%, standard HCL 0,02 N solution, methyl red-methyl blue indicator, Zn grain, Aquades.

2.2. Production of Mackerel Tuna Surimi

The production process of Mackerel tuna surimi is carried out by following the procedure of [6].

The process starts by cleaning the fresh mackerel tuna, then filleting the fish in order to take the white fish meat. The fillet is then ground using a blender. Ice cubes are added in the grinding process in order to maintain a temperature of 22°C. After that, the fish meat is washed using 5-10°C water which has been added with 0.3% salt from the weight of the fish meat. The ratio of water and fish meat is 4: 1. The washing is done in 2 times, the time needed for each washing process is 15 minutes. The next process is pressing the fish meat using calico cloth in order to reduce the water content. Sugar as much as 2% of the weight of the fish meat is added, and then the surimi is frozen at a temperature of -20ºC.

2.3. Production of Mackerel tuna fishballs with arrowroot flour and carrageenan substitution

The ingredients of the Mackerel tuna fishballs are Mackerel tuna surimi, tapioca, arrowroot flour, eggs, salt, sugar, pepper, garlic, ice cubes, carrageenan. The formula of mackerel tuna surimi fishballs with arrowroot substitution = F0 (0% carrageenan); F1 (0,5% carrageenan); F2 (1% carrageenan); F3 (1,5% carrageenan). The production process starts by thawing the previously frozen Mackerel tuna surimi. The surimi is then mixed with the ground spices (garlic, salt, sugar, pepper) and eggs, this process is called mixing I. In the process mixing II, tapioca and arrowroot flour are added. In the mixing III, carrageenan is added. Ice cubes are also added until the dough is smooth. The fishballs dough is pressed manually by kneading the dough until it forms a ball with ± 2 cm diameters. Those fishballs are then boiled with 100ºC temperature until they float. Then the fishballs are drained for at least 10 minutes.

2.4. Physical, Chemical, and Sensory Analysis

The analysis of Mackerel tuna fishballs with arrowroot flour and carrageenan substitution: color (Chromameter [8]), *Water Holding Capacity* [9], Texture [10], Water content [7], Ash content [7], Protein content [7], Sensory test [11].

2.5. Data Analysis

The experimental design in this study used Complete Random Design (CRD) of one factor, namely with variation carrageenan addition is 0.5%; 1% and 1.5%. Each treatment was repeated three times sample and three times analysis. All research data were analyzed use SPSS version 24.0. If the results of the analysis show different between treatments then proceed with Duncan's Multiple Range Test (DMRT) at $\alpha = 0.05$.

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III. RESULTS AND DISCUSSION

3.1 Chemical Characteristics of Mackerel Tuna Surimi

Table 1: Chemical Characteristics of Mackerel Tuna Surimi and Mackerel Tuna fishballs with Arrowroot Flour and Carrageenan Substitution

Sample	Water content (% wb)	Ash content (% db)	Protein content(% db)
Mackerel Tuna Surimi	73.75 ± 0.30	3.88 ± 0.02	88.74 ± 3.51
F0	63,53[a] ± 0,03	2,59[a] ± 0,01	42,62[a] ± 4,61
F1	64,33[b] ± 0,13	2,66[b] ± 0,19	44,57[a] ± 4,06
F2	66,36[c] ± 0,13	2,83[c] ± 0,15	48,75[a] ± 4,42
F3	67,90[d] ± 0,09	2,98[d] ± 0,15	50,88[a] ± 5,52

Note : Different notations in the same column show the real difference in $\alpha = 0,05$. The Mackerel tuna fishballs with arrowroot flour substitution, F0 (0% carrageenan); F1 (0.5% carrageenan); F2 (1% carrageenan); F3 (1.5% carrageenan).

According to Table 1, the surimi has a water content of 73.75% (wb), an ash content of 3.88% (db) and protein content of 88.74% (db). The quality of the surimi is determined by the water, ash, and protein content. It is because the surimi is an intermediate product which will later be processed into various food products.

The high water content in Mackerel tuna surimi is caused by the washing process that increases the hydrophilic characteristic of the fish meat. Besides, the high water content is also caused by the water that infiltrates into the tissue due to the inflation of the salt-soluble protein (myofibril). Such a thing happens because of the influence of Cl- ion from the salt (NaCl).

The ash content of the Mackerel tuna surimi is 3.88% (db). The low ash content is influenced by the washing frequency because it reduces the inorganic materials. [12], stated that the mineral content in the Mackerel tuna surimi is considered low. It is because the high mineral content is stored in the inconsumable parts of the fish such as bone, scale, head, viscera, and the fin. The ash content in the fish body generally consists of phosphor, calcium, iron, magnesium, sulfur, sodium and potassium. The protein content of the mackerel tuna surimi-based on the analysis is 23.27% (wb) or 88.74% (db). The protein content is considered high. It is influenced by the ingredients used to make the surimi. FAO (2014) stated that Mackerel tuna has a protein content of 26.2% (wb).

Based on table 2, fishballs F3 has the highest water content (67.90%), and fishballs F0 has the lowest water content (63.53%). [16] in his research stated that tilapia surimi with the addition of 0.5 - 1.5% carrageenan has a water content of 77.95 – 79.53%. The high water content of the fishballs is caused by the washing process. According to [5], kappa carrageenan has insoluble dietary fiber content of 35.60%. The insoluble dietary fiber is known to be able to bind and trap water in the matrix after the gel-forming. The different water content in each treatment is caused by the water trapped in the carrageenan matrix which has been formed when gelatinization occurs in the heating process. It happens because carrageenan contains a sulfate group that can hold water. Based on the results of the analysis, the higher the carrageenan concentration added, the higher the water content of the Mackerel tuna fishballs obtained.

The ash content in the mackerel tuna fishballs with carrageenan addition is 2.59 – 2.98% (db). [3] stated that the water content of sailfish surimi fishballs with the addition of carrageenan was 1.19% (wb). The results of the variant analysis show that the ash content of the four Mackerel tuna fishball formulas with the carrageenan addition is significantly different. The ash content in the Mackerel tuna fishballs with arrowroot flour substitution and carrageenan addition is lower than the ash content in the mackerel tuna fishballs without carrageenan. The low ash content is caused by the washing process in the mackerel tuna surimi production. Carrageenan addition increases the ash content of the fishballs. It is because carrageenan has a considerably high ash content (17.76%).

The results of the analysis show that the protein content of the four fish ball formulas with carrageenan addition is not significantly different. The protein content of the fish ball is about 42.62 – 50.88% (db). Fishballs F3 with the addition of carrageenan concentration of 1.5% has the highest average of protein content, while fishballs F0 without carrageenan addition has the lowest average of protein content. The protein content in the Mackerel tuna fishballs with arrowroot flour substitution and carrageenan is higher than the other fishballs. The increasing protein content is influenced by the carrageenan concentration in the fishballs. The protein in the fishballs comes from the ingredients that consist of mackerel tuna, egg, tapioca, and arrowroot flour. [13] mentioned that protein has the role of holding water, then protein will create compact tissue structures during the boiling process so that those structures can increase the water holding capacity of the fishballs.

3.2 Physical Characteristics of Mackerel Tuna Fishballs with Arrowroot Flour and Carrageenan Substitution.

Table 2: Physical Characteristics of Mackerel Tuna Fishballs with Arrowroot Flour and Carrageenan Substitution.

Formula	Water Holding Capacity (%)	*Cohesiveness*	*Chewiness* (gmm)	*Springiness* (mm)
F0	$61,74^{a} \pm 0,30$	$0,44^{a} \pm 0,12$	$4197,47^{a} \pm 885,98$	$8,51^{a} \pm 0,16$
F1	$67,66^{b} \pm 0,50$	$0,47^{b} \pm 0,01$	$5479,97^{b} \pm 334,69$	$8,68^{ab} \pm 0,15$
F2	$72,72^{c} \pm 0,92$	$0,48^{bc} \pm 0,13$	$5650,69^{b} \pm 297,09$	$8,86^{bc} \pm 0,17$
F3	$78,79^{d} \pm 0,19$	$0,49^{c} \pm 0,21$	$6294,64^{b} \pm 600,90$	$9,00^{c} \pm 0,22$

Note : Different notations in the same column show the real difference in $\alpha = 0,05$. The mackerel tuna fishballs with arrowroot flour substitution, F0 (0% carrageenan); F1 (0.5% carrageenan); F2 (1% carrageenan); F3 (1.5% carrageenan).

According to Table 2, the average water holding capacity of the mackerel tuna fishballs with arrowroot flour and carrageenan substitution is about 61.74 – 78.79%. Fishballs F0 has the lowest WHC value, while fishballs F3 has the highest WHC value. The higher the carrageenan concentration used, the higher the WHC value of the fishballs obtained [20]. Higher carrageenan addition will strengthen the compactness of the gel matrix and reduce the hollow structures that cause the decrease of the springiness of a material [14]. [15] in his research mentioned that carrageenan has the ability to absorb water so that it can create a compact texture and increase the water holding capacity. Fishballs with carrageenan addition have a better ability to hold water compared to fishballs without carrageenan addition. In this research, 25% arrowroot flour is used as the substitution of tapioca flour.

Arrowroot flour contains high protein. Furthermore, the protein content in a particular food ingredient influences its water holding capacity. Protein has the role to hold water, where protein creates compact tissue during the fishballs cooking process so that it increases the water holding capacity. The protein content of the fishballs is parallel to the WHC value. The higher the protein content in fishballs is, the higher the water holding capacity will be. Arrowroot flour and carrageenan are the supporting and additional ingredients of the fishballs which have a considerably high fiber content. [5] stated that carrageenan has a soluble fiber content of 32.85%. The soluble fiber consists of pectin, gum, mucilage, glycan, and algae.

Cohesiveness, chewiness, and springiness are the parameters of texture analysis in this research. Cohesiveness shows how far the fishballs can change shape before breaking or how well the fishballs can withstand the pressure from the teeth [16]. The better the fishballs withstand, the bigger the cohesiveness of the fishballs will be. Fishball F3 has the highest cohesiveness and fish ball F0 has the lowest. The results of the variant analysis show that adding carrageenan to the fishballs give real effects ($P<0.05$) to the cohesiveness value. The higher the carrageenan concentration added, the higher the cohesiveness value obtained. It is because the carrageenan has the water-absorbing ability so it creates compact and solid textures [15]. Higher carrageenan addition will make the gel matrix more compact and reduce the hollow structures thus making the fishballs solid or cohesive [17].

Besides carrageenan, the use of filler also influences the cohesiveness of the fishballs. In this research, 25% arrowroot flour is used as the substitution of tapioca flour. The percentage of arrowroot is based on the tapioca flour base. The cohesiveness value of the fishballs with carrageenan is 0.44 – 0.49. The range of numbers shows that the percentage of addition of tapioca flour and arrowroot flour provides less compact textures of the fishballs. [18] mentioned that such a thing is caused by the amylose and amylopectin content in the ingredients. Amylose plays a role in the gelatinization of starch which can increase the gel strength of the fishballs because of the molecule durability in the granules increases.

Based on Table 2 the chewiness value of the fishballs with carrageenan addition is 4197.47 – 6294.64 gmm. Fishballs F3 has the highest chewiness, while fishballs F0 has the lowest. Fish ball F1 is significantly different with fishball F0, but it is not significantly different with fishballs F2 and F3. The chewiness difference in each fishballs is influenced by the filler and additives used, and the water addition during the fishballs production. Carrageenan addition gives a positive effect to the fishballs' chewiness because carrageenan creates a good bond with water and protein, so the fishballs can withstand external pressure. [15] supported this fact, he mentioned that the water content in the fishballs influence the chewiness level that is caused by water, fat and the availability of protein extraction resulting in emulsions, so the fishballs become more compact and cannot easily break that they have a high value of chewiness. The starch contains amylose, which means that the higher the amylose content is, the higher the chewiness value will be. Springiness is the ability of fishballs to get to their original shape after experiencing the first pressure until the second pressure begins [16]. If the fishballs return to their original position after being put under pressure, the fishballs has a high springiness value. Based on table 2, the springiness value of the fishballs with carrageenan addition is about 8.51 – 9.00 mm. Fishballs F3 has the highest springiness value, while fishballs F0 has the lowest.

3.3 Color test of Mackerel Tuna Fishballs with Arrowroot Flour and Carrageenan Substitution.

Table 3: Color Characteristics of Mackerel Tuna Fishballs with Arrowroot Flour and Carrageenan Substitution.

Formula	L*	a*	b*	°Hue
F0	53,55[a] ± 2,47	5,26[a] ± 0,13	12,36[a] ± 0,62	85,04[a] ± 0,40
F1	54,25[a] ± 1,99	5,71[a] ± 0,39	12,82[a] ± 0,21	84,52[a] ± 0,18
F2	54,39[a] ± 3,14	5,76[a] ± 0,43	12,93[a] ± 0,87	84,41[a] ± 0,63
F3	54,50[a] ± 1,60	5,78[a] ± 0,21	13,10[a] ± 0,91	84,16[a] ± 0,65

Note: Different notations in the same column show the real difference in α = 0,05. Scale of score: 1 = very like, 2 = like, 3 = rather like, 4 = rather dislike, 5 = dislike, 6 = very dislike. Formula of mackerel tunafishballs with carrageenan, F0 (0% carrageenan); F1 (0.5% carrageenan); F2 (1% carrageenan); F3 (1.5% carrageenan).

The four fishballs formulas are not significantly different, the addition of carrageenan does not have an effect on the Hue value of fishballs. °Hue value will decrease with increasing carrageenan concentration.

3.4 Sensory Characteristics of Mackerel Tuna Fishballs with Arrowroot Flour and Carrageenan Substitution.

Table 4: Sensory Evaluation of Mackerel Tuna Fishballs with Arrowroot Flour and Carrageenan Substitution.

Formula	Warna	Aroma	Flavor	Tekstur			*Overall*
				Cohesiveness	*Chewiness*	*Springiness*	
F0	3,24[a]	3,08[a]	3,00[a]	3,40[c]	3,20[a]	3,40[b]	3,28[a]
F1	3,16[a]	3,24[a]	3,04[a]	2,96[ab]	3,00[a]	2,88[a]	2,96[a]
F2	3,20[a]	3,12[a]	2,96[a]	2,80[a]	3,08[a]	2,72[a]	2,92[a]
F3	3,28[a]	3,20[a]	2,92[a]	3,24[bc]	2,96[a]	3,08[ab]	3,10[a]

Note: Different notations in the same column show the real difference in α = 0,05. Scale of score: 1 = very like, 2 = like, 3 = rather like, 4 = rather dislike, 5 = dislike, 6 = very dislike. Formula of mackerel tunafishballs with carrageenan, F0 (0% carrageenan); F1 (0.5% carrageenan); F2 (1% carrageenan); F3 (1.5% carrageenan).

Overall tuna mackerel fishballs added carrageenan shows values that are not different between samples. Overall, F1 meatballs are meatballs that are preferred by panelists. F1 meatballs have color, aroma, and flavor that tends to be the same as R fishballs because addition of carrageenan did not significantly affect the three parameters that is. In cohesiveness and springiness parameters, F2 fishballs too the most preferred by panelists because it has a compact texture and springiness.

IV. CONCLUSION

Carrageenan addition gives significantly different effects to the water holding capacity (WHC), cohesiveness, chewiness, and springiness but does not give significantly different effects to the color characteristic of the fishballs. Based on the scoring test of the mackerel tuna fishballs with arrowroot flour substitution and carrageenan addition, fishballs of 0.5% carrageenan is most preferred by panelists. The chemical characteristics of the mackerel tuna fishballs with arrowroot flour substitution and carrageenan addition has a parallel relation with the textural characteristics.

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