Nutritional and sensory evaluation of skipjack furikake-substituted catfish

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Abstract. Furikake is a traditional Japanese spice used as a condiment sprinkled on rice, comprising dried skipjack or salmon flakes, toasted sesame seeds, and toasted dried seaweed. Due to the higher price of skipjack, there is an attempt to substitute it with a more affordable fish, catfish. This research investigated the impact of this substitution in the development of Japanese furikake on its nutritional values and sensory acceptance. There were five formulations consisting of various percentage ratios of dried skipjack and catfish flakes, namely formula 1 (100:0), formula 2 (75:25), formula 3 (50:50), formula 4 (25:75), and formula 5 (0:100). The findings in proximate analysis indicated no significant difference between samples in terms of moisture (2.87-3.29%), ash (2.64-3.29%), and fat (25.81-26.26%), meanwhile the protein content tended to decrease with up to 50% of catfish substitution (23.33-21.58%) and is significantly different when substituted with more than 50% catfish (p<0.05). Sensory analysis showed no significant difference among samples in all sensory parameters. Overall, the findings in this study suggest that catfish is a potential substitute in Japanese furikake formulation, from 25% up to 100% substitution with minimal nutritional content difference.

1 Introduction

Furikake is one of Japan’s authentic spices, which are commonly used as condiments and toppings to be sprinkled on cooked rice, consisting of dried fish flakes, toasted sesame seeds, and toasted dried seaweed [1-2]. Furikake are added to dishes to add umami flavor and crisp texture with their dry and granulated texture [3]. They can make meals more palatable for patients [4] and are even proposed in a study to be used as functional supplementation to promote growth acceleration for malnourished children in Indonesia, using locally sourced marine products [5].

The fish used in conventional commercial furikake usually comes from the sea, which includes salmon and skipjacks [6]. There are several innovations in the conventional main ingredient used in furikake rice seasoning, fish flakes, substituting it with local ingredients like coconut worm in Laos [7], fermented soybean [8], and chaya leaves in Thailand [9]. In this research, catfish is used as a substitute for skipjack in furikake as an alternative due to its cheaper price. According to fishinfojatim.net, which captures the average prices of fish per kilogram in Eastern Java cities, during the periods of 19-25 September 2023, skipjacks

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are priced at Rp. 34,555,64-45,333,33/kg while catfish are priced at Rp 25,000,00/kg, causing a 27,65-44,85% cheaper price of fish per kilogram [10].

Catfish are freshwater fish that have no scales and have firm and white meat with a mild flavor that can yield 35% of fillet [11]. In the year 2021, the production of catfish in Indonesia reached 1,06 million tons [12]. The growth of catfish farming is not only seen in Indonesia but globally, contributing to approximately 2.3% of global fish production, and has great potential to stimulate economic growth and reduce poverty in developing countries [13]. The growth of catfish farming in Indonesia increases rapidly due to it being farmed on both large and small scales, including households, since catfish are fast-growing and highly adaptable [14]. The increase of catfish production in Indonesia is projected to increase by 2,3-2,8 times by the year 2030 [15]. With the increase of catfish production also comes the growing trend of innovation in food products utilizing catfish as an ingredient throughout literature, like in commercial foods like nuggets [16] and sausages [17]. Whole catfish utilization is also a topic of interest in literature [18].

With the abundance of catfish in Indonesia and its potential in the global market, the primary research objective in this paper is aimed to determine the feasibility of substituting catfish for Japanese skipjack furikake, taking in mind that the choice of carbohydrate in Indonesians is rice [19], and finding the best formulation that offers cost-effective alternative while maintaining minimal nutritional difference and acceptable sensory attributes, through different formulations of furikake using skipjack with the gradual substitution of catfish, which are tested and compared through parameters of proximate analysis (moisture, ash, fat, protein, and carbohydrate content determination), sensory analysis (hedonic testing and color analysis), and water activity measurement continued with statistical analysis.

2 Methods

2.1 Preparation of Furikake Samples

2.1.1 Preparation of Furikake Ingredients

Fresh skipjack and catfish were bought from a retail supermarket, filleted, washed, and smoked for 3 hours using coconut shells. They are then cooled, shredded, and dehydrated in a food dehydrator for 22 hours at 65℃. The dried, smoked fish were milled into flakes and stored in an air-tight container.

Sesame seeds were bought from a retail supermarket, roasted for 15 minutes at 160℃, cooled, then coarsely milled, and stored in an air-tight container. Seaweeds were bought from a retail supermarket, roasted for 1 minute at 160℃, coarsely milled, then roasted again for another 10 minutes at 160℃, and stored in an air-tight container. Palm sugar and salt were bought from a retail supermarket as well.

2.1.2 Formulation of Furikake Samples

Furikake samples were made in 5 formulations with differing ratios of the two types of dried smoked fish flakes comprised of skipjack and catfish, namely: Formula 1 (100:0), Formula 2 (75:25), Formula 3 (50:50), Formula 4 (25:75), and Formula 5 (0:100), alongside roasted sesame seeds, roasted seaweed, palm sugar, and salt shown in Table 1, showing formulation of one serving of furikake (20g) to be consumed with 1,5 cups of cooked rice. For all formulations, the ingredients prepared beforehand are weighed and combined in one container, then homogenized.
Table 1. Formulation of One Serving of Furikake (20g)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Formula (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Smoked Skipjack Fish Flakes</td>
<td>8</td>
</tr>
<tr>
<td>Catfish</td>
<td>0</td>
</tr>
<tr>
<td>Roasted Sesame Seeds</td>
<td>5</td>
</tr>
<tr>
<td>Roasted Seaweed</td>
<td>2</td>
</tr>
<tr>
<td>Palm Sugar</td>
<td>3</td>
</tr>
<tr>
<td>Salt</td>
<td>2</td>
</tr>
</tbody>
</table>

2.2 Proximate Analysis

2.2.1 Moisture Content Determination

Moisture content determination was done in triplicate with a preheated aluminum dish, cooled in the desiccator, weighed, added 3 grams of samples, and heated in the oven for 24 hours at 98°C, then stored in the desiccator until cooled and weighed. Moisture contents were calculated as seen in Equation 1 below [20].

\[
\%\text{moisture} = \frac{\text{weight of moisture in sample}}{\text{weight of wet sample}} \times 100
\]  

(1)

2.2.2 Ash Content Determination

Ash content determination was done in triplicate, with preheated ash crucibles, cooled in the desiccator, weighed, added 2 grams of samples, and burned in the muffle furnace for 8 hours at 550°C, then allowed to cool overnight and stored in the desiccator to cool further before being weighted. Ash contents were calculated as seen in Equation 2 below [20].

\[
\%\text{ash} = \frac{\text{weight of ash in sample}}{\text{weight of wet sample}} \times 100
\]  

(2)

2.2.3 Fat Content Determination

Fat content determination was done by Soxhlet method in triplicate, with preheated cellulose extraction thimbles, cooled in the desiccator, added 2-3 grams of samples, and closed with a small plug of dried glass wool. Thimbles were then placed in the Soxhlet apparatus, added 350 mL petroleum ether, and extracted for 6 hours; then the flask was dried in the oven for 24 hours at 70°C, cooled in the desiccator, and weighed for its fat extract from the sample. Fat contents were calculated as seen in Equation 3 below [20-21].

\[
\%\text{fat} = \frac{\text{weight of fat in sample}}{\text{weight of wet sample}} \times 100
\]  

(3)
2.2.4 Protein Content Determination

Protein content determination was done by Kjeldahl method in triplicate, starting with the digestion process where 0.1 grams of sample were added in the digestion tube along with one catalyst tablet and 5 mL of concentrated sulfuric acid; a blank was also prepared in the same way without the sample. Samples and the blank were digested for a couple of hours until clear and without any charred materials remaining. Samples were then cooled, followed by the distillation process using a protein distiller, using 5 mL 3% boric acid solution, 18 mL 35% sodium hydroxide solution, and 5 mL water. The distillate solutions then underwent the titration process using an automated titrator with a standardized 0.1 N HCl solution until the endpoint of pH 4.2. Protein contents were calculated as seen in equation 4 and 5 below with a standard protein conversion factor of 6.25 [20].

\[
\%N = \frac{(N \text{ HCl})(\text{mL titration} - \text{mL blank})}{[\text{weight of wet sample (g)}][14\text{ g N mol}^{-1}]} \times 100
\]

\[
\%\text{protein} = \%N \times (\text{protein conversion factor})
\]

2.2.5 Carbohydrate Content Determination

Carbohydrate content determination was done by difference method for total carbohydrates in triplicate to obtain standard deviation, by subtracting 100% from %moisture, %ash, %fat, and %protein, as seen in equation 6 below [21].

\[
\%\text{carbohydrate} = 100\% - \%\text{water} - \%\text{ash} - \%\text{fat} - \%\text{protein}
\]

2.3 Sensory Analysis

2.3.1 Hedonic Testing

Hedonic testing was done with 62 untrained panelists by giving out five sets of samples for each formulation, served with the 20 grams/1.5 cooked rice serving instruction, and shaped into rice balls with a diameter of 1.5 cm each. Instructions were to rate each sample with a hedonic scale of 1-9 for aroma, color, taste, texture, and overall liking with a scaling description as seen in Table 2 and to cleanse the palate with water before testing every sample; data were collected through Google Forms [22].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dislike extremely</td>
</tr>
<tr>
<td>2</td>
<td>Dislike very much</td>
</tr>
<tr>
<td>3</td>
<td>Dislike moderately</td>
</tr>
<tr>
<td>4</td>
<td>Dislike slightly</td>
</tr>
<tr>
<td>5</td>
<td>Neither like nor dislike /neutral</td>
</tr>
<tr>
<td>6</td>
<td>Like slightly</td>
</tr>
<tr>
<td>7</td>
<td>Like moderately</td>
</tr>
<tr>
<td>8</td>
<td>Like very much</td>
</tr>
<tr>
<td>9</td>
<td>Like extremely</td>
</tr>
</tbody>
</table>
2.3.2 Color Analysis

Color analysis was carried out using a calibrated colorimeter in triplicate to analyze parameters of relative ΔL*, Δa*, Δb*, and ΔE* for each formula (Formula x) to the average of 100% skipjack furikake (Formula 1) as base [21].

2.4 Water Activity Measurement

Water activity measurement was carried out using a calibrated dewpoint water activity meter in triplicate by placing samples in the meter’s cup until they covered its surface, then placed and sealed in the meter for reading [21].

2.5 Statistical Analysis

Data are expressed in mean ± SD. All data were tested for normality using the Shapiro-Wilk test with α=0.05 and equality of variances using Levene’s test with α=0.05; if both tests are satisfied, then it is continued with ANOVA (Analysis of Variance) with α=0.05 to see if there are significant difference, if there are, it is followed by Duncan’s test to obtain alphabetical rank orders. If the data does not satisfy the normality and equality of variances assumptions of ANOVA, then it is analyzed using Kruskal-Wallis with α=0.05, followed by Dunn’s test if there are significant differences and ranked alphabetically according to the group’s median order [23].

3 Result and Discussion

Fish generally are comprised nutritionally of 66-81% moisture, 1.2-1.5% ash, 0.2-2.5% fat, 16-21% protein, and <0.50% carbohydrate and is considered biologically important for human consumption due to their essential amino acids, micronutrients, and high levels of omega-3 and omega-6 when compared with other human-consumed meats [24]. With the only independent variable being the skipjack and catfish ratio in the furikake formulation, it can be inferred that the significant difference caused in protein and carbohydrate content is due to the substitution of catfish in the furikake formulation. Table 3 shows the difference in nutritional values in raw skipjack [25] and catfish [26] caught in Indonesia from the literature. Skipjack is considered a low-fat/lean and high-protein fish; meanwhile, catfish is considered a medium-fat and a protein fish, which explains the lower protein content in furikake formulations with higher catfish substitution [27].

<table>
<thead>
<tr>
<th>%Content</th>
<th>Skipjack</th>
<th>Catfish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>71.76%</td>
<td>76.43%</td>
</tr>
<tr>
<td>Ash</td>
<td>1.49%</td>
<td>1.21%</td>
</tr>
<tr>
<td>Fat</td>
<td>0.60%</td>
<td>4.53%</td>
</tr>
<tr>
<td>Protein</td>
<td>25.29%</td>
<td>17.40%</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0.87%</td>
<td>0.44%</td>
</tr>
</tbody>
</table>

Table 3. Nutritional Value Difference of Skipjack [23] and Catfish [24]

Table 4 shows the nutritional value of the furikake samples, showing no significant difference in moisture, ash, and fat contents among formulas. Meanwhile, the protein content shows a decreasing tendency in furikake with catfish substitution up to 50% and becomes significantly decreased in substitution of catfish higher than 50%. Carbohydrate content also
shows an increasing tendency in catfish substitution up to 75% and becomes significantly increased in substitution of catfish higher than 75%.

Table 4. Nutritional Value of Furikake Samples

<table>
<thead>
<tr>
<th>%Content</th>
<th>Formula 1</th>
<th>Formula 2</th>
<th>Formula 3</th>
<th>Formula 4</th>
<th>Formula 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>3.06 ± 0.22a</td>
<td>3.29 ± 0.44a</td>
<td>2.97 ± 0.27a</td>
<td>2.87 ± 0.13a</td>
<td>2.95 ± 0.26a</td>
</tr>
<tr>
<td>Ash</td>
<td>12.58 ± 0.46a</td>
<td>11.95 ± 0.73a</td>
<td>11.92 ± 0.51a</td>
<td>12.30 ± 0.52a</td>
<td>11.04 ± 0.70a</td>
</tr>
<tr>
<td>Fat</td>
<td>25.84 ±0.46a</td>
<td>25.81 ± 0.19a</td>
<td>26.01 ± 0.21a</td>
<td>25.94 ± 0.18a</td>
<td>26.26 ± 0.20a</td>
</tr>
<tr>
<td>Protein</td>
<td>23.33 ± 1.01a</td>
<td>22.75 ± 0.00a</td>
<td>21.58 ± 1.01ab</td>
<td>20.42 ± 1.01bc</td>
<td>19.25 ± 0.00c</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>35.52 ± 1.03b</td>
<td>36.33 ± 0.64b</td>
<td>37.44 ± 1.22b</td>
<td>38.35 ± 1.21ab</td>
<td>40.94 ± 0.39a</td>
</tr>
</tbody>
</table>

The smoking and dehydration process in the making of the fish flakes in furikake lowered the moisture levels of the fish, making it drier. Although moisture and fat content are seen higher in raw catfish compared to raw skipjack, the proximate analysis of furikake samples shows no significant difference between formulas; this might be due to the smoking process that melts the moisture and fat from catfish, noting that water holding capacity has an inverse relationship with the amount of fat in fish, causing a loss in more moisture and fat in catfish than in skipjack meat [28]. The carbohydrate content of both fishes are similar in terms of value but show a significant increase in 75% catfish substitution and above; this may be due to inaccurate analysis of the other proximate contents that the carbohydrate content depends on because it uses the difference method. It should also be noted that different methods of cooking and smoking can result in significantly different proximate composition results [29-30] and also that the state of fish phase of fishes when they are farmed/caught also cause significant fluctuations in nutritional composition among the same species [27].

Table 5 shows the result of the hedonic sensory evaluation of Furikake samples in 62 untrained panelists, analyzed with Kruskal-Wallis due to a skewed data distribution, showing no significant difference among all parameters for all furikake samples.

Table 5. Average Hedonic Rating of Furikake Samples

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula 1</th>
<th>Formula 2</th>
<th>Formula 3</th>
<th>Formula 4</th>
<th>Formula 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroma</td>
<td>6.71 ± 1.66a</td>
<td>6.45 ± 1.89a</td>
<td>6.48 ± 1.84a</td>
<td>6.89 ± 1.96a</td>
<td>7.19 ± 1.53a</td>
</tr>
<tr>
<td>Color</td>
<td>6.81 ± 1.66a</td>
<td>6.71 ± 1.93a</td>
<td>6.76 ± 1.86a</td>
<td>7.10 ± 1.76a</td>
<td>7.23 ± 1.64a</td>
</tr>
<tr>
<td>Taste</td>
<td>6.79 ± 1.70a</td>
<td>6.61 ± 1.85a</td>
<td>6.73 ± 1.97a</td>
<td>6.97 ± 1.72a</td>
<td>7.10 ± 1.83a</td>
</tr>
<tr>
<td>Texture</td>
<td>6.89 ± 1.83a</td>
<td>6.82 ± 1.87a</td>
<td>6.63 ± 1.84a</td>
<td>6.76 ± 1.79a</td>
<td>7.15 ± 1.72a</td>
</tr>
<tr>
<td>Overall</td>
<td>6.97 ± 1.61a</td>
<td>6.76 ± 1.88a</td>
<td>6.85 ± 1.76a</td>
<td>7.08 ± 1.67a</td>
<td>7.18 ± 1.75a</td>
</tr>
</tbody>
</table>

The test was done towards a random group of people, showing that almost all parameters among all formulas fall in the like slightly to like scale very much. It should also be noted that these results can also be affected by the rice used to be the medium of feeding. Overall, the panelists show a similar liking towards each of the formulated samples, which means that sensorially, skipjack furikake with catfish substitution can be accepted as a substitution for skipjack furikake.

Table 6 shows the color analysis, with comparisons of relative $\Delta L^*$, $\Delta a^*$, $\Delta b^*$, and $\Delta E^*$ with Formula 1 as a base. Each parameter shows significant difference to the gradual increase of catfish substitution.
Table 5 shows the result of the hedonic sensory evaluation of Furikake samples in 62 untrained panelists, analyzed with Kruskal-Wallis due to a skewed data distribution, showing significant fluctuations in nutritional composition among the same species [27].

Cooking and smoking can result in significantly different proximate composition results [29-30] and also that the state of fish phase of fishes when they are farmed/caught also cause on because it uses the difference method. It should also be noted that different methods of to inaccurate analysis of the other proximate contents that the carbohydrate content depends value but show a significant increase in 75% catfish substitution and above; this may be due than in skipjack meat [28]. The carbohydrate content of both fishes are similar in terms of relationship with the amount of fat in fish, causing a loss in more moisture and fat in catfish that melts the moisture and fat from catfish, noting that water holding capacity has an inverse shows no significant difference between formulas; this might be due to the smoking process higher in raw catfish compared to raw skipjack, the proximate analysis of furikake samples the moisture levels of the fish, making it drier. Although moisture and fat content are seen shows an increasing tendency in catfish substitution up to 75% and becomes significantly among all formulas fall in the like slightly to like scale very much. It should also be noted the panelists show a similar liking towards each of the formulated samples, which means that

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula 1</th>
<th>Formula 2</th>
<th>Formula 3</th>
<th>Formula 4</th>
<th>Formula 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔL*</td>
<td>-0.00 ± 0.05a</td>
<td>-0.70 ± 0.07b</td>
<td>-3.59 ± 0.02c</td>
<td>-6.04 ± 0.03d</td>
<td>-8.97 ± 0.03e</td>
</tr>
<tr>
<td>Δa*</td>
<td>0.00 ± 0.02c</td>
<td>0.12 ± 0.01d</td>
<td>0.17 ± 0.01c</td>
<td>0.27 ± 0.01b</td>
<td>0.34 ± 0.02a</td>
</tr>
<tr>
<td>Δb*</td>
<td>-0.00 ± 0.03a</td>
<td>-1.05 ± 0.02b</td>
<td>-2.72 ± 0.07c</td>
<td>-3.47 ± 0.01d</td>
<td>-7.08 ± 0.01c</td>
</tr>
<tr>
<td>ΔE*</td>
<td>-0.00 ± 0.03a</td>
<td>-1.58 ± 0.06b</td>
<td>-3.13 ± 0.04c</td>
<td>-5.42 ± 0.02d</td>
<td>-7.42 ± 0.02e</td>
</tr>
</tbody>
</table>

ΔL* points to the lightness of color; the lower the value, the lighter the color, and the higher the value, the darker the color; Δa* points to the red-green axis; the higher the value, the more red the color, the lower the value, the more green the color, Δb* points to the yellow-blue axis, the higher the value, the more yellow, the lower the value, the more blue, and ΔE* points to the total color difference that shows the magnitude of color difference between two colors [21]. With that in mind, we can see that the ΔE* values increase as catfish substitution increases, which means that the magnitude of color difference caused is significant. When we see the ΔL*, Δa*, and Δb* values, we can see to which degree it does against Formula 1. The increased ratio of catfish substitution resulted in a brighter, less red, and more yellow color. This is due to the nature of these fishes; skipjack meat is relatively darker than catfish due to its richer level of myoglobin [31]. Meanwhile, catfish meat is white in color due to lower concentrations of myoglobin [32]. This can visually be seen in the prototype figure below with Formula 1-5 ordered numerically.

![Sample Prototype of Formula 1-5](image)

Table 6 shows the water activity of furikake samples as one of the product’s stability analysis in this study, which shows no significant difference in all the formulated samples. The furikake samples are low-moisture in terms of their moisture content (2.87-3.29%), being under 10%, but intermediate-moisture in terms of their water activity, being in the 0.6-0.9 range. Water activity significantly correlates to the stability and quality of food products; the intermediate level of water activity can support microbial growth and might negatively impact the sensory attributes of the product over time. Therefore, methods to lower water activity are recommended for a more stable product, which can be utilized through food processing or packaging [33].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula 1</th>
<th>Formula 2</th>
<th>Formula 3</th>
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<th>Formula 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔL*</td>
<td>-0.00 ± 0.05a</td>
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<td>-3.59 ± 0.02c</td>
<td>-6.04 ± 0.03d</td>
<td>-8.97 ± 0.03e</td>
</tr>
<tr>
<td>Δa*</td>
<td>0.00 ± 0.02c</td>
<td>0.12 ± 0.01d</td>
<td>0.17 ± 0.01c</td>
<td>0.27 ± 0.01b</td>
<td>0.34 ± 0.02a</td>
</tr>
<tr>
<td>Δb*</td>
<td>-0.00 ± 0.03a</td>
<td>-1.05 ± 0.02b</td>
<td>-2.72 ± 0.07c</td>
<td>-3.47 ± 0.01d</td>
<td>-7.08 ± 0.01c</td>
</tr>
<tr>
<td>ΔE*</td>
<td>-0.00 ± 0.03a</td>
<td>-1.58 ± 0.06b</td>
<td>-3.13 ± 0.04c</td>
<td>-5.42 ± 0.02d</td>
<td>-7.42 ± 0.02e</td>
</tr>
</tbody>
</table>

4 Conclusion

Overall, the findings in this study suggest that catfish is a potential substitute in skipjack furikake formulation, from 25% substitution up to 100% substitution. The substitution results
in minimal nutritional difference and no significant difference in perceived sensory parameters (despite significant difference in color). There are still loads of room for improvement in optimizing the best formulation for substituted furikake to be favored by the public. Additionally, further research is needed to design optimal processing methods to ensure good quality and stability, as well as to enhance the product’s accessibility and appeal to consumers.

References

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