Organoleptic, Chemical, and Microbial Characteristics of Extrudate Products from the Synthesis of Shrimp Shell and Milk Bones Waste as a High Source of Protein and Calcium

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Abstract
The high level of shrimp and milkfish commodity waste which is not managed further in the small and medium enterprise industry in East Java can cause various problems, one of which is the aspect of health and environmental pollution. Therefore, innovative efforts are needed to manage this waste by turning it into an extruded snack product. This research will use an experimental study by starting with the synthesis of shrimp shell and bone waste into flour which is then mixed with corn granules and processed using an extruder machine according to the specified formulation (70:30, 50:50, 30:70). After that, the extrudate product will be analyzed in the laboratory to carry out organoleptic tests, chemical tests and microbial tests. The organoleptic test results obtained were then analyzed using the variance analysis method and the Duncan advanced test, while the chemical test and microbial test results were carried out with descriptive analysis by comparing the SNI 01-2886-2015 standard regarding extruded snacks. The results of this research describe the organoleptic, chemical and microbial characteristics of the extrudate product from the synthesis of milkfish bone shrimp shell waste combined with corn granules based on the specified formulation, namely with proportions of 70:30, 50:50, 30:70 so that it can be determined which formulation is best.

Keywords: Snack, Extrudate, Milkfish Bone Shrimp Skin Flour, Organoleptic Test, Chemical Test, Microbial Test

1. Introduction

East Java Province has extraordinary potential in the fisheries sector. According to the Central Statistics Agency (2021), fisheries cultivation in East Java in 2020 reached 1,264,159 tons. One of the largest contributors came from pond cultivation amounting to 259,899 tons. Gresik and Sidoarjo districts are one of the largest pond cultivation centers in East Java with a contribution of 60% of the total pond area in East Java, namely 15,601 Ha and 15,220 Ha so that the region is able to produce very high production values (East Java Maritime Fisheries Service, 2020). Some examples of cultivated products from the fisheries sector are shrimp and milkfish. In the downstream industry, these commodities are processed into various food products such as smoked milkfish, presto milkfish, milkfish brains, crackers and shrimp paste which can be produced up to 75,085.8 tons (Indonesian Creative Economy Agency, 2020). However, it is quite unfortunate that the increase in the culinary sector and fisheries cultivation in this region has not been accompanied by good waste management so that it has the potential to become an environmental pollutant. Milkfish and shrimp waste in Sidoarjo Regency according to Muzaki et al (2021) can reach 450 kg/month in the form of bones or spines, while according to Hilkias et al

(2017) shrimp waste in the form of heads, skin, legs and tails reaches 4%, namely 494.8 tons/year. On the other hand, waste shrimp shells and milkfish bones apparently have the potential to become functional food through high nutritional content such ascrude protein (39.62%), ash (30.82%), crude fiber (21.29%), calcium (15.88%), chitin (15.24%), water (8.96%), crude fat (5.43%), BETN (2.92%) and phosphorus (1.90%) in shrimp shell flour products (Mirzah and Filawati, 2013) and protein content (53.47%), carbohydrates (28, 53%), calcium (20.84%), water (8.97%), ash (8.84%) and fat (0.19%) in milkfish bones (Marthadinata, 2019) so that it can provide benefits for the body such as forming new tissue, maintaining existing tissue, growing bones and teeth, regulating muscle reactions and maintaining body growth (Fitri et al, 2016).

Therefore, to reduce the high waste of shrimp shells and milkfish bones, massive and innovative efforts are needed through innovation in processing highly nutritious food using an extrusion process which is usually called extrudate/snack. According to SNI 2886:2015, extruded snacks are ready-to-eat snacks made from food sources of carbohydrates and proteins through an extrusion process with or without the addition of other food ingredients with a raw material composition made from food sources of carbohydrates and proteins in the form of grains, grits, powder or flour. Sloan (2021) reports that there will be an increase in snack consumption by 46% in 2021. The high rate of snack consumption is due to the product's characteristics which are crunchy, practical and can indirectly be an effort to release stress. However, some snack manufacturers add MSG and preservatives which are not good for health. This is proven by the results of the P2MI survey (Indonesian Monosodium Glutamate & Glutamic Acid Factory Association) which explains that MSG consumption in Indonesia has increased from 100,568 tons to 122,966 tons where snacks contain an average of 200 mg. Consuming MSG that exceeds the maximum limit can cause health problems, one of which is malnutrition (Cahyani, 2020). So it is not surprising that Indonesia becoming the country with the highest level of malnutrition in Southeast Asia, reaching 17.7 million people in 2021 (Ahdiat, 2022). From the above background, the research team developed an extrudate product made from the synthesis of shrimp shell waste and milkfish bones combined with corn flour as an alternative extrudate food that is rich in nutrition and free from MSG and other dangerous food ingredients. The product results are then subjected to organoleptic testing, whereis a test based on the sensing process including color, aroma, texture and taste (negara et al., 2016); chemical tests which are tests using chemical analytical methods such as proximate and macro-micro nutrients (Mukti, 2021); as well as microbiological tests which aim to determine dangerous microbial contamination.

2. Research Method

The tool used in this research is blender, oven, pressure cooker, flour sifter, digital scale, plastic box, flour shovel, silicone solet, stainless tray, aluminum foil, extrudate printing machine, a organoleptic test kits, proximate test kits, calcium test kits and food microbial test kits. Meanwhile, the material used in the research is corn starch obtained from an agricultural shop in Sidoarjo, shrimp shells obtained from a shrimp waste warehouse in Sidoarjo, and milkfish bones obtained from the otak-otak Mrs. Muzanah Gresik.

This research is a type of experimental research supported by quantitative data for the results of characteristic tests of extrudate products made from synthetic waste shrimp shells and milkfish bones combined with corn flour. Organoleptic test data were analyzed using analysis of variance (ANOVA) with a Duncan's advanced test level of 5%, where the combination formula of corn flour, shrimp shell flour and milkfish bone flour was symbolized by P530 (30% shrimp shell flour, 70% milkfish bone flour), P195 (50% shrimp shell flour, 50% milkfish bone flour), and P823 (70% shrimp shell flour, 30% milkfish bone flour). The number of panelists used was 31 people with the criteria being untrained panelists (contractor workers working within PT. Unilever Rungkut Surabaya). The parameters observed in the organoleptic test are color, aroma, texture and taste using a hedonic scale of 1 (very dislike) to 7 (very like). Furthermore, the chemical test parameters in this study are by carrying out proximate tests (ash content, fat content, total energy, carbohydrate content, protein content, water content) and calcium tests, while the microbial test parameters in this study are total plate number (ALT), E. coli, Salmonella sp., Staphylococcus aures, and Vibro cholerae. The chemical test and microbial test data obtained were then analyzed descriptively by comparing the test results obtained with the SNI 01-2886-2015 standard regarding extruded snacks and discussed in accordance with the relevant literature.

Process for Making Extruded Snacks from Corn Flour, Shrimp Skin and Milkfish Bones

This research began with the preparation of the main ingredients, namely waste shrimp shells and milkfish bones, which were washed and dried naturally, then the milkfish bones were pressure-cooked for 1 hour, resulting in a soft texture. The process continues with an oven at a temperature of 200 ^{o}C for 1 hour, after that it is milled using a blender so that it becomes coarse flour and continues with sieving to obtain fine flour. The manufacture of extruded snacks is carried out at UPTI Makanan, Minuman dan Kemasan in East Java, starting with mixing the main raw materials, namely corn flour with shrimp shell flour and milkfish bone flour with a composition of 90%: 10%. The mixed ingredients are then fed into the extruder which will then undergo an extrusion process to produce extruded snacks with extrusion machine specifications, namely cylinder 1 temperature 39 ^{o}C, cylinder 2 temperature 56 ^{o}C, cylinder 3 temperature 81 ^{o}C, cylinder 4 temperature 88 ^{o}C, adapter temperature 115 ^{o}C , cutter rotation speed 0 rpm, feeder rotation speed 8 rpm, and screw rotation speed 98 rpm. The resulting extruded snacks are

then packaged in plastic boxes to avoid physical and chemical damage. And then organoleptic, chemical (proximate and calcium) and microbial characterization tests were carried out. The following is a flow diagram of the stages of making extruded snacks from corn flour, shrimp shells and milkfish bones:

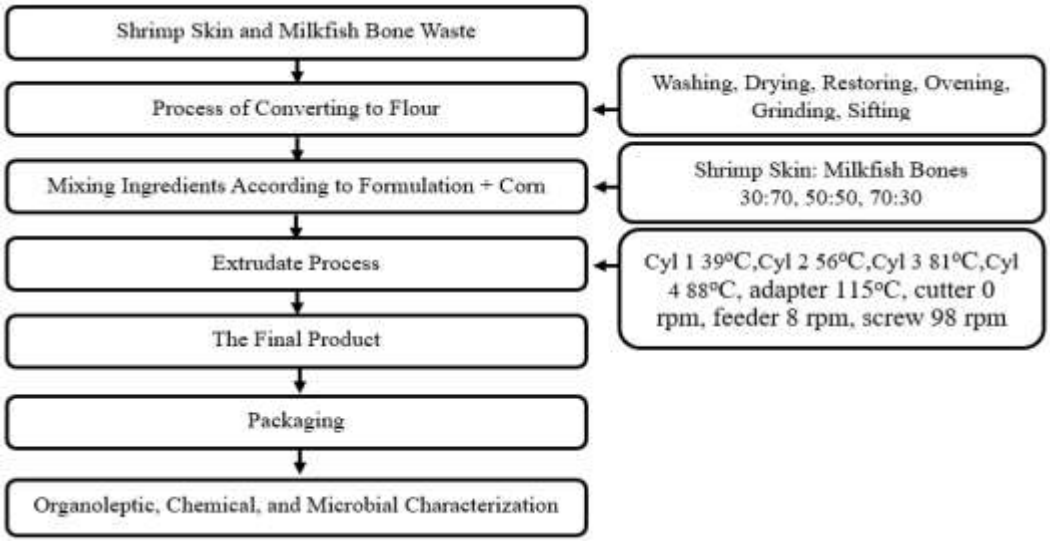

Figure 1. Flow diagram for making corn flour extrudate snacks, shrimp skin and milkfish bones

3. Results and Discussions

Results of research and diversity analysis along with further tests for organoleptic parameters of extruded snacks can be seen in the table below:

Table 1. Analysis of the diversity of organoleptic properties of extruded snacks

Treatment	Organoleptic Test			
	Color	Aroma	Flavor	Texture
P823	5.06a ± 1.18	4.84a ± 1.29	4.68a ± 1.38	5.84a ± 1.10
P195	4.97a ± 1.18	4.58a ± 1.06	4.90b ± 1.22	5.84b ± 1.00
P530	4.47a ± 1.48	4.84a ± 1.24	4.52a ± 1.39	5.68a ± 1.28

Note: Organoleptic data was obtained from 31 panelists and analyzed using ANOVA followed by the Duncan test. Different letters in the columns indicate there is a significant difference ($P < 0.05$)

Figure 2. Snack extrudate combination of corn flour, shrimp skin and milkfish bones

Organoleptic Analysis

Based on the results of the diversity analysis of the organoleptic properties of color and aroma of extruded snacks, it shows that between the 3 treatments there were no significant differences. This is because the three treatments have almost the same color, namely dark yellow. The dark yellow color is obtained from the basic color of the raw material, namely corn flour itself. In addition, during the extrusion process, browning reactions occur such as caramelization, maillard reactions and the loss of several pigments contained in the material (Nasir et al, 2018). In the maillard reaction, a reaction occurs between the amino groups from shrimp shell flour and milkfish bone meal with reducing sugars from corn flour so that melanoidin compounds are formed which causes the extrudate to turn brown in color and taste slightly bitter. Please note that excessive brown color can cause the color and appearance to be less attractive and the taste to be less favorable. Not only that, the use of corn as the main raw material for extruded snacks causes the distinctive aroma of shrimp shell flour and milkfish bone meal to be disguised, causing the dominant aroma to be corn. The dominant aroma of corn in the extruded snack does not really affect the panelists' level of preference for the aroma of the extruded snack produced.

Based on the results of the diversity analysis of the organoleptic properties of taste and texture of extruded snacks, it shows that between the 3 treatments there are significant differences. Where panelists tend to prefer extruded snacks with sample P195, namely with a composition of 50% shrimp shell flour and 50% milkfish bone flour. This proves that the balanced composition of shrimp shell flour and milkfish bone flour produces the right taste in the extruded snack, namely it doesn't taste too fishy and doesn't taste too sea. The dominant combination of shrimp shell flour causes a shrimp taste that is too strong, while the dominant combination of milkfish bone flour causes a fishy taste that is too strong. Not only that, extruded snacks with a 50:50 composition can produce a crunchier texture compared to extruded snacks with a composition of 70:30 or 30:70. This is supported by the addition of corn flour as a raw material which makes the texture of the extruded snack crisper, which according to Istinganah

(2017) explains that the more substitutes for corn flour, the less hardness the biscuit will have and the easier it will be to break, resulting in a crunchier texture.

The results of the chemical characteristics of extruded snacks based on the proximate test and calcium test can be explained in the table below:

Table 2. Nutrient content of extruded snacks

Parameter	Standard SNI 2886:2015	Treatment		
		Variable 1 (P530)	Variable 2 (P195)	Variable 3 (P823)
Ash content (%)				
a. Simplo	-	2.97	2.94	2.59
b. Duplo		3.10	2.81	2.54
c. Average		3.04	2.88	2.57
Energy from fat (Kcal/100g)				
a. Simplo	-	27.36	18.45	15.39
b. Duplo		28.26	19.08	16.11
c. Average		27.81	18.77	15.75
Total fat content (%)				
a. Simplo	Max 30%	3.04	2.05	1.71
b. Duplo		3.14	2.12	1.79
c. Average		3.09	2.09	1.75
Total energy (Kcal/100g)				
a. Simplo	-	378.48	371.13	374.63
b. Duplo		378.06	373.24	374.63
c. Average		378.27	372.19	374.63
Carbohydrate content (%)				
a. Simplo	-	77.31	77.09	79.02
b. Duplo		76.86	77.44	78.84
c. Average		77.09	77.27	78.93
Protein content (%)	-			
a. Simplo		10.47	11.08	10.79
b. Duplo		10.59	11.10	10.79
c. Average		10.53	11.09	10.79
Water content (%)				
a. Simplo	Max 4%	6.21	6.84	5.89
b. Duplo		6.31	6.53	6.04
c. Average		6.26	6.69	5.97
Calcium level (mg/100g)				
a. Simplo	-	995.64	980.72	818.23
b. Duplo		953.80	957.79	818.77
c. Average		974.72	969.26	818.50

Note: Chemical data in the form of proximate tests and calcium tests are carried out in the Saraswati Laboratory in Surabaya

Chemical Analysis

The average value of the ash content test for extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The results of the ash content test obtained values ranging from 2.57% to 3.04%, where the highest ash content value was shown in the treatment with a composition ratio of shrimp shell flour and milkfish bone flour of 30:70, while the lowest ash content value was shown in the treatment with a composition ratio of 70 :30. The ash content value is neither higher nor lower than the requirements of SNI 2886:2015, this is because in SNI 2886:2015 the required ash content is only for ash content that is not soluble in acid with a maximum limit of 0.1%.

The average test value for the fat content of extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The results of the fat content test obtained values ranging from 1.75% to 3.09%, where the highest fat content value was shown in the treatment with a composition ratio of shrimp shell flour and milkfish bone flour of 30:70, while the lowest fat content value was shown in the treatment with a composition ratio of 70 :30. The fat content value meets the requirements of SNI 2886:2015, this is because in SNI 2886:2015 the required fat content is a maximum of 30%.

The average calorie test value of extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The calorie test results obtained values ranging from 372.19 kcal/100g to 378.27 kcal/100g, where the highest calorie value was shown in the treatment with a composition ratio of shrimp shell flour and milkfish bone flour of 30:70, while the lowest calorie value was shown in the treatment with a composition ratio of 50: 50. The calorie value is neither higher nor lower than the requirements of SNI 2886:2015, this is because SNI 2886:2015 does not include calories as a requirement for extruded snacks.

The average test value for the carbohydrate content of extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The results of testing carbohydrate content obtained values ranging from 77.09% to 78.93%, where the highest carbohydrate content value was shown in the treatment with a composition ratio of shrimp shell flour and milkfish bone flour of 70:30, while the lowest carbohydrate content value was shown in the treatment with a composition ratio of 30:70. The carbohydrate content value is neither higher nor lower than the requirements of SNI 2886:2015, this is because SNI 2886:2015 does not include carbohydrate content as a requirement for extruded snacks.

The average value of the protein content test for extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The results of the water content test obtained values ranging from 10.53% to 11.09%, where the highest protein content value was shown in the treatment with a composition

ratio of shrimp shell flour and milkfish bone flour of 50:50, while the lowest protein content value was shown in the treatment with a composition ratio of 30:70. The protein content value is neither higher nor lower than the requirements of SNI 2886:2015, this is because SNI 2886:2015 does not include protein content as a requirement for extruded snacks.

The average test value for the water content of extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The results of protein content testing obtained values ranging from 5.97% to 6.69%, where the highest water content value was shown in the treatment with a composition ratio of shrimp shell flour and milkfish bone flour of 50:50, while the lowest water content value was shown in the treatment with a composition ratio of 70:30. The water content value does not meet the requirements of SNI 2886:2015, this is because in SNI 2886:2015 the maximum water content required for extruded snacks is 4%.

The average test value for the calcium content of extruded snacks with different combinations of corn flour, shrimp shells and milkfish bones from the 3 treatments can be seen in table 2 above. The results of calcium content testing obtained values ranging from 818.50 mg/100g to 974.72 mg/100g, where the highest calcium content value was shown in the treatment with a composition ratio of shrimp shell flour and milkfish bone flour of 30:70 while the lowest calcium content value was shown in the treatment with a ratio of 30:70. composition 70:30. The calcium content value is neither higher nor lower than the requirements of SNI 2886:2015, this is because SNI 2886:2015 does not include calcium content as a requirement for extruded snacks.

The results of the microbial characteristics of extruded snacks can be explained in the table below:

Table 3. Microbial content of snack extrudates

Parameter	SNI Standard 2886:2015	Treatment		
		Variable 1 (P530)	Variable 2 (P195)	Variable 3 (P823)
ALT	Max 1x104	30 CFU/g	< 10 CFU/g	< 10 CFU/g
E-coli	<3	Negative	Negative	Negative
Salmonella sp.	Negative/25 g	Negative	Negative	Negative
Staphylococcus aures	Max 1x102	Negative	Negative	Negative
Vibrio cholerae	-	Negative	Negative	Negative

Note: Microbial test data was carried out at the Surabaya Health Laboratory Center

Microbial Analysis

The results of the analysis of ALT values for extruded snack products in table 3 above show that the combination of raw materials is treated shrimp shell and milkfish bone flour 30:70 was able to contain as many as 30 CFU/g of bacteria, whereas the 50:50 raw material

combination treatment was able to contain <10 CFU/g of bacteria, and the 70:30 raw material combination treatment was able to contain <10 CFU/g of bacteria. 10 CFU/g. So it can be ensured that the extruded snack products from the 3 treatments have met the SNI 2886:2015 standard which requires a maximum ALT parameter of $1x10^4$ CFU/g. The results of the analysis of the microbial values of E-coli, Salmonella sp, and Staphylococcus aures in extruded snack products showed negative results from 3 treatments so it can be confirmed that extruded snack products have met SNI 2886:2015 standards regarding microbial contamination. The results of the analysis of the Vibrio cholerae bacteria from the three treatments also showed negative values, where this bacterial parameter, although not a requirement for SNI 2886:2015, needs to be known because the Vibrio cholerae microbe can cause cholera diarrhea in food.

4. Conclusions

Extruded snacks with a 50:50 ratio of adding corn flour, shrimp shells and milkfish bones are able to produce products with the best organoleptic, chemical and microbial characteristic values, namelywith the taste and texture most liked by panelists, low fat content of 2.09%, high calorie content of 372.19 kcal/100g, high protein content of 11.09%, high calcium content of 969.26 mg/100g, and microbial contamination (ALT, Ecoli , Salmonella sp, Staphylococcus aures) which complies with SNI 2886:2015 standards regarding extruded snacks.

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