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# Physicochemical Properties and Sensory Evaluation of Wheat-Mocaf-Based Dried Noodles Enriched with Catfish Bone Flour *(Clarias sp.)*

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**ABSTRACT:** Fishbone is one of industrial waste that can be used as a calcium source. This study aims to physicochemical and sensory evaluation of dried noodles, and the contribution of calcium-enriched dried noodles to the Indonesian Recommended Dietary Allowance (RDA) of calcium. The physicochemical properties (moisture, ash, protein, fat, carbohydrate, calcium, phosphor, water absorption, cooking loss, and extensibility) and sensory evaluation of dried noodles enriched with catfish bone flour in several variations (0%, 2%, 4%, 6%, 8%, and 10%) were investigated. Catfish bone flour significantly increased protein, fat, calcium, and phosphor content yet significantly decreased the moisture content, cooking loss, extensibility, and consumer acceptance (appearance and taste) of dried noodles. Dried noodles enriched with catfish bone flour had a calcium-phosphoros ratio of 1:2 to 2:1. Dried noodles with the catfish bone flour level of 2% seemed to be the most efficient formulation with the Indonesian RDA contribution of 45.8% in a serving size of 70g.

**Keywords:** *catfish bone flour, calcium, dried noodles, physicochemical properties, Indonesian RDA contribution*

## INTRODUCTION

Calcium is one of the micronutrients that is substantial in bone formation. Calcium deficiency can lead to the decrease of bone density or is widely known as osteoporosis so that the weakness of bone structure occurred (Heaney, 2006). Calcium consumption in Indonesia can be categorized as a low number (254mg/day).

Catfish (*Clarias* sp.) is one of the fishery commodities that has a high production level in Indonesia. According to data from Kementerian Kelautan dan Perikanan (2020), its production is up to 5.96 million tons. Fisheries industrial products such as abon and other catfish products produce fish bones as by-products that have the highest proportion of fish weight with the number of 32.4% (Firawati, 2018). Catfish bones can be processed into fishbone flour with calcium levels up to 17.46% and phosphor content of 5.40% (Ratnawati et al., 2018). The previous study has verified that tuna bone flour could be used as an alternative source of calcium for humans in the form of supplements and fortificants (Nemati et al., 2017). Another study has shown that the bioavailability of calcium from tilapia bone flour is as good as commercial calcium supplements (Hemung & Sample, 2013). Fishbones that have been processed into flour can also be applied to a product to meet calcium needs. The application of fishbone flour into biscuits, pastries, and cookies has a good level of consumer acceptance (Ferazuma et al., 2011; Darmawangsyah et al., 2018; Pangestika et al., 2021). However, the quality of fishbone flour applied in the products must be in concern. Fishbone flour with high whiteness value is the desire characteristic to be applied in products. The method used in the process greatly affects the quality of the fishbone flour. Previous studies suggested that protein hydrolysis method with bases was used to obtain fishbone flour with higher calcium content and whiteness value (Cucikodana et al., 2010; Putranto et al., 2016; Ratnawati et al., 2018; Lekahena et al., 2014).

Noodles are the most favorable products that are widely known. Dried noodles are wet noodles that have gone through a drying process so that they have a longer shelf life (Rosmeri, 2013). In general, the basic ingredient of noodles is wheat flour. However, in order to minimize wheat consumption, several studies have developed substitution of wheat flour with mocaf because mocaf has properties that seemed to be similar to wheat so that it will produce noodles with the same characteristics (Rosmeri, 2013; Lala et al., 2013).

The enrichment of noodles using fishbone flour has been carried out by Susanti et al. (2011) and Maruka et al. (2016), however, the contribution of dried noodles enriched with fishbone flour to the Indonesian Recommended Dietary Allowance (%RDA) is still rarely discussed. It is expected that the addition of catfish bone flour to dried noodles can fulfill the calcium needs. This study aims to determine the use of catfish bone as a calcium source in dried noodles, its effect on the physicochemical properties and sensory evaluation of dried noodles, and the contribution of calcium-enriched dried noodles to the Indonesian Recommended Dietary Allowance (RDA) of calcium.

## MATERIALS AND METHODS

### *Material*

The catfish bones were obtained from Balibu Food Industry Yogyakarta. Ingredients of dried noodles (high protein wheat flour, mocaf flour, water, and salt) were obtained from the market. The chemicals used in this study are analytical. Water bath shaker (MRC WBT-200), OXONE manual noodle maker (PASTA ROLLER 355AM), drying oven (JISICO J-NDS1), vacuum oven (EYELA WFO-601 SD), muffle furnace (Barnstead Thermolyne 1400), BUCHI Digestion Unit K424, BUCHI Distillation Unit K350, BUCHI Soxhlet Unit (B-811), *Atomic absorption spectroscopy* (AAS) Perkin Elmer 3110, and UV-Vis Spectrophotometer (BIO-EQUIP UV-6100) were used as analytical equipment.

### *Fishbone flour preparation*

Fishbone flour preparation was carried out based on the method of Ratnawati et al. (2018) using alkaline hydrolysis with slight modifications. The catfish bones were washed thoroughly with water to remove the remaining blood and dirt and cut into small sizes. The bones were then boiled in boiling water for 15 minutes with a water-fishbone ratio of 2:1 and the remaining skin and meat were removed. The catfish bones were soaked for 60 minutes at 60°C using 10% NaOH solution and stirred slowly in a water bath shaker. The catfish bones were then washed using distilled water until the pH was neutral and the remaining NaOH was removed. Drying was then carried out at 60°C for 24 hours. The dried fish bones were grounded and sieved through a 100 mesh sieve. The catfish bone flour was then put into a plastic clip and stored in a jar for further analysis as well as for the dried noodles processing. The yield of CBF was investigated as well as chemical properties such as moisture and protein content according to SNI 01-2354-2006 (Badan Standardisasi Nasional, 2006), calcium using Atomic Absorption Spectroscopy (AAS), and phosphor using spectrophotometer according to the method of AOAC (1995). Calcium-phosphorous ratio was calculated from calcium and phosphorous content obtained by analysis.

### *Dried noodles preparation*

The method of dried noodles preparation was adapted according to Rosmeri (2013) with a slight modification. The ingredients consisting of wheat flour, mocaf flour, salt, and fishbone flour with several concentrations of 0% (P0), 2% (P1), 4% (P2), 6% (P3), 8% (P4), and 10% (P5) was mixed. The concentration of fishbone flour was based on the total solid ingredients. Water was then added to the mixture little by little and stirred until the dough is smooth and homogeneous. The dough was incubated for approximately 45 minutes then pressed and molded using a manual noodle maker. The noodles were then dried at 80°C for two hours. Dried noodles are packaged and stored for further analysis. The chemical (proximate, calcium, phosphor) and physical properties (water absorption, cooking loss, extensibility), sensory evaluation, and the contribution of dried noodles to the Indonesian Recommended Dietary Allowance (RDA) were investigated. Chemical properties analysis was carried out using the method of SNI 01-2354-2006 (Badan Standardisasi Nasional, 2006) for proximate analysis, AOAC (1995) for calcium and phosphor using Atomic Absorption Spectroscopy (AAS) and spectrophotometer respectively. Appearance (for uncooked noodles), texture, flavor, and taste (for cooked noodles) with five levels of preference scale: extremely like (5), like (4), quite like (3), dislike (2), and extremely dislike (1) were used for sensory evaluation

### *Water absorption and cooking loss*

Water absorption and cooking loss analysis were carried out based on the method described by Lu et al. (2009). Noodles (5g; 5cm each) were weighed (W1) and cooked in 50ml of water for 4 minutes. The cooked noodles were drained for 1 min and weighed (W2). The cooking water that was obtained was dried at 105°C for 16 hours. The glass filled with residue was weighed and the residue could be determined as the difference between glass filled with residue and the empty glass. Water absorption and cooking loss can be calculated as follows:

$$\text{Water Absorption (\%)} = \frac{(W2-W1)}{W1} \times 100\%$$

$$\text{Cooking Loss (\%)} = \frac{\text{Residue}}{\text{Uncooked Dried Noodles}} \times 100\%$$

### *Extensibility*

Extensibility analysis was carried out using the method described by Qosim et al. (2018). Noodles were cooked for 4 minutes. The cooked noodles were then stretched on the ruler until the noodles were broken off. Extensibility can be described as the percentage of the extension to the length of noodles before being extended.

### *Contribution of dried noodles to Indonesian Recommended Dietary Allowance*

The contribution of dried noodles to the Indonesian RDA is calculated as a percentage of calcium content at a certain serving size to the Indonesian RDA for calcium based on the "Nutrition Label Reference" according to the regulation from BPOM (2016). Microsoft Excel software was used for calculation with the following steps:

1. Calcium per gram was calculated from (calcium content obtained from analysis (%) x 1000)/100
2. Calcium at a certain serving size was calculated as calcium per gram x serving size
3. The contribution of calcium-enriched dried noodles to Indonesian RDA was described as the percentage of calcium at a certain serving size to Indonesian RDA for calcium

### *Statistical analysis*

The design used was a completely randomized design (CRD) with one factor and six variations. The physicochemical properties of dried noodles were analyzed using One-Way ANOVA with Duncan's Multiple Range Test (DMRT) for further analysis at a 95% confidence level. The sensory evaluation was analyzed using Kruskal-Wallis test with the Mann-Whitney for further analysis at a 95% confidence level. Data analysis was performed using IBM Statistics SPSS version 22.

## RESULT AND DISCUSSION

### *Characteristic of catfish bone flour (CBF)*

The yield and chemical composition of CBF compared to previous studies can be seen in Table 1. The yield of fishbone flour in this study was still below 50%. This can be related to the large amounts of content that were removed when washing with distilled water after soaking in NaOH solution and the amount of water lost due to the drying process (Cucikodana et al., 2010; Trilaksani et al., 2006). The protein content of the CBF in this study was lower than Ferazuma et al. (2011) and slightly higher than Ratnawati et al. (2018). The protein hydrolysis method using a strong base like NaOH can cause the cleavage of the peptide chains in the protein resulting in a decline of protein content (Ratnawati et al., 2018). However, not all proteins in fishbones can be hydrolyzed due to the presence of stromal proteins which are insoluble in acids and bases (Hemung & Sample, 2013). This can be related to the higher protein content of CBF in this study than Ratnawati et al. (2018). In addition, the difference of protein content among fishbone sources lead to the slightly higher protein content of CBF.

The calcium and phosphorus content of CBF was higher than Ferazuma et al. (2011) and lower than Ratnawati et al. (2018). CBF in this study and Ratnawati et al. (2018) was processed by protein hydrolysis using strong bases so that the calcium extraction from the bone was more effective. Calcium in bones is attached to protein which mostly consists of collagen and is difficult to digest by pepsin and pancreatin. Collagen can cause the formation of water-soluble gelatin when the heating process is carried out. Hydrolysis with a strong base accompanied by heating will cause the cleavage of peptide chains so that the protein will be released from the bones and no longer attached to calcium (Trilaksani et al., 2006). Amitha et al. (2019) also suggested that boiling fishbones in NaOH solution was able to increase the ash content of fishbone flour with lower protein content than boiling treatment with water. CBF in this study had a good calcium-phosphorus ratio for calcium absorption. The calcium will be better to absorb when the calcium-phosphorus ratio (Ca/P) is 1:1 to 3:1 (Agustini et al., 2011).

Table 1. The yield and chemical composition of CBF compared to previous studies

| | Catfish bone flour in this study | Ferazuma *et al.* (2011) | Ratnawati *et al.* (2018) |
|---|---|---|---|
| Yield (%) | 35.96±0.001 | - | 64.89±0.78 |
| Moisture (%) | 4.64±0.05 | 8.72 | 6.15±0.01 |
| Protein (%) | 15.09±0.017 | 51.15 | 12.35±0,03 |
| Calcium (%) | 8.37±0.05 | 5.68 | 17.46±0.01 |
| Phosphor (%) | 2.28±0.002 | 3.78 | 5.40±0.03 |
| Ca:P ratio | 3.5:1 | 1.5:1 | 3.2:1 |

Values are shown as an average ± SD.

***Chemical characteristics of dried noodles***

The chemical characteristics of dried noodles can be represented as proximate composition and calcium and phosphorous content. The proximate composition of dried noodles is shown in Table 2 and the calcium and phosphorus content of dried noodles can be seen in Figure 1. The moisture and carbohydrate content of dried noodles decreased as the levels of CBF added increased ($p<0.05$). This is due to the addition of solids causing the moisture content of the product to decrease. In addition, calcium in CBF reacts with water particles by binding to hydroxide anions ($OH^-$) from water particles and leads to the decrease of the water in the mixture (Darmawangsyah et al., 2018). The decrease of the carbohydrate can be related to the increase of other chemical compositions because the carbohydrate was calculated by difference. Dried noodles enriched with CBF had higher ash, protein, and fat content than control (P0) ($p<0.05$). The ash, protein, and fat content of dried noodles increased as the levels of CBF increased. It can be related to the contribution of the nutritional content of CBF.

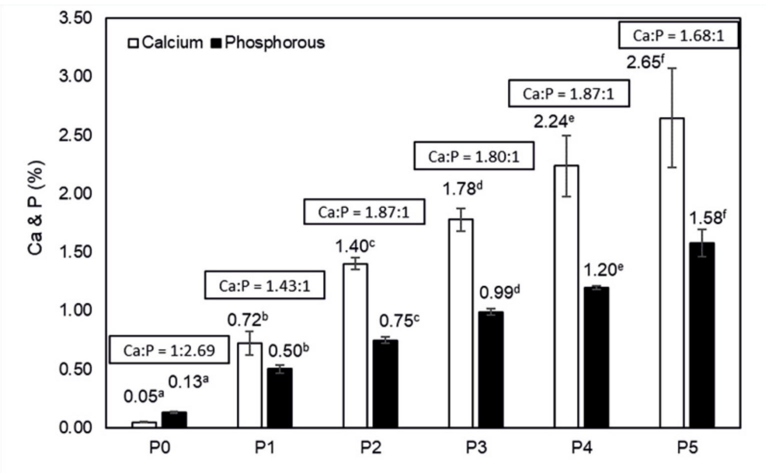


Figure 1. Calcium and phosphorous content of dried noodles. Values are shown as an average ± SD. Values followed by different superscript letters are significantly different ($p<0,05$).

Dried noodles enriched with CBF had greater calcium and phosphorus content than control (P0) ($p<0.05$). The calcium and phosphorus content of dried noodles increased as the levels of CBF increased. It can be indicated that CBF has a contribution to the increase of calcium and phosphorus content of dried noodles. The best calcium absorption is when the calcium-phosphorus ratio ranges from 1:1 to 3:1 (Agustini et al., 2011). —Loughrill et al., 2017) also reported that the appropriate range of calcium-phosphorus ratios for food products is from 1:1 to 2:1. The absorption of calcium and phosphorus in the intestine is regulated by 1,25-dihydroxy vitamin D. The absorption will be disrupted when the amount of calcium and phosphorus intake is not balanced —(Goff, 2018). In addition, calcium phosphate complexes will be formed in the intestine. A higher amount of phosphorus intake will impair the calcium absorption so that free calcium levels in the blood decline inducing an increase of parathyroid hormone and osteocalcin which can lead to a lower bone density. In contrast, greater calcium intake will also result in poor absorption of both calcium and phosphorus (Koshihara et al., 2004; Lamberg-Allardt & Kemi, 2017; Sax, 2001; Takeda et al., 2014). In conclusion, the calcium-phosphorus ratio of dried noodles with the CBF levels of 2%-10% (P1-P5) was still in the range. Based on the chemical characteristics of dried noodles, P5 gave the highest contribution to the calcium level. However, there are still some factors that should be in concern to decide the best formulation of dried noodles.

Table 2. Proximate composition of dried noodles

| Dried Noodles | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate (%) |
|---|---|---|---|---|---|
| P0 | 11.77±0.23[a] | 1.27±0.11[a] | 9.46±0.04[a] | 0.47±0.05[a] | 84.41±0.19[a] |
| P1 | 11.05±0.15[b] | 2.74±0.26[b] | 10.07±0.10[b] | 0.55±0.15[a] | 83.41±0.67[b] |
| P2 | 10.56±0.20[c] | 4.61±0.05[c] | 10.60±0.08[c] | 0.88±0,12[b] | 80.98±0.15[c] |
| P3 | 10.69±0.13[c] | 6.13±0.11[d] | 10.85±0.01[d] | 1.09±0.07[c] | 79.39±0,15[d] |
| P4 | 9.32±0.18[d] | 7.41±0.05[e] | 10.86±0.06[de] | 1.08±0.03[c] | 78.56±0.17[e] |
| P5 | 8.62±0.14[e] | 8.63±0.09[f] | 11.01±0.12[e] | 1.34±0.12[d] | 77.18±0.14[f] |

Values are shown as an average ± SD. Values followed by different superscript letters in the same column are significantly different ($p<0.05$).

***Physical characteristics of dried noodles***

The physical characteristics of the dried noodles are shown in Table 3. CBF did not have a significant effect on the water absorption of dried noodles ($p<0.05$). A similar finding was also reported by Desmukh et al. (2019) that the addition of millet flour had no significant effect on water absorption. However, different results are obtained from other studies in which the addition of tilapia bone flour, banana flour, oyster mushroom flour significantly increased water absorption (Anggraeni and Saputra, 2018; Arora et al., 2018; Sirichokworrakit, 2014). The protein in the mixture including gluten in the noodle dough will undergo denaturation during heating and lead to a network formation between proteins that can prevent water from entering the noodle dough resulting in a chewy noodle texture. The addition of solids will impair the network formation causing the water absorption to increase(Anggraeni & Saputra, 2018; Kovacs et al., 2004). The difference in results among several studies is due to the differences in the composition and formulation used.

Cooking loss of dried noodles increased as the CBF levels increased up to 4%, and decreased until the CBF level was 8%. Similar results also demonstrated the increase of cooking loss due to the addition of tilapia bone meal, mung bean flour, oyster mushroom flour, and banana flour (Anggraeni & Saputra, 2018; Arora et al., 2018; Sirichokworrakit, 2014; Slathia et al., 2016). Cooking loss is a solid content (mostly starch) that leached out during heating (Arora et al., 2018). It can be related to the weakening of protein-starch bonds in the dough so that it is unable to hold solid particles leaching out of the dough (Arora et al., 2018; Aydin & Gocmen, 2011). The decrease of cooking loss at a CBF level of 8% can be related to the strong protein network due to the higher protein content in the dough. During heating, the proteins in the dough undergo denaturation which generates the formation of a three-dimensional network between proteins followed by gel formation that can strengthen the structure of the dough and prevent cooking loss (Kovacs et al., 2004; Totosaus et al., 2002).

The extensibility of the dried noodles decreased as the levels of CBF increased up to 2% and rose until the CBF level of 4%. The decrease of extensibility is similar to the study reported by Sirichokworrakit (2014) in which the addition of tilapia bone meal led to a decrease of extensibility. It can be related to the disruption of the dough structure due to the addition of solids in the dough which can impair gluten network formation during heating (Sirichokworrakit, 2014). The increase of protein content due to the contribution of CBF led to an increase of extensibility at a CBF level of 4%. The protein denaturation will occur and the three-dimensional network was formed followed by gel formation. It causes a strong structure formed in the dough which can lead to a chewy texture due to the gel formation(Kovacs et al., 2004; Totosaus et al., 2002). A similar result was reported by (Arora et al., 2018) in which the addition of mushroom flour to noodles led to an increase of extensibility.

Table 3. Physical characteristics of dried noodles

| Dried Noodles | Water Absorption (%) | Cooking Loss (%) | Extensibility (%) |
|---|---|---|---|
| P0 | 155 ± 7.07[a] | 6.32 ± 0.07[ab] | 31.58 ± 1.48[a] |
| P1 | 180 ± 0.00[a] | 6.11 ± 0.13[a] | 18.95 ± 1.48[b] |
| P2 | 155 ± 7.07[a] | 7.82 ± 0.22[c] | 24.21 ± 1.48[c] |
| P3 | 165 ± 7.07[a] | 6.77 ± 0.18[b] | 25.79 ± 0.74[c] |
| P4 | 150 ± 14.14[a] | 5.81 ± 0.45[a] | 25.79 ± 0.74[c] |
| P5 | 165 ± 7.07[a] | 5.83 ± 0.02[a] | 22.63 ± 2.23[c] |

Values are shown as mean ± SD. Values followed by different superscript letters in the same column are significantly different (p<0.05).

***Sensory evaluation***

The sensory evaluation of the dried noodles can be seen in Figure 2. The addition of CBF did not have a significant effect on the texture and aroma (p<0.05), but significantly decreased the appearance and taste. Nevertheless, the consumer acceptance level of the four attributes was still in the acceptable range and P1 was the most acceptable. The decrease of appearance can be related to the low moisture of the dough so that it had a rough appearance on the surface. The addition of CBF increased the number of solids in the dough which can lead to an unbalanced water-solid ratio. Calcium from CBF binds to the hydroxide anion ($OH^-$) from water particles in the dough and causes the water content to decrease (Darmawangsyah et al., 2018). The increase of ash content can cause the color of the dough to become darker and reduce the level of consumer acceptance. Flour and products with higher ash content tend to have a darker color (Chambó et al., 2018; Suas, 2009).

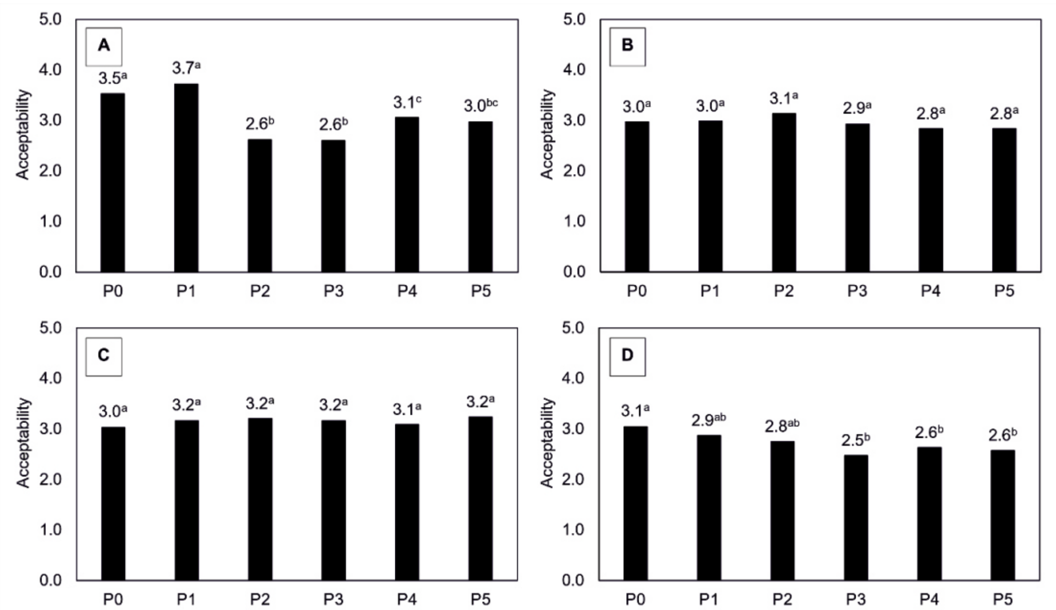


Figure 2. Sensory evaluation of dried noodles on the attributes of appearance (A), texture (B), aroma (C), and taste (D). Values are shown as an average. Values followed by different superscript letters are significantly different (p<0,05)

The decrease of taste can be linked to the taste of fish in dried noodles which is less preferred by the panelists. The taste of fish in dried noodles can be related to the protein and fat content of CBF which are some of the flavor precursors. The boiling process of noodles causes the formation of volatile compounds from flavor precursors that can lead to a distinctive aroma and taste (Kosowska et al., 2017; Purba, 2014).

***Contribution of dried noodles to Indonesian RDA for calcium***

The contribution of dried noodles to the Indonesian RDA for calcium was calculated based on the "Nutrition Label Reference" regulated by BPOM RI (2016). Indonesian RDA for calcium is 1100 mg per day. The contribution of dried noodles to the Indonesian RDA for calcium at a serving size of 70g compared to several commercial dried noodles are shown in Table 4. The serving size of 70g was chosen based on the serving size of commercial instant noodles. Dried noodles with CBF levels of 2% to 10% had a greater contribution to Indonesian RDA for calcium compared to the commercial dried noodles and control (P0). It indicates that CBF can be used as a calcium fortificant that can prevent people from calcium deficiency. However, it is necessary to consider the efficiency of daily calcium consumption and CBF used as fortificant.

According to the on the regulation of "Supervision of Claims on Labels and Advertisements of Processed Food", food products (in solid) can be categorized as a source of vitamins/minerals when the contribution to Indonesian RDA of 15% at a 100g and can be categorized as high/rich in minerals when the contribution to Indonesian RDA is two times higher than the 15%. Dried noodles at a CBF levels of

2% (P1) contributed to the Indonesian RDA for calcium at the number of 65.5% in 100g servings size and could be categorized as "High Calcium". Therefore, P1 seemed to be the best and the most efficient formulation based on its contribution to Indonesian RDA for calcium. In addition, P1 has physical characteristics and the sensory evaluation that was not significantly different from the control (P0).

Table 4. The contribution of dried noodles to Indonesian RDA for calcium

| Serving size: 70 g | | |
|---|---|---|
| Dried Noodles | mgCa/servingsize | % RDA |
| P0 | 34 | 3.1 |
| P1 | 504 | 45.8 |
| P2 | 982 | 89.3 |
| P3 | 1245 | 113.2 |
| P4 | 1567 | 142.4 |
| P5 | 1854 | 168.5 |
| Commercial 1 | 22 | 2.0 |
| Commercial 2 | 17 | 1.5 |
| Commercial 3 | 14 | 1.3 |

Recommended Dietary Allowance is basedon daily energy needs of 2150kcal

## CONCLUSION

The addition of CBF increased the protein, fat, calcium, and phosphorus levels of dried noodles but significantly decreased water content. CBF had no significant effect on the water absorption but increased cooking loss until the CBF level of 4% and rose again at a CBF level of 8%. The extensibility of dried noodles decreased at a CBF level of 2% and increased at a CBF level of 4%. All formulation were still in acceptable sensory range but P1 was the most acceptable. P1 (2%) was the best and most efficient formulation because it contributed to the Indonesian RDA for calcium at the number of 45,8% at a serving size of 70g and could be categorized as a "High Calcium" at a serving size of 100g.

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## REFERENCES

Agustini, TW., Ratnawati, SE., Wibowo, BA., and Hutabarat, J. 2011. Pemanfaatan cangkang kerang simping (Amusium pleuronectes) sebagai sumber kalsium pada produk ekstrudat. Jurnal Pengolahan Hasil Perikanan Indonesia. 14(2):13442. https://doi.org/10.17844/jphpi.v14i2.5322.

Amitha, C.V., Raju, I.P., Lakshmisha, P., Arun Kumar, A., Sarojini, Gajendra, and Jag Pal. 2019. Nutritional composition of fish bone powder extracted from three different fish filleting waste boiling with water and an alkaline media. International Journal of Current Microbiology and Applied Sciences. 8(02):294248. https://doi.org/10.20546/ijcmas.2019.802.342.

Anggraeni, R. and Saputra, D. 2018. Physicochemical characteristics and sensorial properties of dry noodle supplemented with unripe banana flour. Food Research. 2(3):27078. https://doi.org/10.26656/fr.2017.2(3).061

Arora, B., Kamal, S., and Sharma, VP. 2018. Nutritional and quality characteristics of instant noodles supplemented with oyster mushroom (p. Ostreatus). Journal of Food Processing and Preservation. 42(2):18. https://doi.org/10.1111/jfpp.13521

Association of Official Analytical Chemist. 1995. Official Methods of Analysis of AOAC International. Association of Official Analytical Chemists, Washington DC.

Aydin, E. and Gocmen, D. 2011. Cooking quality and sensorial properties of noodle supplemented with oat flour. Food science and biotechnology. 20(2):50711. https://doi.org/10.1007/s10068-011-0070-1.

Badan Standardisasi Nasional. 2006. Cara uji kimia-bagian 2: penentuan kadar air, abu, protein, lemak pada produk perikanan. SNI-01-2354.1-4-2006. Badan Standarisasi Nasional, Jakarta

BPOM. 2016. Peraturan kepala badan pengawas obat dan makanan republik indonesia nomor 13 tahun 2016 tentang pengawasan klaim pada label dan iklan pangan olahan. Badan Pengawas Obat dan Makanan, Jakarta.

BPOM RI. 2016. Peraturan kepala badan pengawas obat dan makanan republik indonesia nomor 9 tahun 2016 tentang acuan label gizi. Badan Pengawasan Obat dan Makanan Republik Indonesia, Jakarta.

Chambo, APS., Souza, MLRD., Olovera, ERND., Mokcha, JMG., Marques, DR., Maostrovocz, FC., Vosentaoner, JV, Goes, ESDR. 2018. Roll Enriched with Nile Tilapia Meal: Sensory, Nutritional, Technological and Microbiological Characteristics. Food Science and Technology. 38(4):72632. https://doi.org/10.1590/1678-457x.15317.

Cucikodana, Y., Supriadi, A., Purwanto, B. 2012. Pengaruh perbedaan suhu perebusan dan konsentrasi NaOH terhadap kualitas bubuk tulang ikan gabus (Channa Striata). FishtecH. 1(1):91101.

Darmawangsyah, D., Jamaluddin, P., and Kadirman. 2018. Fortifikasi tepung tulang ikan bandeng (Chanos chanos) dalam pembuatan kue kering. Jurnal Pendidikan Teknologi Pertanian. 2(2): 149. https://doi.org/10.26858/jptp.v2i2.5170.

Desmukh, AS., Parmar, A. 2019. Development of noodles supplemented with pearl millet flour. International Journal of Scientific Research. 3:2021.

Ferazuma, H., Marliyati, SA., and Amalia, L. 2011. Substitusi tepung kepala ikan lele dumbo (Clarias gariepinus sp.) untuk meningkatkan kandungan kalsium crackers. Jurnal Gizi dan Pangan. 6(1):18-27. https://doi.org/10.25182/jgp.2011.6.1.18-27 .

Firawati. 2018. Isolasi dan karakterisasi fisika kimia gelatin pada gabungan tulang kepala ,tulang badan, dan sirip ikan cakalang (Katsuwonus pelamis l.). Prosiding Seminar Nasional Biologi dan Pembelajarannya. 7482.

Goff, JP. 2018. Invited review: mineral absorption mechanisms, mineral interactions that affect acidbase and antioxidant status, and diet considerations to improve mineral status. Journal of Dairy Science. 101(4):27632813. http://dx.doi.org/10.3168/jds.2017-13112.

Heaney, RP. 2006. Calcium intake and disease prevention. Arquivos Brasileiros de Endocrinologia E Metabologia. 50(4):68593. https://doi.org/10.1590/S0004-27302006000400014.

Hemung, B. 2013. Properties of tilapia bone powder and its calcium bioavailability based on transglutaminase assay. International Journal of Bioscience, Biochemistry and Bioinformatics. 3(4):25. http://www.ijbbb.org/papers/219-S015.pdf.

Kementerian Kelautan dan Perikanan. (2020). Produksi Perikanan. Statistik KKP. https://statistik.kkp.go.id/home.php?m=total&i=2.

Koshihara, M., Masuyama, R., Uehara, M., and Suzuki, K. 2004. Effect of dietary calcium: phosphorus ratio on bone mineralization and intestinal calcium absorption in ovariectomized rats. BioFactors. 22(14):3942. https://doi.org/10.1002/biof.5520220107.

Kosowska, M., Majcher, MA., and Fortuna, T. 2017. Volatile compounds in meat and meat products. Food Science and Technology. 37(1): 17. https://doi.org/10.1590/1678-457X.08416.

Kovacs, M. I.P., Fu, B. X., Woods, S. M., and Khan, K. 2004. Thermal stability of wheat gluten protein: its effect on dough properties and noodle texture. Journal of Cereal Science. 39(1):919. https://doi.org/10.1016/S0733-5210(03)00058-4.

Lala, FH., Susilo, B., and Komar, N. 2013. Uji Karakteristik Mie Instan Berbahan-Baku Tepung Terigu Dengan Substitusi Mocaf Characteristics Test of Instant Noodles Made from Wheat Flour with Mocaf Substitution MOCAF Sendiri Merupakan Singkatan Dari

Modified Cassava Flour Yang Berarti Tepung Singko. Jurnal Bioproses Komoditas Tropis: 1(2):1120.

Lamberg-Allardt, C. and Kemi, V. 2017. Clinical aspects of natural and added phosphorus in foods. Clinical aspects of natural and added phosphorus in foods. 88:14557. https://doi.org/10.1007/978-1-4939-6566-3.

Lekahena, V., Faridah, DN., Syarief, R., and Peranginangin, R. 2014. Karakterisasi fisikokimia nanokalsium hasil ekstraksi tulang ikan nila menggunakan larutan basa dan asam. Jurnal Teknologi dan Industri Pangan. 25(1):5764. https://doi.org/10.6066/jtip.2014.25.1.57.

Loughrill, E., Wray, D., Christides, T., and Zand, N. 2017. Calcium to phosphorus ratio, essential elements and vitamin d content of infant foods in the uk: possible implications for bone health. Maternal and Child Nutrition. 13(3): 110. https://doi.org/10.1111/mcn.12368.

Lu, Q., Guo, S., and Zhang, S.. 2009. Effects of flour free lipids on textural and cooking qualities of chinese noodles. Food research international. 42(2):22630. http://dx.doi.org/10.1016/j.foodres.2008.11.007.

Maruka, SS., Siswohutomo, G., and Rahmatu, RD. 2016. Mutu organoleptik mie kering yang diproduksi dari tepung tulang ikan dan tepung wortel sebagai pensubtitusi tepung terigu. e-Jurnal Mitra Sains. 4(1):8488.

Nemati, M., Huda, N., and Ariffin, F. 2017. Development of calcium supplement from fish bone wastes of yellowfin tuna (Thunnus albacares) and characterization of nutritional quality. International Food Research Journal. 24(6):241926.

Pangestika, W., Putri, FW., and Arumsari, K. 2021. Pemanfaatan Tepung Tulang Ikan Patin Dan Tepung Tulang Ikan Tuna Untuk Pembuatan Cookies. Jurnal Pangan dan Agroindustri. 9(1): 4455. https://doi.org/10.21776/ub.jpa.2021.009.01.5.

Purba, Maijon. 2014. Pembentukan flavor daging unggas oleh proses pemanasan dan oksidasi lipida. WARTAZOA. 24(3):10918. http://dx.doi.org/10.14334/wartazoa.v24i3.1068.

Putranto, HF., Asikin, AN., and Kusumaningrum, I. 2016. Karakterisasi tepung tulang ikan belida (Chitala sp.) sebagai sumber kalsium dengan metode hidrolisis protein. ZiraaAh Majalah Ilmiah Pertanian. 41(1):1120. https://doi.org/10.31602/zmip.v41i1.315.

Qosim, N., Qiram, I., and Rubiono, G. 2018. Pengaruh modifikasi pisau pemotong dan kecepatan putaran terhadap unjuk kerja mesin pemipih dan pemotong adonan mie. Jurnal V-Mac. 3(2):2427.

Ratnawati, SE., Ekantari, N., Pradipta, RW., and Paramita, BL. 2018. The application of response surface methodology (RSM) on the optimization of catfish bone calcium extraction. Jurnal Perikanan Universitas Gadjah Mada. 20(1):41. https://doi.org/10.22146/jfs.35663.

Rosmeri, VI and Monica, BN. 2013. Pemanfaatan tepung umbi gadung (Dioscorea hispida dennst) dan tepung mocaf (modified cassava flour) sebagai bahan substitusi dalam pembuatan mie basah, mie kering, dan mie instan. Teknologi Kimia Dan Industri. 2(2): 24656.

Sax, Leonard. 2001. The institute of medicines dietary reference intake for phosphorus: a critical perspective. Journal of the American College of Nutrition 20(4):27178. https://doi.org/10.1080/07315724.2001.10719047.

Sirichokworrakit, Supatchalee. 2014. Physical, textural and sensory properties of noodles supplemented with tilapia bone flour (Tilapia nilotica). International Journal of Biological, Veterinary, Agricultural and Food Engineering. 8(7):68991. http://www.waset.org/publications/9998916.

Slathia, N., Bandral, JD., and Sood, M. 2016. Quality evaluation of noodles supplemented with germinated mungbean flour. International Journal of Food and Fermentation Technology. 6(2):451. https://doi.org/10.5958/2277-9396.2016.00071.4.

Suas, Michel. 2008. "Advanced bread and pastry". Delmar Cengage Learning, Clifton Park, NY, USA.

Susanti, L., Zuki, M. and Syaputra, F.. 2011. Pembuatan mie basah berkalsium dengan penambahan tulang ikan tenggiri (Somberomorus lineolatus). Jurnal Agroindustri. 1(1): 3544. https://doi.org/10.31186/j.agroind.1.1.35-44.

Takeda, E., Yamamoto, H., Yamanaka-Okumura, H., and Taketani, Y. 2014. Increasing dietary phosphorus intake from food additives: potential for negative impact on bone health. Advances in Nutrition. 5(1):9297. https://doi.org/10.3945/an.113.004002.

Totosaus, A., Montejano, JG., Salazar, JA., and Guerrero, I. 2002. A review of physical and chemical protein-gel induction. International Journal of Food Science and Technology 37:589601. https://doi.org/10.1145/800219.806660.

Trilaksani, W., Salamah, E., and Nabil, M. 2006. Pemanfaatan limbah tulang ikan tuna (Thunnus sp.) sebagai sumber kalsium dengan metode hidrolisis protein. Jurnal Pengolahan Hasil Perikanan Indonesia. 9(2):3445. https://doi.org/10.17844/jphpi.v9i2.983.