Chemical, physical, and sensory characteristics of milkfish *(Chanos chanos)* and mung bean flour *(Vigna radiata L.)* simulations chips

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Abstract. Diversification of food products, one of which can be applied to snacks. One type of snack that is quite successful in the market is the chips. To improve the value of the nutritive value of these chips is by making simulation chips. Based on the protein content of milkfish and mung beans are high then used as raw material for the manufacture of simulated chips. This study aims to determine the best simulation of milkfish and mung bean flour based on characteristics of chemical, physical, and sensory. Experimental design using in this research was Completely Randomized Design (CRD) with one factor, which was ratio variation of milkfish and mung bean flour. Based on the results of chemical, physical, and sensory analyzes obtained were analyzed statistically by using one way ANOVA method; if there was a difference, it was followed with a significance test using Duncan’s Multiple Range Test (DMRT) at a significance level of α = 0.05. Based on the results of the study showed the best formulation results on F3 (20% milled milkfish meat + 80% mung beans flour). Result of chemical analysis of simulation chips at F3 that is 3.53% wb of moisture content; 3.44% db of ash content; 25.78% db of fat content; 18.84% db of protein content; 51.93% db of carbohydrate content; 0.45% db of FFA content; 5.57% db of crude fiber content; and 527.17 kcal/100 grams of total calories. Result of physical analysis of simulation chips on F3 that is 7.95 N of hardness and 92.97% of wholeness. While on the sensory analysis, the highest F3 value on parameters of color, texture, and overall.

1. Introduction

Protein consumption affects national resilience and the growth of the next generation of young people. According to the Indonesian Ministry of Health's Data and Information Center [1], protein consumption in Indonesian people is still relatively low, which is only 14.4% of the total protein, fat and carbohydrate needs per day. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 75 of 2013 concerning the Recommended Nutrition Adequacy Rate (RDA) for the Indonesian people, the protein requirement for children is 35–72 grams, while for teenagers it is 59–66 grams [2].

Diversification of food products can be applied to snacks, including those on chips. According to Koswara [3] types of chips consist of ordinary chips and simulation chips. Common chips are light and crispy foods made through stripping and cleaning, thin slices, and frying. According to Rosida and Purwanti [4], simulation chips are chips made with flour. The manufacturing process includes flour mixing, thin sheet making, printing according to the desired shape, and frying. The making of simulation chips aims to improve the nutritional value of the simulation chips and to get a more same product according to shape, size and taste.

One of the materials that can be used in making simulation chips is milkfish. Some advantages compared to other types of fish are that they have a fairly tasty and savory taste. Besides, the price is also affordable by all levels of society [3]. Whereas according to Hikmayani and Putri [5], the nutrient content contained in milkfish is 40% protein, almost the same as salmon. Milkfish production can almost be found in all provinces in Indonesia. The increase in milkfish production from 2010 to 2014 reached an average of 10.84% [6]. The nutritional content of...
milkfish itself is 0.853% of fat content; 24.175% protein content; 70.787% of moisture content;
1.405% of ash content; and 2.780% of carbohydrates content [11]. While other materials used in
making simulation chips are mung beans. According to Brishti et al. [7] mung bean flour has the
main nutritional content, namely protein content 23.84%; 1.53% of fat content; 4.95% of fiber
content; 3.02% of ash content; 10.21% of moisture content; and 56.43% of carbohydrate content.

Based on the high protein content of milkfish and mung beans, if made in processed
products in the form of simulation chips, it is expected to have high protein content, which is
useful for the growth of children and adolescents. Study chemical, physical, and sensory
characteristics are needed to find the best formula of milkfish (Chanos chanos) and mung bean
flour (Vigna radiata L.) simulation chips.

2. Methodology

2.1. Materials

The materials used are milled milkfish, mung bean flour, tapioca flour, salt, water, garlic,
onion, margarine, and cooking oil. While the chemicals used for the analysis of simulated chips
were petroleum ether solvent; concentrated sulfuric acid; mercury oxide; potassium sulfate;
sodium thiosulfate hydroxide solvent; saturated boric acid solvent; 0.02 N hydrochloric acid
solvent; neutral alcohol; PP indicator; and 0.1 N; H$_2$SO$_4$; NaOH; and ethanol NaOH solvents.

2.2. Research Stages

The research consisted of six main stages, namely: making milled milkfish meat, making
mung bean flour, making simulation chips, chemical analysis of simulation chips, physical
analysis of simulation chips, and sensory analysis of simulation chips.

a. Milled Milkfish Meat

Fresh milkfish were cleaned to separate fish meat from the head, bones, stomach
contents, tail, and gills. Then the milkfish results from weeding and then washed with clean
water to remove dirt that sticks to the fish and fillet are produced. Separation of meat was
done to select white meat and then remove red meat, skin, and thorns. Steaming was done on
white milk fillet meat with a temperature of 100ºC for 15 minutes to soften the texture of
milkfish meat so that it was easy to do the grinding process. In the grinding process, fillet
milkfish meat that has been steamed and then ground using a blender until smooth. The final
result in this process was smooth milled meat.

b. Mung bean flour

Washing was done on 300 grams of peeled mung bean using clean water to remove
dirt that was still attached to mung bean. Draining was done to reduce the water content of
mung beans with a moisture content of ± 10% [8]. Steam blanching was done by steaming at
a temperature of 75–95ºC for 10 minutes. Roasting was done with a temperature of 80–90ºC
for 5 minutes to remove the distinctive aroma of roasted mung bean. The destruction of mung
bean was done to get the results in the form of mung bean flour. Sieving with 80 mesh sieve
was done to get finer grains of mung bean flour.

c. Simulation chips

In making these simulation chips using 4 formulations namely control (100 grams
of wheat flour), F1 (50 grams of milled milkfish and 50 grams of mung bean flour), F2 (35
grams of milled milkfish and 65 grams of mung bean flour), and F3 (20 grams of milled
milkfish and 80 grams of mung bean flour). The manufacturing process includes milled
milkfish and mung bean flour with a predetermined formula mixed with tapioca flour, onion,
garlic, margarine, and salt that has been mashed. Then mixed evenly and given water and
kneaded until the dough becomes smooth. The simulation chips dough was then formed into
sheets with a thickness of ± 3 mm to make it easy to print. The simulation chip dough sheet
was then manually printed in a square shape with a size of 3 cm x 3 cm. Assume that the bates stick to the tool 0.1%. Frying is done by a deep-frying method. The frying temperature is 176 ± 4 °C for 42 seconds. After the frying process, the simulation chips are then drained to reduce the sticky oil content.

d. Chemical, Physical and Sensory Analysis

Chemical analysis was carried out on simulated chips included moisture content, ash content, fat content, protein content, carbohydrate content, FFA content, total calories, and crude fiber content. Physical analysis of simulation chips included hardness and wholeness. Sensory analysis of simulation chips is using a preference test to predict the level of consumer preference for simulation chips, which include aspects of color, taste, aroma, texture, and overall. Obtained data examination was analyzed with One Way Analysis of Variances method (ANOVA) if there was a difference among the treatments, it is continued with Duncan Multiple Range Test (DMRT) insignificant of 5% (p ≤ 0.05) used SPSS 18.0.

3. Results and Discussion

3.1. Chemical Analysis

Table 1. Chemical Characteristic of Milkfish (Chanos chanos) and Mung Bean Flour (Vigna radiata L.) Simulations Chips

| Parameter        | Unit     | Control            | F1               | F2               | F3               |
|------------------|----------|--------------------|------------------|------------------|------------------|
| Moisture content | %wb      | 2.86± ± 0.04       | 3.90± ± 0.03     | 3.83± ± 0.05     | 3.53± ± 0.01     |
| Ash content      | %wb      | 1.37± ± 0.03       | 3.93± ± 0.02     | 3.81± ± 0.03     | 3.32± ± 0.05     |
|                  | %db      | 1.41± ± 0.03       | 4.09± ± 0.02     | 3.96± ± 0.03     | 3.44± ± 0.05     |
| Fat content      | %wb      | 24.33± ± 0.17      | 27.11± ± 0.20    | 25.21± ± 0.13    | 24.87± ± 0.15    |
|                  | %db      | 25.05± ± 0.18      | 28.21± ± 0.21    | 26.22± ± 0.13    | 25.78± ± 0.15    |
| Protein content  | %wb      | 7.72± ± 0.18       | 21.56± ± 0.27    | 20.07± ± 0.21    | 18.18± ± 0.11    |
|                  | %db      | 7.94± ± 0.19       | 22.44± ± 0.29    | 20.87± ± 0.21    | 18.84± ± 0.12    |
| Carbohydrate     | %wb      | 63.71± ± 0.29      | 43.49± ± 0.16    | 47.07± ± 0.32    | 50.10± ± 0.13    |
|                  | %db      | 65.59± ± 0.28      | 45.26± ± 0.16    | 48.95± ± 0.31    | 51.93± ± 0.12    |
| FFA content      | %wb      | 0.47± ± 0.03       | 0.80± ± 0.04     | 0.77± ± 0.03     | 0.43± ± 0.05     |
|                  | %db      | 0.48± ± 0.03       | 0.83± ± 0.04     | 0.81± ± 0.03     | 0.45± ± 0.05     |
| Crude fiber      | %wb      | 2.55± ± 0.13       | 3.53± ± 0.18     | 3.76± ± 0.14     | 5.37± ± 0.15     |
|                  | %db      | 2.63± ± 0.14       | 3.67± ± 0.19     | 3.91± ± 0.14     | 5.57± ± 0.15     |
| Total calories   | kcal/100 grams | 567.42± ± 4.65   | 548.97± ± 4.01   | 547.17± ± 4.15   | 527.17± ± 3.27   |

Note:
Different letter notations in the same column show a significant difference at the significance level (α) = 0.05.
Control : 100% wheat flour
F1 : 50% milled milkfish + 50% mung bean flour
F2 : 35% milled milkfish + 65% mung bean flour
F3 : 20% milled milkfish + 80% mung bean flour

a. Moisture Content

Table 1. showed that the four formulations were significantly different. These results indicate that only controls that have a moisture content value following SNI 01-2602-1992 [9] about fried tempe chips are a maximum of 3% wb. While based on SNI 01-2886-2000 [10] about extrudate snacks, the four simulation chips formulations are in accordance with SNI, which is a maximum of 4% wb.

Based on Nisa et al. [8], proteins have two types of bonds, namely hydrophobic and hydrophilic. The protein content in the mung bean flour is hydrophilic, which has a high water absorption capacity so that if the moisture content of protein in mung beans is high, the moisture content of the sample is also high. Another factor is the content of moisture content
in mung bean flour by 10.21% wb [7] and milkfish by 70.778% wb [11]. It can be concluded that the more addition of milkfish meat, the higher the moisture content value of the simulation chips.

b. Ash Content

Based on Table 1. shows that the four formulations are significantly different. These results indicate that only controls that have ash content values in accordance with SNI 01-2602-1992 [9] about fried tempe chips are a maximum of 3% wb. Factors that influence the high ash content of chips and milkfish simulation were mung beans because of the high ash content of milkfish, which is 3.53% wb [12]. While the ash content of mung bean flour is 3.02% wb [7]. Whereas the control using wheat flour results in accordance with SNI 01-2602-1992 [9] about fried tempe chips because the ash content of wheat flour is only 0.6% wb [13]. Besides, according to Pakpahan et al. [14], loss of material components such as ash content due to heat. This is due to the many mineral components (ash) that dissolve in oil during the frying process. It can be concluded that the more addition of milkfish meat, the higher the ash content value of simulation chips.

c. Fat Content

Based on Table 1. shows that the four formulations are significantly different. These results indicate that all four formulations have fat content values in accordance with SNI 01-2886-2000 [10] about extrudate snacks of a maximum of 38% wb. According to Widyarini [12], the fat content of milkfish is 10.44% wb which will affect the fat content of the simulated chips made. Whereas in mung bean flour according to Brishite et al. [7], only has a fat content of 1.53% wb so it does not have too much effect on the fat content of the simulation chips made. Whereas in control using wheat flour, wheat fat content was 1.3% wb [13]. Other factors that are processing using oil and high temperatures (frying) can affect the quality of fat content [15]. It can be concluded that the more addition of milkfish meat used, the higher the fat content value of the simulation chips.

d. Protein Content

Based on Table 1. shows that the four formulations are significantly different. These results indicate that only F1 and F2 have protein content values in accordance with SNI 01-2602-1992 [9] on fried tempe chips at a minimum of 20% wb. According to Sitompul [9], the limiting amino acids in mung beans are methionine with content of only 0.1%, whereas the excess of mung beans has a large enough amino acid cysteine value of around 0.3%. The limiting amino acids in milkfish according to Hafiludin [11], namely cysteine by 0.136%, while the excess of milkfish has amino acid methionine which is quite large, which is about 0.223%. So that the combination of vegetable and animal protein is expected to complement each other's deficiencies in the content of essential amino acids.

Factors that influence the protein content of simulated chips are milkfish, which have a high protein content of 24.175% wb [11] and mung bean flour at 23.84% wb [7]. While in the control that uses wheat flour, the level of wheat protein is only 8.9% wb [13]. While the effect of frying on protein according to Sundari et al. [16] the higher the temperature used, the lower the protein content in food. It can be concluded that the more addition of milkfish meat used, the higher the protein content value of the simulation chips.

According to BPOM RI [17], minimum requirements for food sources of protein in solid form are 20% ALG (Nutrition Label Reference) per 100 grams and high protein products at least 35% ALG. The value of 20% ALG means 20% of the general consumer group ALG protein (60 grams), so 20% ALG is 12 grams of protein per 100 grams in solid form and 35% ALG is equal to 21 grams of protein per 100 grams of ingredients. So that the simulation chips F1, F2, and F3 can be said to be food sources of protein even in F1 can be said to be high in protein. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 75 of 2013 [2] concerning Nutrition Adequacy Rate (RDA) which is
recommended for protein needs for children as much as 35–72 grams per day, while for adolescents is 59–66 grams per day. It can be concluded that the simulation chips can contribute to protein needs that are good for children and adolescents when consumed.

e. Carbohydrate Content

Based on Table 1. shows that the four formulations are significantly different. These results indicate that the control has the highest carbohydrate content. According to Welis and Rifki [18], a person has high resistance when consuming high carbohydrates according to the Nutrition Adequacy Rate (RDA) of 60–70% so that only control formulations are in accordance with RDA.

f. Free Fatty Acid (FFA)

Based on Table 1. shows that the control and F3 are significantly different from F1 and F2. These results indicate that all four formulations have free fatty acid content values in accordance with SNI 01-2602-1992 [9] concerning fried tempe chips at a maximum of 1% wb. During the frying process, the oil is in high temperature; the presence of air and water contained in the material causes damage to the oil. This causes unsaturated fatty acids to be easily oxidized and hydrogenated. In the frying process can cause the double bonds to become saturated and will cause the double bonds to oxidize, forming peroxide groups and cyclic monomers [19].

Meanwhile, according to Sopianti et al. [20], high acid levels indicate that free fatty acids present in vegetable oils are also high so that the quality of the oil is even lower. This reaction is accelerated in the presence of heat, water, acidity, catalyst (enzyme) factors. The longer this reaction takes place, the more FFA content is formed.

g. Crude Fiber Content

Based on Table 1. shows that F1 and F2 are not significantly different, but F1 and F2 are significantly different from controls and F3. These results indicate that only controls that have crude fiber content values in accordance with SNI 01-2602-1992 [9] about fried tempe chips are a maximum of 3% wb. Factors that influence this result are mung bean flour, which has a high crude fiber content (2.76% wb) [21]. Whereas in milkfish only contains crude fiber of 0.16% wb [22]. In addition to the controls that use wheat flour, the content of wheat fiber is only 1.92% wb [13]. According to Nilasari et al. [23] treatment of temperature and duration of cooking does not affect the yield of crude fiber. This is because crude fiber is difficult to decipher even with a high cooking temperature treatment for a long time. It can be concluded that the more proportions of mung bean flour added, the higher the crude fiber content of the simulation chips.

h. Total Calories

Based on Table 1. shows that F1 and F2 are not significantly different, but F1 and F2 are significantly different from controls and F3. The factor that influences the calorific value of simulation chips is the calorie content of mung beans at 345 kcal / 100 grams [8]. Whereas in milkfish have a calorie of 148 kcal / 100 grams [12]. In addition to the controls that use flour, the wheat calorie content is 364 kcal / 100gram [24]. There is no requirement for the caloric content limit in simulation chips in SNI or other reference standards.

3.2. Physical Analysis

Table 2. Physical Characteristic of Milkfish (Chanos chanos) and Mung Bean Flour (Vigna radiata L.) Simulation Chips

| Parameter          | Unit | Formulation |
|--------------------|------|-------------|
|                    |      | Control     | F1 | F2 | F3 |

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Table 3. Sensory Characteristic of Milkfish (*Chanos chanos*) and Mung Bean Flour (*Vigna radiata* L.) Simulations Chips

| Formulation of Simulation Chips | Color   | Taste   | Aroma   | Texture  | Overall  |
|--------------------------------|---------|---------|---------|----------|----------|
| Control                        | 3.10abc±1.06 | 3.45abc±0.90 | 3.28abc±0.85 | 3.25bc±1.10 | 3.43bc±0.67 |
| F1                             | 2.83abc±0.84 | 3.00abc±1.09 | 2.53abc±0.96 | 2.93bc±0.92 | 3.00abc±1.01 |
| F2                             | 3.05abc±1.06 | 2.85abc±0.86 | 3.38abc±0.84 | 2.75bc±1.06 | 2.98abc±0.89 |
| F3                             | 3.48abc±0.93 | 3.13abc±1.11 | 3.15abc±0.89 | 3.33abc±0.97 | 3.53abc±0.78 |

Note:
Different letter notations in the same column show a significant difference at the significance level (α) = 0.05.

Value scale:
1= very dislike, 2= dislike, 3= neutral, 4= like, 5= very like

Control : 100% wheat flour
F1 : 50% milled milkfish + 50% mung bean flour
F2 : 35% milled milkfish + 65% mung bean flour
F3 : 20% milled milkfish + 80% mung bean flour

Based on Table 3., the value on F3 shows results that are significantly different from controls, F1, and F2. This shows that the panelists less prefer the F1 simulation chips formulation with the proportion of adding high ground beef because it produces a darker product color (brown). During the frying process, the color changes will become brown (Maillard) caused by the reaction between reducing sugars and amines which form intermediate compounds N-substituted glycosylamine. These intermediate compounds will form the next intermediate compound and produce brown compounds called melanoidin [28].

The color of the simulation chips made from milkfish and mung bean flour is golden yellow tend to be a little brown depending on the material formulation. Based on Table 3., the value on F3 shows results that are significantly different from controls, F1, and F2. This shows that the panelists less prefer the F1 simulation chips formulation with the proportion of adding high ground beef because it produces a darker product color (brown). During the frying process, the color changes will become brown (Maillard) caused by the reaction between reducing sugars and amines which form intermediate compounds N-substituted glycosylamine. These intermediate compounds will form the next intermediate compound and produce brown compounds called melanoidin [28].

Based on Table 3., the value of the control shows significantly different results with F1, F2, and F3. These results have not been according to the results of the study according to Linardi et al. [26] stated that mung beans have a high protein content which can provide a savory taste. In other studies according to Sa’adah [29] states that the presence of fish meat gives a savory taste typical of fish because of its protein content.
The scent of the simulation chips is influenced by the two main ingredients, namely milkfish and mung beans. Based on Table 3, the value on F1 shows results that are significantly different from controls, F2 and F3. This is due to the proportion of the addition of mung bean flour which has a not too strong (direct) aroma [8]. To eliminate it according to Aminah and Hersoelistyorini [30], steam blanching is done by steaming at a temperature of 75–95°C for 10 minutes. The sweet smell of mung beans is caused by the enzyme lipoygenase which hydrolyzes or decomposes the fat of mung beans to produce a bad smell. Besides that, the fish’s distinctive aroma due to the protein content that decomposes into amino acids, especially glutamic acid, will cause delicious taste and aroma [29].

Based on Table 3, shows that panelists give the highest score on F3. Values at F3 showed results that were not significantly different from controls but were significantly different from F1 and F2. This shows that the more addition of mung bean flour, the more the panelists prefer the texture. The value in F3 was not significantly different from the control but was significantly different from F1 and F2.

3.4. Weighting Analysis

Table 4. The score of Weighting of Milkfish (Chanos chanos) and Mung Bean Flour (Vigna radiata L.) Simulations Chips

| Parameter          | BV  | BN  | F1  | F2  | F3  |
|--------------------|-----|-----|-----|-----|-----|
|                    | NE  | NH  | NE  | NH  | NE  | NH  |
| Moisture content   | 1   | 0.083 | 0.0000 | 0.0000 | 0.1892 | 0.0158 | 1.0000 | 0.0833 |
| Ash content        | 1   | 0.083 | 0.0000 | 0.0000 | 0.2000 | 0.0167 | 1.0000 | 0.0833 |
| Fat content        | 1   | 0.083 | 1.0000 | 0.0833 | 0.5639 | 0.0470 | 0.0000 | 0.0000 |
| Protein content    | 1   | 0.083 | 0.0000 | 0.0000 | 0.0526 | 0.0044 | 1.0000 | 0.0833 |
| Carbohydrate       | 1   | 0.083 | 1.0000 | 0.0833 | 0.8737 | 0.0728 | 0.0000 | 0.0000 |
| content (Hardness) | 0.5 | 0.042 | 0.0000 | 0.0000 | 0.9174 | 0.0382 | 0.0000 | 0.0000 |
| Wholeness          | 1   | 0.083 | 1.0000 | 0.0833 | 0.5574 | 0.0465 | 0.0000 | 0.0000 |
| Color              | 1   | 0.083 | 0.0000 | 0.0000 | 0.3385 | 0.0282 | 1.0000 | 0.0833 |
| Taste              | 1   | 0.083 | 0.5357 | 0.0446 | 0.0000 | 0.0000 | 1.0000 | 0.0833 |
| Aroma              | 0.5 | 0.042 | 0.0000 | 0.0000 | 1.0000 | 0.0417 | 0.7294 | 0.0304 |
| Texture            | 1   | 0.083 | 0.3103 | 0.0259 | 0.0000 | 0.0000 | 1.0000 | 0.0833 |
| Overall            | 0.5 | 0.042 | 0.0364 | 0.0015 | 0.0000 | 0.0000 | 1.0000 | 0.0417 |
| Total              | 12  | 1   | 0.3220 | 0.3896 | 0.6971 |

Note:
BV: Weight of Variables, BN: Normal Weight, NE: Value of Effectiveness, NH: Result Value
Control : 100% wheat flour
F1 : 50% milled milkfish + 50% mung bean flour
F2 : 35% milled milkfish + 65% mung bean flour
F3 : 20% milled milkfish + 80% mung bean flour

Based on the results of the weighting test which can be seen in Table 4, the weighting test was carried out based on SN1 01-2602-1992 [9] parameters about fried tempe chips. Based on the results of the weighting analysis, the largest number of results (NH) was found in F3 (20% milled milkfish + 80% mung bean flour) with a value of 0.6971. Based on these results, it can be concluded that the selected formulation is F3 (20% milled milkfish + 80% mung bean flour).
4. Conclusion

The more addition of milkfish meat affects the increase in moisture content (3.53–3.90% wb); ash content (3.32–3.93% wb); fat content (24.87–27.11% wb); protein content (18.84–22.44% wb); free fatty acid levels (0.43–0.80% wb); and total calories (527.17–567.42 kcal/100 grams). However, the more addition of milled milkfish meat also affects the decrease in carbohydrate levels (43.49–50.10% wb) and crude fiber (3.53–5.37% wb). Then, the more addition of milled milkfish meat affects the higher value of hardness (texture) (7.95–8.50 N) and the integrity of the product (92.97–97.15%). Furthermore, the results of the sensory analysis showed that panelists liked F3 simulation chips based on color, texture and overall parameters. Panelists like control simulation chips based on taste parameters. In addition, the panelists also liked the F2 simulation chips based on aroma parameters. The best formula based on chemical, physical, and sensory characteristics is F3 (20% milled milkfish + 80% mung bean flour with a value of 0.6971).

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