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Characteristics of Chips From Scales of Carp, Tilapia and Gourami Fish Using Various Coating Flours

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ABSTRACT

Fish scales are waste and most of them are thrown away during processing. The components of fish scales include 70% water, 27% protein, 1% fat and 2% ash. Therefore, the scales can be used as a food product in the form of chips. Fish scales can be processed into chips due to their composition of collagen, which provides structural support and flexibility to the scales. The collagen fibers within the scales can be arranged and compacted to create a thin, chip-like structure that maintains its integrity and shape. Processing of fish scale chips requires flour coating. Coating can help to bind processed fish scales together, adding structural support and preventing the chips from crumbling or breaking apart during handling and consumption. This study used a randomized complete block design with two factors. The first factor is the type of fish scales, A1 (carp fish scales), A2 (tilapia fish scales) and A3 (gourami fish scales). The second factor is the type of flour, B1 (corn starch), B2 (tapioca) and B3 (rice flour). Analysis of fish scales produced included: chemical characteristics (moisture content, ash, fat, protein), physical characteristics (colour and texture), and organoleptic preference (colour, taste, aroma and texture). The results of this study indicate that variations in the types of fish scales have a significant effect on organoleptic (colour and taste), organoleptic (aromatic) significant effect. However, it did not significantly affect the moisture content, ash content, fat content, protein content, total colour difference, texture (hardness, fracture, chewiness, and cohesiveness), and organoleptic (texture). Variations in the type of flour have a significant effect on organoleptic (colour), significantly affect texture (fracture) organoleptic (taste). However, it did not significantly affect the moisture content, ash content, fat content, protein content, color, texture (hardness, chewiness, and cohesiveness), organoleptic (aromatic, and texture). The rice flour gourami scale chips and rice flour carp scale chips produced comply with SNI 8644:2018 except for the fat content. The recommended treatment is fish scale chips from gourami fish scales coated with rice flour.

Keywords: Carp scales, Chips, Flour type, Gourami scales, Texture, Tilapia scales

INTRODUCTION

Fish processing produces several wastes, including fish scales of 5% (Coppola *et al.*, 2021). Fish scales have organic compounds, including 41-84% organic proteins. Fish scale also contain mineral and inorganic salts like magnesium carbonate and calcium carbonate (Junianto, *et al*., 2022). So fish scales can be processed into protein-rich fish chips.

The fish fillet industry produces fish scales in large quantities which can be extracted into collagen (Rajabimashhadi *et al*., 2023). Fish scales can also be used as raw material for chitosan and gelatin. Fish scale also used as raw material for non-food purposes, such as handicraft products, brooches, and beads (Junianto, *et al*., 2022).

The freshwater fish scales such as carp fish, tilapia, and gourami fish have low commercial value, so their scales wastes are discarded (Lee *et al*., 2022). This not only causes environmental pollution but also leads to loss of value-added by-products in the waste. It also reduces dissolved oxygen levels in water and, when decomposed, produces toxic products that contaminate aquatic habitats and endanger various biodiversity resources.

The lower salt content makes freshwater fish scales easier to process for food or industrial purposes. They tend to be less hard or brittle when dried or processed, and may have a more neutral taste when used in food products. Freshwater fish scales are typically less exposed to the same level of marine pollutants, so it is safe as food.

Fish scales consist of a superficial layer containing hydroxyapatite and calcium carbonate, and a deeper layer consisting mainly of collagen. Elements such as Ca, Mg, P, Na, and S are also present in low concentrations (Harikrishna et al., 2017).

Freshwater fish scales contain high protein. Fish scale protein content varies. Tilapia scales have a dry protein content of 55.87% and an ash content of 36.48% (Zhang *et al*., 2019). The fat content of the golden goatfish is 0.83±0.1%. The moisture and protein content of the golden goatfish is 23.79±1.57% and 34.46±0.10%, respectively (Matmaroh *et al*., 2011). The carp fish contain 29,8-40,9% protein (Nurjanah *et al*., 2010).

Based on the nutritional value, especially its protein highly, some researchers have been able to create nutritious foods and meals out of fish scales (Salindeho *et al*., 2022). So that fish scales have the potential to be used as a raw material of fish scale chips. Previous research on fish scale chips used red snapper scales and used cornstarch and wheat. (Mulyani & Farida, 2012; Pattipeilohy et al., 2022).

Chips are crackers that are dry, crunchy (crispy) and relatively high fat content. Chips are popular because of their distinctive texture, delicious taste, long shelf life, practical portability and storage. Crispness is a distinctive characteristic of chips products.

The problem that often occurs in chip products is excessive absorption of oil during the frying process so that there is a potential for changes in texture and rancidity after storage. The other problem, fish scales have a tough, sometimes leathery texture, making them difficult to crispy. To overcome this problem is coating the fish scales with flour or starch before frying (Yusuf *et al*., 2012).

The soft, moist interior and porous, crispy outer skin of improve palatability, making these products an essential part of the human diet. The flours that can be used to make fish scale chips are corn flour, tapioca/starch, rice flour and wheat flour. Cornstarch, tapioca, and rice flour are high in starch content. Starches help create the desired crispy, crunchy texture when the chips are fried. The starch helps the chips hold their shape and creates a distinctive fish scale-like pattern. Starch have good binding properties, which help the dough or batter stick together and maintain the fish's scale shape during cooking. The different flours impart varying textures - corn and rice flours tend to produce a lighter, more delicate chip, while tapioca and wheat flours can create a chewier texture (Milde et al., 2012; Sresatan et al., 2024).

Starch granule size appears to be correlated with gelatinization temperature. The higher the gelatinization temperature, the smaller the starch granule size (Abdullah *et al.*, 2018). Starch granule shape and size is determined by the composition of amylose and amylopectin. The amount of amylose is less than that of amylopectin due to the smaller molecular size of amylose (Abdullah *et al*., 2018).

Cornstarch is one of the most commonly used materials in the production of edible food coatings (de Araújo *et al*., 2023). Corn starch can be used as an ingredient in making chips, because it can also form a gel. Corn starch contains 75% amylopectin and 25% amylose (Yu and Moon, 2022). Corn starch is a source of carbohydrates used for making bread, pastries, biscuits, baby food, and possibly can be made fettuccine, and can be used in the pharmaceutical industry (Zainuddin, 2019).

Tapioca is starch extracted from cassava. Due to the high amylopectin content of tapioca, products made with tapioca flour have a crunchy texture. Tapioca is a water-soluble fiber that is commonly used as a filler and binder in the manufacture of chips and to create bio plastic in the food industry. Tapioca flour contains amylose, which produces a more cohesive texture (Hikmah *et al*., 2019).

The amylose content of rice flour is lower, ranging from 16% to 20% (Ronie and Hasmadi, 2022). A product made from rice flour with a low amylose content has dampness, softness, and chewiness. Rice flour with a high amylose content (>30%), on the other hand, provides crispness and firmness to the product texture due to the formation of a three-dimensional network (Ronie and Hasmadi, 2022).

The aim of this research were : (1) to determine the effect of the corn starch, tapioca and rice flour as coating material on the characteristics of carp fish, tilapia, and gourami fish scales chip, (2) determine the type of coating flour and type of fish scales that produce fish scale chips that are most preferred by panelists and comply with SNI 8644:2018.

MATERIALS AND METHODS

Tools and Materials

The materials used in the manufacture of fish scale chips are fish scale chips, namely carp scales, tilapia scales, gourami scales. The fish scales were obtained from the Jogja fish market, Yogyakarta. The length of carp fish, tilapia and gourami are 15-17 cm, 13-17 cm and 25-30 cm respectively, wheat flour, shallots, garlic, ginger, turmeric, coriander, pepper, lime leaves, salt, sugar, lime, and cooking oil. The chemicals used for analysis were n-hexane (Merck), distilled water, sulfuric acid (Merck), sodium acetate, methyl red indicator (Sigma-Aldrich), sodium hydroxide (Merck), gallic acid (Sigma-Aldrich), and sodium bicarbonate.

Preparation of fish scales

Carp, Tilapia, and Gourami fish scales are washed to remove the dirt. Soaked fish scales in lime juice for 30 minutes. Refining spices such as shallots, garlic, ginger and turmeric, clean the skin and then mix it with coriander and pepper, then grind it using a blender. Then wash it and wash the scales of carp, tilapia, carp that have been soaked in lime juice with clean water and drain. The scales soaked with the spices that have been mashed for 3 hours so that the spices are absorbed, then steam for 45 minutes.

Preparation of flour coating

Prepare cornstarch, rice flour, and tapioca flour, in a different place and then combine with wheat flour in a ratio of 1: 1 (100 g: 100 g).

Preparation of fish scale chip

A 100 g of fish scales (Carp, Tilapia and Gourami fish scale) mixed with 100 g flour (tapioca, cornstarch and rice flour) and 100 g wheat flour at ratio of 1: 1 w/w. Stirred and added 1 egg, stirred again and after it is thoroughly mixed, let it stand for less than 1 hour. After coating, the fish scales have deep frying until cooked. The fish scale chips were analyzed: moisture (Sudarmadji et al., 2010), ash content (Sudarmadji et al., 2010), fat content (Sudarmadji et al., 2010), protein content (Sudarmadji et al., 2010), color using Chroma meter, texture using texture analyzer (Jirukkakul, 2021) and organoleptic preference (Kartika et al., 1998).

Moisture analysis (Sudarmadji et al., 2010),

Weigh the weighing bottle (a gram) after drying it in the oven (Memmert) for about 15 minutes. The ground samples were weighed with a difference of ± 1 g and weighed (b grams). Next, heat the weighing bottle at 100-105 °C for 4-6 hours using an oven. After the weighing bottle has cooled in the desiccator, its weight is weighed. Repeat until a constant weight (c grams) is obtained. Water content is calculated using formula :

Moisture content (%) $=\frac{b-c}{b-a}$ x100%…...(1)

a= weight of bottle,
b= weight of bottle + sample
c= weigh the bottle + sample after oven dried

Ash analysis (Sudarmadji et al., 2010),

Ash content analysis was carried out with a Muffle Furnance (Thermo Scientific) in the following way. The crucible was dried in an oven at a temperature of 100°C to 105°C for 1 hour, cooled in a desiccator for 15 minutes then weighed the empty cup (W). 2 grams of sample was weighed in a crucible (W1). The samples were dried in a muffle furnace at a temperature of 500°C for 5 hours. After the ashing process, the sample was cooled in a desiccator for 15 minutes, then weighed the crucible containing the ash (W2). The ash content is calculated using the formula:

Ash content (%) = $\frac{W2-W}{W1}\ x\ 100\%$...........(2)

W= weight of crucible
W1 = weight of sample before ashing
W2 = weight of crucible + sample after ashing

Fat analysis (Sudarmadji et al., 2010),

Fat content analysis was carried out using the soxhlet method. Weigh a 2 gram sample and put it in a 250 ml Erlenmeyer flask. Add 100 ml of distilled water and 10 mL of 25% HCl for hydrolysis for 30 minutes at 100°C. Filter with filter paper, then wash the remainder until neutral. The sample was placed in an oven at a temperature of 105 °C until constant. Take the sample and put it in the sleeve. Put the sample in the oven until it remains constant, then weigh it. Add a suitable solvent, such as hexane to the sample. Extraction using Soxhlet for 5 hours. After the extraction, the solvent containing the extracted fat is collected. Evaporate the solvent, using a rotary evaporator. Weigh the extracted fat residue and record the weight The fat content is calculated as a percentage of the original sample weight using the following formula:

Fat content (%) =

$\frac{(Weight\ of\ extracted\ fat)}{Weight\ of\ sample}\ x\ 100\%$.............(3)

Protein analysis (Sudarmadji et al., 2010),

Protein content analysis was carried out using the Kjeldahl method as follows. Digestion stage: weigh 0.2 grams of soil sample and place it in a Kjeldahl flask. Add 0.7 grams of N catalyst (250 grams Na_2SO_4 + 5 grams $CuSO_4$ + 0.7 grams selenium/TiO_2). Add 4 mL concentrated H_2SO_4. Crush it in a fume cupboard until the color turns clear. Distillation stages: after it has cooled, add 10 mL of distilled water and add 20 mL of NaOH – Tio (NaOH 40% + $Na_2S_2O_3$ 5%) and the resulting distillate is collected using 4% H_3BO_3 which has been given the Mr-Bcg indicator. Distill: 60 mL of the distillate is collected in an Erlenmeyer flask (changes color from pink to bluish green). Titration stages: titration of the obtained solution with 0.02 N HCl (color change from bluish green to pink). record the titration volume. Calculate the total N or percent protein in the example, using the formula:

Protein content (%) =

$$\frac{\text{V titration x N HCl (0,0154 N)x(14,008)x6,25}}{\text{Sample weight x 1000}} \text{ x } 100\%$$

....(4)

Textures analysis (Jirukkakul, 2021)

The texture of fish scale chips was analyzed using the Texture Analyzer method (Lloyd type TAI, Godalming, UK). Place the fish scale chips on a flat metal plate about 0.5 cm thick. The sample was compressed twice with a force of 5.0 g P/50 R probe (aluminum cylinder diameter 50 mm) until it reached 50% of the sample height at a testing speed of 5 mm/s. Repetition was carried out 4 times. The texture profile analysis curve shows several parameters, namely hardness, cohesiveness and chewiness, and susceptibility to damage.

Color analysis

Color analysis using a chromameter (3nh Colorimeter NH310) was carried out as follows. Make sure the chromameter is in good condition and properly calibrated before use. Prepare samples. Turn on the chromameter and place the tool head horizontally on the sample. Press the button to measure the color of the sample. Record the values of L, a, and b produced by the tool. Use the measurement results to analyze color changes or the total color difference between samples (ΔE), with the formula:

$$\Delta E = \sqrt{(\Delta L *^2 + \Delta a *^2 + \Delta b *^2)} \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

ΔL = (L*value of sample - L* standart)

Δa = (a*value of sample - a* standart)

Δb = (b*value of sample - b* standart)

Organoleptic preferences

The organoleptic preference test was carried out using the hedonic method with 20 semi-trained panelists. The hedonic test includes preference for color, taste, aroma, texture and overall preference. The preference score is 1-5, where 1= really dislike, 2= don't like, 3= neutral, 4= like and 5= really like.

Statistical analysis

Data processing was carried out using the IBM SPSS Statistic version 25 application. The data obtained was carried out an analysis of variance (ANOVA) to determine the influential factors and then the Duncan test was carried out to determine the differences between the influential treatments.

RESULTS AND DISCUSSION

Moisture of fish scale chip

The moisture of fish scale chips showed in Table 1. The type of fish scales did not significantly affect the moisture of fish scales chips. The type of coating flour does not affect the moisture of fish scale chips. The moisture of fish scale chips ranged from 4.12 to 6.07%.

The type of fish scales did not significantly affect the moisture due to frying time and temperature were carried out under the same conditions. The size of the fish scales of the three types scales are same and classified into the type of cycloid scales (circles) so the process of absorbing oil during frying is almost the same. This result is in accordance with Sari *et al*. (2021) which obtained a moisture content of salted-egg fish skin chips of 4.44% - 5.73%. The moisture of carp scale chips and gourami scale chip according to SNI 8644:2018 (the moisture less than 5%).

The type of coating flour does not affect the moisture of fish scale chips. The moisture content of fish scale chips is primarily determined by the drying process and the inherent water-holding properties of the fish scales themselves, rather than the type of coating flour used. Coating flours, such as wheat flour or rice flour, typically have low moisture content, usually less than 15%. The amount of coating flour used on the fish scales is relatively small compared to the weight of the fish scales. Therefore, the moisture contributed by the coating flour is negligible compared to the overall moisture content of the final fish scale chips.

The moisture of fish scale chips using the rice flour coating tends to be lower than others. It is due to the rice flour contain amylose lower than other flour. Hamarashid (2020) reported that the amylose acts as a barrier defense, minimizing moisture loss and providing less space for oil absorption. Fish scale chips with a low moisture content can be stored for a longer duration than those with a higher moisture content.

Ash content of fish scale chip

The amount of ash in fish scale chips showed in Table 2. The ash content in fish scale chips reflects the mineral content, which can vary among different fish species. Gourami fish scales may contain different proportions of minerals compared to carp and tilapia scales, leading to a higher ash content. Fish scale chips coated with rice flour tend to have a higher ash content. The ash content ranged from 3.56-7.02%.

The higher ash content in gourami fish scale chips compared to carp and tilapia fish scale chips indicates that gourami scales have a greater concentration of minerals. This difference in mineral composition among fish species can affect the overall ash content of their scales.

Bangabandhu *et al*. (2017) reported that the Tilapia scale contain of 19.72% ash. Zu *et al*. (2023) reported that the Carp scale contain of 19.66% ash and gourami scale contain 22% ash (Nurjanah *et al*., 2010). Fish scale chips coated with rice flour tend to have a higher ash content. It is due to rice flour has a higher ash content than two other flours, which is around 2.22% (Oppong *et al*., 2021), while tapioca flour contains 0.17% ash (Aleman *et al*., 2021) and corn flour contains 1.24% ash (Olakunle Moses & Olanrewaju, 2018). The amount of ash in the coating flour affects the amount of ash in the fish scale chips.

Higher mineral content can provide a unique flavor, which can be enhanced or masked by flour coatings. Frying can increase the crispiness of the flour while allowing the development of flavors that are influenced by mineral content.

Fat content of fish scale chip

The fat content of fish scale chips showed in Table 3. Table 3 showed that the type of fish scales has no significant effect on the fat content. Fish scale chips coated with rice flour tend to have a higher fat content than two other flours.

The type of fish scales has no significant effect on the fat content. The fat content in freshwater fish scales is generally low in various species. Scales consist of collagen and other structural proteins, with minimal fat content compared to fish flesh. Although there may be slight variations depending on the species and individual fish. The fat content of carp scale was 0.93% (Zu *et al*., 2023). The gourami scale's fat content was 0.66-0,79% (Nurjanah *et al*., 2010). The tilapia scale's fat content was 0.82% (Bangabandhu *et al*., 2017).

Fish scales chips fat content after frying higher than natural fish scales. It due to during frying, oil absorption will occur into the scales and coating flour. Oil absorption begins during deep frying as soon as the surface of the fish scale product dries slightly (Lumanlan *et al*., 2020). After cooling, the total oil content of potato and tortilla chips was absorbed at 65% and 64%, respectively (Lumanlan *et al*., 2020). The fat content of the fish scale chips produced does not according to the SNI 8644:2018 standard (maximum fat content of 10%).

Fish scale chips coated with rice flour tend to have a higher fat content than two other flours. It is due to rice flour contain lower amylose than tapioca and cornstarch flour so the oil absorption higher. Amylose is a type of starch that tends to make foods firmer and can reduce oil absorption during frying. Because rice flour contains less amylose, it can fry more oil, leading to a higher fat content in the finished product, like fish scale chips.

Protein content of fish scale chips

The protein content of fish scale chips showed in Table 4. Protein content of fish scale chips ranged from 61.34 – 68.45%. The type of fish scales and type of flour has no significant effect on protein levels.

The type of fish scales has no significant effect on protein levels because freshwater fish scales have a similar protein content. Protein content of tilapia scale is 51.14% (Bangabandhu *et al*., 2017), in gourami and carp scales are 35-39% and 74.07%, respectively (Nurjanah *et al*., 2010; Zu *et al*., 2023). Fish scales are primarily composed of collagen, a structural protein that is the main constituent of the scale matrix. Regardless of the fish species, the collagen content and composition in fish scales are generally similar, as they serve the same structural function. There may be minor variations in the protein content of different fish species' scales, these differences are not significant enough to affect the overall protein content of the final fish scale chips

The type of flour did not significantly affect the protein content of fish scale chips. This indicates that the protein content is relatively the same for various types of flour. This could mean that the fish scales are the main protein source in the fish scale chips. The amount of flour used as a coating or binder in the production of fish scale chips is relatively small compared to the weight of the fish scales. Therefore, the type of flour used does not contribute significantly to the overall protein content of the final product. The protein content of fish scale chips produced complies with SNI 8644:2018 standards (minimum protein content 15%)

Textures of fish scale chips

The textures analysis of fish scale chips showed in Table 5. From Table 5, it can be seen that the average the hardness test of fish scale chips with carp scales is higher. The hardness test for cornstarch fish scale chips is higher.

The texture profile analysis of the fish Scale chip is influenced by hardness, fracture, chewiness, and cohesiveness. The texture of fish scale chips is influenced by various factors, including the ingredients used. The type of fish scales used can affect the texture, as different fish species may have varying scale compositions and structures. Harder and more rigid fish scales can result in a crunchier, more brittle texture with a higher hardness and fracture. Softer fish scales may produce a more tender, chewy texture with lower hardness and higher cohesiveness.

The amount of coating flour used can also impact the overall texture. Flours with higher gluten content can contribute to a more cohesive, chewy texture, while low-gluten flours (like rice flour) may result in a more fragile, less cohesive texture.

The tapioca Gourami scale chips have higher hardness, it due to gourami scale contain higher minerals including calcium carbonate and hydroxyapatite, contributes to their hardness.

The cornstarch tilapia scale chips have a lower fracture toughness, indicating increased brittleness compared to other scale chips. Cornstarch is a highly granular carbohydrate that, when used as a coating, may not bond as effectively or provide the same level of mechanical strength as other coatings.

The rice flour carp scale chips have a higher chewiness, indicating increased toughness compared to other scale chips. Rice flour has a different starch composition compared to other flours (like cornstarch or tapioca flour). It contains amylose and amylopectin, which can form a more cohesive and elastic structure when cooked. This contributes to a chewy texture.

The rice flour gourami scale chips have a higher cohesiveness because rice flour contain higher amylose than other flours (Nakamura et al., 2020). The type of flour or starch used can greatly impact cohesiveness. Flours with higher protein content often provide better binding properties compared to those with lower protein content. The protein contributes to cohesion and elasticity of scale fish coating. fish scale chips with higher cohesiveness can lead to a more enjoyable eating experience with better structural integrity.

Color analysis of fish scale chips

The color analysis of fish scale chips showed in Table 6. Chromatophores are pigment-containing cells found in a variety of fish that contribute significantly to coloration. The total color difference (ΔE) measures how different two colors appear using specific color models.

In color analysis, the L* value represents the color's lightness on a scale of 0 (black) to 100 (white). It refers to how light or dark a color appears. The a* Value indicates the position along the green-red axis. Positive values indicate red hues, while negative values represent green hues. The b* Value: Indicates the position along the blue-yellow axis. Positive values indicate yellow hues, and negative values indicate blue hues.

The rice flour gourami scale chips have a higher L* value indeed suggests that the color of gourami fish scales tends toward a lighter shade. The a* value of the fish scale chips is not significantly different. The tapioca carp scale chips have a higher b* value compared to the other fish scale chips. A higher b* value indicates that the color of the tapioca carp scale chips tends more towards the yellow hue. The scales of carp may exhibit a higher concentration or distinct types of yellow (xanthophore chromatophores) in comparison to other fish species. Xanthophores are chromatophores characterized by the presence of yellow pigments, including pteridines, which contribute yellow or golden coloration to the fish's appearance.

The total color difference of tapioca gourami fish scale chips and cornstarch gourami fish scale were higher. It due to gourami scales have colorless (transparent) fish scales. The main types of chromatophores found in gourami scales are iridophores, xanthophores, erythrophores and melanophores. The Iridophores are capable of producing blue, green, and silvery colors. Xanthophores are responsible for the yellow, orange, and golden hues observed in the scales of gourami fish (Nurjanah *et al*., 2010). Erythrophores contribute the red and reddish-brown tones to gourami coloring. Melanophores can produce dark, almost black patterns and markings on gourami scales. The combination and distribution of these different types of chromatophores, as well as their ability to change size and shape, results in the diverse and vibrant coloration patterns observed in various gourami species. Cornstarch has a slightly yellowish color that is paler and cloudy (Anggraeni *et al*., 2014).

Organoleptic preference of fish scale chips

The organoleptic preference of fish scale chips showed in Table 7. Table 7 Showed that the type of fish scales has a significant effect on the color preference test. The vibrant and distinctive coloration of gourami scales can make the chips more visually appealing and attractive to consumers. Table 7 Showed that the type of fish scales has a significant effect on the flavor preference test. It was due to the panelists quite liking the strong smell of fish scale chips. More and more spices are used in the ingredients so that the fishy smell from fish scales does not smell. The preference of flavor in carp scale chips is lower because carp have a more “muddy” or earthy aroma from their scales compared to other fish. This causes some consumers to not like the more pungent fishy aroma of their scale chips.

The type of fish scales has a significant effect on the taste preference test, because the chips taste delicious and can be accepted by all groups. The type of flour has a significant effect on the taste preference test, because the taste of the flour which is quite sharp causes the panelists to feel neutral towards the taste produced (Yuliani *et al*., 2018). The preference for color gourami scale chips in all coating flour is higher than other fish scales. Gourami scales are generally softer and more flexible compared to other fish scales. The softer and more delicate texture of gourami scales may be perceived as more appealing or delicate by some consumers, compared to the potentially harder or crunchier texture of chips made from other fish scales.

CONCLUSION

Variations in the types of fish scales have a significant effect on organoleptic (color and taste), organoleptic (aromatic) significant effect. However, it did not significantly affect the moisture content, ash content, fat content, protein content, total color difference, texture (hardness, fracture, chewiness, and cohesiveness), and organoleptic (texture). Variations in the type of flour have a significant effect on organoleptic (color), significantly affect texture (fracture) organoleptic (taste). However, it did not significantly affect the moisture content, ash content, fat content, protein content, color, texture (hardness, chewiness, and cohesiveness), organoleptic (aromatic, and texture). The rice flour gourami scale chips and rice flour carp scale chips produced comply with SNI 8644:2018 except for the fat content. The recommended treatment is fish scale chips from gourami fish scales coated with rice flour.

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Table 1. Moisture of fish scale chips (%).

Type of coating flour	Types of fish scales*		
	Carp	Tilapia	Gourami
Cornstarch	5.35±0.25[a]	5.03±0.47[a]	6.04±1.33[a]
Tapioca	6.07±0.16[a]	5.67±0.55[a]	5.25±0.08[a]
Rice flour	4.12±0.9[a]	5.02±0.98[a]	4.46±1.06[a]

* Mean ± SD (n=3). Mean with the same letter in the same row or column is not significantly different in the Duncan Multiple Range Test (DMRT) at a significance level of 5%

Table 2. Ash content of fish scale chips (%)

Type of coating flour	Types of fish scales*		
	Carp	Tilapia	Gourami
Cornstarch	4.55±1.70[a]	3.56±0.76[a]	6.09±2.96[b]
Tapioca	4.33±0.44[a]	4.90±0.40[a]	5.32±0.52[a]
Rice flour	7.02±3.13.7[b]	6.22±0.89[b]	5.69±0.61[a]

* Mean ± SD (n=3). Mean with the same letter in the same row or column is not significantly different in the Duncan Multiple Range Test (DMRT) at a significance level of 5%.

Table 3. Fat content of fish scale chips (%)

Type of coating flour	Types of fish scales*		
	Carp	Tilapia	Gourami
Cornstarch	32.32±3.89[a]	32.06±4.74[a]	35.06±1.15[a]
Tapioca	33.54±0.18[a]	30.31±5.63[a]	33.66±1.17[a]
Rice flour	33.18±1.70[a]	34.02±2.27[a]	34.70±2.94[a]

* Mean ± SD (n=3). Mean with the same letter in the same row or column is not significantly different in the Duncan Multiple Range Test (DMRT) at a significance level of 5%.

Table 4. Protein content of fish scale chips (%)

Type of coating flour	Types of fish scales*		
	Carp	Tilapia	Gourami
Cornstarch	31.77±1.37[a]	33.09±0.05[a]	33.33±0.40[a]
Tapioca	31.29±4.41[a]	30.67±3.27[a]	32.33±3.54[a]
Rice flour	32.79±1.30[a]	32.94±0.79[a]	34.20±0.04[a]

* Mean ± SD (n=3). Mean with the same letter in the same row or column is not significantly different in the Duncan Multiple Range Test (DMRT) at a significance level of 5%.

Table 5. Textures analysis of fish scales chips (%)

Type of coating flour	Types of fish scales	Textures analysis*			
		Hardness (N)	Fracture (N)	Chewiness (N)	Cohesiveness (N)
Cornstarch	Carp	18.21±6.0^{cd}	2.65±1.2^{c}	6.40±1.0^{b}	0.28±0.02^{b}
	Tilapia	25.79±1.0^{b}	2.07±0.4^{c}	7.20±4.7^{a}	0.25±0.02^{b}
	Gourami	20.55±1.7^{bc}	5.62±1.1^{b}	2.89±0.4^{cd}	0.39±0.15^{b}
Tapioca	Carp	22.98±2.4^{bc}	8.93±1.0^{a}	6.84±2.6^{ab}	0.29±0.05^{b}
	Tilapia	9.90±3.1^{d}	4.70±1.6^{b}	5.84±0.3^{c}	0.14±0.05^{b}
	Gourami	28.78±7.6^{a}	5.64±3.4^{b}	6.00±2.9^{ab}	0.4±0.11^{b}
Rice flour	Carp	7.92±0.3^{d}	3.76±0.2^{c}	8.06±0.3^{a}	0.37±0.25^{b}
	Tilapia	16.44±5.7^{cd}	2.38±0.1^{c}	4.66±2.5^{c}	0.37±0.08^{b}
	Gourami	18.02±0.0^{cd}	4.53±0.9^{b}	6.35±1.7^{ab}	0.89±0.43^{a}

* Mean ± SD (n=3). Mean with the same letter in the same column is not significantly different in the Duncan Multiple Range Test (DMRT) at a significance level of 5%.

Table 6. Color analysis of fish scales chips (%)

Type of coating flour	Types of fish scales	Textures analysis*			
		L* value	a* value	b* value	ΔE
Cornstarch	Carp	37.03±7.4^{b}	4.10±2.3^{a}	1.12±0.2^{b}	19.75±7.6^{b}
	Tilapia	36.85±8.9^{b}	3.92±0.1^{a}	2.26±0.3^{b}	20.34±8.3^{ab}
	Gourami	35.32±9.9^{b}	4.85±1.2^{a}	0.75±0.2^{c}	22.01±9.4^{a}
Tapioca	Carp	40.71±12.4^{a}	4.79±0.4^{a}	4.47±0.4^{a}	18.10±9.6^{b}
	Tilapia	36.60±6.3^{b}	3.95±0.9^{a}	1.06±0.6^{b}	20.14±6.5^{ab}
	Gourami	34.67±6.9^{b}	5.09±0.7^{a}	1.15±0.2^{b}	22.42±6.5^{a}
Rice flour	Carp	35.84±8.3^{b}	4.56±1.0^{a}	0.94±0.4^{c}	21.25±7.9^{a}
	Tilapia	42.69±1.4^{a}	3.37±0.7^{a}	1.55±0.2^{b}	13.98±1.6^{d}
	Gourami	41.29±6.6^{a}	4.40±0.5^{a}	3.46±0.5^{a}	16.59±4.7^{c}

* Mean ± SD (n=3). Mean with the same letter in the same row or column is not significantly different in the Duncan Multiple Range Test (DMRT) at a significance level of 5%. Control (L=56.35, a= 0.42, b= 1.3)