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THE EFFECT OF ADDITION SWIMMING CRAB SHELLS FLOUR *(Portunus pelagicus)* FOR PHYSICAL AND CHEMICAL QUALITY OF EDIBLE SPOON

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ABSTRACT

Edible spoon product is a spoon-shaped cutlery that is fit to be eaten, this product was developed with the addition of alginate, however, it required high-cost raw material. Swimming crab shells were potential waste from underused swimming crabs which contained calcium carbonate ($CaCO_3$) to strengthen the tissues, sources of calcium minerals, and formed edible spoon mixture. Swimming crab shells flour was the addition to the physicochemical quality of edible spoon and the best concentration for the product. This research utilized a completely randomized design (CRD) with different concentrations of swimming crab shell flour (0%, 8%, 10%, and 12%). The data were carried out with ANOVA and Tukey's HSD. The results showed that the addition of different swimming crab shell flour concentrations has a significant effect (P<5%) on the hardness parameters, melting time, hedonic properties, protein content, moisture content, carbohydrate content, and ash content except on fat content. The best concentration was 12% swimming crab shells flour with a hardness value of 10.32 ± 0.60 kgf, melting time of 15.02 ± 0.44 minutes, moisture content of 2.65 ± 0.24%, protein content of 8.31 ± 0.23%, carbohydrate content of 83.64 ± 0.29% , fat content of 1.42 ± 0.40% and ash content of 3.66 ± 0.06%. Edible spoon preferably has a hedonic value of 7.97 <µ <8.37 for appearance, odor, taste, and texture parameters.

Keywords*:* Alginate; biodegradable; calcium; edible spoon; swimming crab shells

INTRODUCTION

The increase in single-used plastic directly proportional to technology, industry, and population. This occurred by the reason of plastic was lightweight, practical, economical and could replace the function of items such as glass plates, stainless steel spoons and other household appliances. These characters caused a high usage of nondegradable plastic waste (Olusunmade, 2019).

Edible spoon was a spoon-shaped tableware that could be eaten immediately. Edible spoon made with simple ingredients such as rice flour, wheat flour, and sorghum flour, which formed into a spoon-like food product (Natarajan et al. 2019). Edible spoon was also developed by Puspitasari (2018) by replacing raw material such as wheat flour and adding additional ingredients such as alginate. The addition of alginate predicted improve the texture of edible spoon. Alginate is known to act as plasticizer, surfactant, antibrowning agent. Alginate as edible film can improve the texture of fruit (Parreidt et al. 2018). However, alginate has a quite high price, it reached Rp 500,000 / kg in 2020 so that the product would be more expensive. Therefore, we could decrease the alginate usage but still have a similar function as it.

Swimming crab shells was an underrated potential waste of pasteurization processing. The processing of crab shell waste in addition to increasing factory income also decreased the costs and produced less waste output and minimal levels of pollution. Swimming crab shells contained high minerals, especially calcium (19.97%), phosphorus (1.81%) and chitin (20-30%) (Gadgey and Bahekar, 2017). Calcium crab shell flour was also included in the group of calcium carbonate ($CaCO_3$) which was needed by the body in large quantities. The main function of $CaCO_3$ was to strengthen tissues, provide alkaline conditions, source of calcium minerals (Koroleva et al. 2017; Yanuar, 2013), so it can form an edible spoon mixture. Based on the explanation above, this research conducted on the production of new edible spoon compositions by adding swimming crab shell flour to reducing the alginate usage and improve the quality of edible spoon products.

The manufacture of edible cutlery with crab shell flour has never been done yet. Crab shell flour has been used for fortification in food products to increase calcium content. Hapsoro et al. (2017) stated that the higher the addition of crab shell flour, the higher the calcium content in the product. It would affect the texture of the product, which is getting harder. Beybidanin et al. (2016) used various concentration 5%, 10%, and 15%, these were calculated from the total amount of material before adding water. The result showed that the addition of crab shell flour by 15% in a product has panelists' preference at dislike level. Khasnah and Hartati (2016) also stated that the addition of 10% of crab shell flour could increase the proximate content. Based on these statements, the best concentration of adding crab shell flour is necessary to produce a hard texture of edible spoon, favored by panelists and has high nutritional content. Thus, for the first time carried out in this study.

The purpose of this research was to determine the effect of adding different concentrations of swimming crab shell flour to the physical and chemical quality of edible spoon products (hedonic, hardness, melting time and proximate content) and to determine the best concentration of swimming crab shell additions to edible spoon products.

RESEARCH METHODS

Materials

Swimming crab shells obtained from one of the swimming crab stripping miniplant in Betah Walang Village, Bonang District, Demak Regency, Central Java. Alginate flour is obtained from CV. Total Equipment Pharmacy, Semarang. Other raw materials included wheat flour, rice flour, sugar, salt and water. The materials used in the analysis were selenium, concentrated H_2SO_4, distilled water, 40% NaOH, H_3BO_3, indicators (MR and BCG), 0.1 N HCl and N-hexane. The tool we used were cooking utensils, analytical scales, pans, thermometers, Texture analyzers (Brookfield, USA), waterbath (Memmert, Germany), Kjedahl flasks, Soxhlet, desiccators, saucers, porcelain cups and furnaces.

Making Swimming crab shell Flour

Swimming crab shell flour was made based on Yanuar (2013) with modification. Swimming crab shells were boiled at 100 °C for 30 minutes to facilitate cleaning of the remnants of meat, dried using an oven (Memmert, Germany) with a temperature of 70° C for 8 hours, and reduced in size to 1-2 cm. Grinder process (Ballmill, Tencan, China), sifting with a size of 80 mesh and stored in plastic at room temperature.

Making Edible Spoon with Addition of Swimming Crab Flour

The method of making edible spoon refers to the research of Puspitasari (2018) which was modified on the materials of its manufacture. The best formulation obtained from preliminary research was the addition of 1% alginate concentration and 10% swimming crab shell flour concentration. So that the addition of alginate was used as a control and a range of concentrations of swimming crab shell flour was selected, which was 8%; 10%; and 12%. All ingredients were mixed until evenly (smooth), the dough was ground using a grinding tool (Nagako, Indonesia) so that it has the same thickness. The dough sheet was printed using an iron mold that has a spoon-like shape. The mold has a length of about 14 cm, a width of under 4.5 cm, and a width of 2 cm. Then placed on a stainless steel spoon to maintain the shape of the spoon arches and roasted with a temperature of ± 150 ° C for 25 minutes. The edible spoon formulation with the addition of swimming crab shell flour were presented in Table 1.

Table 1. Formulation of Edible Spoon

No	Materials	Treatments (%)							
		0		8		10		12	
		Weight (g)	%	Weight (g)	%	Weight (g)	%	Weight (g)	%
1	Swimming Crab Shell Flour	0	0	8	8	10	10	12	12
2	Alginate	1	1	1	1	1	1	1	1
3	Wheat flour : Rice flour 1:1)	94	94	86	86	84	84	82	82
4	Sugar	3	3	3	3	3	3	3	3
5	Salt	2	2	2	2	2	2	2	2
	Total	100	100	100	100	100	100	100	100

Analysis

Tests for edible spoon included hardness (AOAC, 2007), melting time (Puspitasari, 2018), hedonic test with 30 panelist. The hedonic test is carried out with 9 scales, namely 1 = very, very dislike, 2 = very dislike, 3 = dislike, 4 = somewhat disliked, 5 = neutral, 6 = rather like, 7 = like, 8 = very like , and 9 = very, very like (National Standardization Agency, 2006), moisture content (AOAC, 2007), protein content (AOAC, 2007), carbohydrate content (AOAC, 2007), fat content (AOAC, 2007) and ash content (AOAC, 2007).

Statistics

The experimental design used was a completely randomized design (CRD) with 4 treatments 3 replications. Treatment A (addition of swimming crab shell flour 0%), Treatment B (addition of swimming crab shell flour 8%), Treatment C (addition of swimming crab shell flour 10%) and Treatment D (addition of swimming crab shell flour 12%). Data from observations of hardness test, melting time test, hedonic test and proximate test obtained were analyzed normality and analysis of variance (ANOVA) and BNJ advanced test, while the hedonic test was analyzed by Kruskall-Wallis and Mann-whitney tests using SPSS 16 with P <5%.

RESULTS AND DISCUSSION

Edible Spoon Hardness Value

The results of hardness value test on edible spoon with the addition of various concentration of swimming crab shell flour were presented in Table 2.

Table 2. Edible Spoon Hardness Value

Treatment	Hardness (kgf)
A	3.97 ± 0.49^a
B	7.77 ± 0.31^b
C	9.02 ± 0.14^c
D	10.32 ± 0.60^d

Note : Data followed by different superscript letters in the same column shows significant differences between treatments (P<0.05)

In the treatment with the addition of swimming crab shell flour, the level of hardness rised with the addition of 1concentration. The texture of the product added with swimming crab shell flour tended to be harder because swimming crab shell contains calcium carbonate, which is a component of chitin in the shell. Calcium carbonate is able to release Ca^{2+} ions capable of forming bonds in the network, which increases hardness (Gadgey and Bahekar, 2017; Gao et al., 2019). The hardness texture of the edible spoon due to the increasing addition of crab shell flour. The results in this study were consistent with Lovera et al. (2014), which stated that the higher the calcium concentration, the harder the papaya fruit. Rahma et al. (2019) also stated that the addition of swimming crab shell can enhance the hardness of wet noddles because the swimming crab shell in the formulation can affect the water content which affect the gelatinitation process.

The hardness level of edible spoon influenced by the bond between the content of swimming crab and alginate flour. Calcium contained in swimming crab shells was able to bind with guluronic acid in alginate and provide a linking area for cross bonds between alginate molecules (Husni et al. 2012).

When alginate was dissolved or mixed with water, it would increase the viscosity which would be shaped like a gel with the addition of calcium to the solvent of sodium alginate. Gel was formed due to chemical reaction, in that process calcium replaced the sodium of alginate and bind to the alginate molecule. This process didn't require heat and the gel that formed would not melt if heated (Liu et al. 2016).
Texture was related to the water content. The decreased of water content inversely proportional with the increased concentrations of swimming crab shell flour. During the roasting process, the material would vanish and result in water content decreased. According to Diniyah et al. (2012), roasting time would cause an increase in viscosity. This due to the water that evaporated and the total dissolved solid would increase, this occurred an increasing viscosity. In addition, the increasing viscosity was also influenced by the concentration or molecular weight. It occurred in harder product texture.The results of this research were comparable to similar products in the research of Hapsoro et al. (2017), the hardness value of cookies with the addition of swimming crab shell flour was influenced by its constituent ingredients. The higher concentration of swimming crab shell flour would increase the hardness of cookies.

Edible Spoon Melting Time

The results of melting time test on edible spoon with the addition of various concentration of swimming crab shell flour were presented in Table 3.

Tabel 3. Edible Spoon Melting Time

Treatment	Melting Time (minutes)
A	6.05 ± 0.47[a]
B	10.08 ± 0.51[b]
C	12.10 ± 0.45[c]
D	15.02 ± 0.44[d]

Note : Data followed by different superscript letters in the same column shows significant differences between treatments (P<0.05)

In the treatment with the addition of swimming crab shell flour, the length of melting time increased with the addition of concentration. It is related to the content of the crab shell, which can increase the hardness along with the increasing concentration of the crab shell flour. Different results were showed by Puspitasari et al. (2018), who made an edible spoon with alginate and the test result showed edible spoon melting time was 15.38 minutes.

The hardness level of a food product affected the melting time (changed in the shape of solid products to liquid) of the product. Under certain conditions, melting ability was a good benchmark for the quality of edible spoon products. Determination of the melting time was done by calculating the time needed for the product to melt or disintegrate when placed in water at a temperature of 70 ° C. When edible spoon products bind with water, the water will diffuse into the product so the texture would be soften and the hardness was decreased (Puspitasari, 2018).

The high index of water absorption could reduce the level of hardness due to the more water absorbed, the product would be softer. This also occurred in an edible spoon with the addition of swimming crab shell flour where the higher this addition, the lower water content inside the edible spoon, which could be interpreted the higher the value of hardness. The water solubility index also has the same effect, if the water solubility index is high then the level of hardness would decrease and become easily destroyed (Atukuri et al. 2019).

Moisture Content

The results of the analysis of edible moisture content were presented in Table 4.

Table 4. Moisture Content of Edible Spoon

Treatment	Moisture Content (%)
A	5.82 ± 0.25[c]
B	3.84 ± 0.28[b]
C	2.95 ± 0.33[a]
D	2.65 ± 0.24[a]

Note : Data followed by different superscript letters in the same column shows significant differences between treatments (P<0.05)

The moisture content product determined by the moisture content compound of the raw material (Pratama et al. 2014). According to Agustini et al. (2011), the higher the concentration of shell flour added, the smaller the moisture content due to the addition of shell flour resulted in a reduction in the use of wheat flour in the dough so that it would reduce the water binding capacity.

During roasting process, some water evaporated from the biscuit dough. The baking conditions required for the biscuits would not be the same because the way the structure were formed and the amount of moisture content that must be reduced depends on the formulation. One of the differences that could be seen in the baked biscuit dough was to reduce the moisture content up to 1-4%. During this roasting process, there was also moisture content loss from the surface of the product by evaporation followed by the transfer of water to the surface which was constantly being lost to the oven environment (Guiné, 2018).

Protein Content

Swimming crab shells contain high protein. Edible spoon protein levels with the addition of different concentrations of swimming crab shell flour were presented in Table 5.

Table 5. Protein Content of Edible Spoon

Treatment	Protein Content (% wb)	Protein Content (% db)
A	5.93 ± 0.41[a]	6.29 ± 0.42[a]
B	6.30 ± 0.25[ab]	6.56 ± 0.27[ab]
C	6.93 ± 0.29[b]	7.14 ± 0.31[b]
D	8.09 ± 0.23[c]	8.31 ± 0.23[c]

Note : Data followed by different superscript letters in the same column shows significant differences between treatments (P<0.05)

Swimming crab shells contain high protein. According to Yanuar (2013), protein content in swimming crab shell waste was 15.80%. Even distribution of water also caused an increase in the concentration of dissolved solids in materials including proteins. According to Prayoga et al., (2015), in accordance with a study of ice cream cones, that the high levels of protein were caused by the high addition of swimming crab shell flour to ice cream cones.

Protein increased level of the edible spoon caused the color changed into brown due to swimming crab shells protein content that would pass through the Maillard reaction during the roasting process, this also related to the water content of the material. According to Abraha et al. (2018), a decrease in water content would cause the protein content in the material to increase. The use of heat in food processing could reduce the percentage of water content which caused the percentage of protein content to increase. The drier a material, the higher its protein content.

Carbohydrate Content

The results obtained from the addition of different concentration of swimming crab shell flour has a significant effect on the carbohydrate content. The results of the analysis of carbohydrate content were presented in Table 6.

Table 6. Carbohydrate Content of Edible Spoon

Treatment	Carbohydrate Content (% wb)	Carbohydrate Content (% db)
A	86.41 ± 0.62^{c}	86.02 ± 0.67^{c}
B	85.79 ± 0.47^{b}	85.37 ± 0.49^{b}
C	85.64 ± 0.86^{b}	85.07 ± 0.91^{b}
D	84.32 ± 0.26^{a}	83.64 ± 0.29^{a}

Note : Data followed by different superscript letters in the same column shows significant differences between treatments (P<0.05)

Analysis of edible spoon carbohydrate content in treatment A (without the addition of swimming crab shell flour) has an average carbohydrate content of 86.02%, while edible spoon products added with swimming crab shell flour has an average carbohydrate content of 83.64% to 85.37%. In the treatment with the addition of swimming crab shell flour, carbohydrate content decreased with the addition of different concentration.

The carbohydrate content in edible spoon mainly come from wheat flour and rice flour. Carbohydrate value in edible spoon added with swimming crab shell flour were lower than the without addition treatment. This was due to the increasing addition of concentrations of swimming crab shell flour would reduce the composition of wheat flour and rice flour in the dough. Carbohydrate levels calculated by different treatment were influenced by other nutritional components. The lower the other nutritional components (water, ash, fat, protein), the higher value resulted of carbohydrates. Carbohydrate content in wheat flour was around 73.38% (Hyacinthe et al. 2018).

Fat Content

The results obtained from the addition of different concentration of swimming crab shell flour has a significant effect on the fat content. The results of the analysis of fat content were presented in Table 7.

Table 7. Fat Content of Edible Spoon

Treatment	Fat Content (% wb)	Fat Content (% db)
A	0.84 ± 0.62^{a}	0.89 ± 0.51^{a}
B	1.12 ± 0.21^{a}	1.17 ± 0.20^{a}
C	1.26 ± 0.67^{a}	1.29 ± 0.63^{a}
D	1.38 ± 0.81^{a}	1.42 ± 0.40^{a}

Note : Data followed by the same superscript letters in the same column shows no significant differences between treatments (P<0.05)

The concentration added of swimming crab flour did not affect the fat content (Table.8). This occurred due to the other nutrients such as protein and ash in the proximate test increased because of the addition of swimming crab shell flour. The fat content in edible spoon with the addition of swimming crab shell flour were influenced by its composition namely shortening and natural fat content contained from swimming crab shell as raw material for shell flour (Pratama *et al*. 2014). Fat content contained in swimming crab shell flour has a low number as raw material.

Ash Content

The results obtained from the addition of different concentration of swimming crab shell flour has a significant effect on the ash content. The results of the analysis of ash content were presented in Table 8.

Table 8. Ash Content of Edible Spoon

Treatment	Ash Content (% wb)	Ash Content (% db)
A	0.99 ± 0.05^{a}	1.05 ± 0.05^{a}
B	2.94 ± 0.06^{b}	3.06 ± 0.07^{b}
C	3.22 ± 0.09^{c}	3.32 ± 0.09^{c}
D	3.56 ± 0.05^{d}	3.66 ± 0.06^{d}

Note : Data followed by different superscript letters in the same column shows significant differences between treatments (P<0.05

The high amount of ash content in the crab shell indicated the high amount of mineral content in the crab shell, ranged from 6.89 - 15.95% (Pratama *et al*. 2014). Swimming crab shells have a high mineral content, so the addition of swimming crab shell flour would also cause high levels of edible spoon ash content. Haryati et al. (2019) stated that mineral composition of crab shell waste was calcium 93.00%, phospor 4.07% and others 2.93%. Ash content of a substance related to the mineral content found in food (Kusumaningrum and Asikin, 2016).

The results of this research were comparable to similar products in Khasanah and Hartati, (2016) research, the higher the addition of swimming crab shell flour in the formulation of noddle, the higher the ash content. This due to the raw material used between different formulation noddle with noddle control, where in addition to using wheat flour noddle control formulations used wheat flour only.

Hedonic Characteristics

The results of hedonic test on edible spoon with the addition of various concentration of swimming crab shell flour were presented in Table 9.

Appearance

The appearance parameters of edible spoon without the addition of crab shell flour was received by the panelists at a neutral level to slightly like. The edible spoon with the addition of crab shell flour was received by the panelists at the like to very like level, where the edible spoon with the addition of 10% crab shell flour was no different than the edible spoon with the addition of crab shell flour 12%. The addition of swimming crab shell flour caused the appearance of edible spoon to be speckled and brownish in color due to the brown pigment contained in the crab shell. According to Yanuar (2013), swimming crab shells contained chitin, protein, $CaCO_3$ as well as a small amount of $MgCO_3$ and astaxanthin pigments. The color produced in each treatment tends to brown, this was also due to the process of baking the dough causing Maillard reactions. Maillard reaction was a reaction between carbohydrates, especially sugars with primary amino groups. The results of this reaction were brown products (Ladamay & Yuwono, 2014).

Table 9. Hedonic Data of Edible Spoon

Treatment	Parameters				Average
	Appearance	Odor	Taste	Texture	
A	5.83 ± 1.29[a]	6.03 ± 1.13[a]	6.03 ± 1.27[a]	6.10 ± 1.10[a]	6.10 ± 1.20[a]
B	7.10 ± 0.99[b]	7.27 ± 1.01[b]	6.90 ± 1.49[b]	7.10 ± 1.32[b]	7.09 ± 1.20[b]
C	8.00 ± 0.83[c]	7.67 ± 1.03[b]	7.47 ± 1.01[b]	7.73 ± 1.08[c]	7.71 ± 0.99[b]
D	8.33 ± 0.80[c]	8.03 ± 0.85[b]	7.97 ± 0.72[c]	8.33 ± 0.71[d]	8.17 ± 0.77[c]

Note : Data followed by different superscript letters in the same column shows significant differences between treatments ($P<0.05$)

Odor

Based on odor parameters, the edible spoon without the addition of crab shell flour was received by the panelists at the slightly like level, while the edible spoon with the addition of crab shell flour was received by the panelists at the like to very like level. Edible spoon with the addition of swimming crab shell flour has a specific odor but there was not much difference between concentrations. This due to the odor of the swimming crab shell flour was not too strong, so the odor that raised in all treatments were specifically in general and there was no real differences. Beybidanin *et al*. (2016), the odor produced from cheese sticks with the addition of swimming crab shell flour has a distinct odor due to the swimming crab shell flour added.

Taste

The taste parameters of edible spoon with the addition of 10% and 12% crab shell flour was accepted by panelists with a like to very like level. The results obtained from the addition of swimming crab shell flour significantly affected the taste of edible spoon. The taste of edible spoon has a significant difference between treatments A, B, C and D. Enhancement concentration of swimming crab shells flour on the hedonic test value did not always have significantly different results, this result was comparable to the research of Hapsoro *et al*. (2017) which stated that the addition of swimming crab shell flour did not have a significant effect on cookies taste. However, in this study, the addition of swimming crab shell flour caused a slightly gritty taste and has a distinctive savory taste of crab, this flavor comes from the amino acids in the crab shell. Sarower et al. (2012) stated that the amino acids glycine, proline, arginine, and taurine cause special flavor in the crab. It concluded that the taste of edible spoon was influenced by the addition of swimming crab shell flour.

Texture

Based on texture parameters, edible spoon with the addition of crab shell flour of 10% and 12% was received by panelists with a like to very like level, compared to the edible spoon without the addition of crab shell flour, which was only accepted by panelists at somewhat like level. The results obtained from the addition of swimming crab shell flour has a significant effect on the texture of the edible spoon. The edible spoon texture has significant differences between treatments A, B, C and D. The increased of hardness value indicates implies that the texture was getting denser and less crispy compared to products that have a lower hardness value. According to Najibullah *et al*. (2013), the addition of fish bone flour to fishery products could increase its hardness value. The level of hardness was influenced by the degree of gelatinization, degree of development, water solubility index and water absorption index. The higher degree of starch gelatinization would cause a higher degree of development, so that the value of hardness decreased.

CONCLUSION

The addition of different concentrations of swimming crab shell flour has a significantly different effect on physical quality (hardness, melting time, hedonic) and chemical quality (protein, carbohydrate, lipid, water and ash contents) of edible spoon product. The addition of 12% swimming crab shell flour has the best amount with a hardness value: 10.32 ± 0.60 kgf, melting time: 15.02 ± 0.44 minutes, protein content: 8.31 ± 0.23%, carbohydrate content: 77.40 ± 0.32%, lipid content: 1.42 ± 0.40%, water content: 2.65 ± 0.24% and ash content: 9.57 ± 0.34%.

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