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Characteristics of Crackers Fortified with the Sailfin Catfish (*Pterygoplichthys pardalis*) Bone Meal

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ABSTRACT

Calcium is the mineral most needed by the body. One of the diseases caused by calcium deficiency is osteoporosis, which is a degenerative condition caused by a diet low in minerals such as calcium and phosphorus. The sailfin catfish (*Pterygoplichthys pardalis*) bones has been proved to contain a lot of minerals and phosphorus. The population of the sailfin catfish in Tempe Lake, Wajo Regency, has increased rapidly in recent years. The sailfin catfish bones can be processed into crackers. The purpose of this study was to analyze the quality characteristics of crackers fortified with the sailfin catfish bone meal (*Pterygoplichthys pardalis*). The acceptability of crackers was tested hedonically by 100 panelists to determine the best variation in the addition of the sailfin catfish bone meal. The chemical analysis included the moisture, ash, fat, protein, carbohydrate, calcium, and phosphorus content of crackers from the best treatment. Hedonic test results showed that the addition of 20% of the sailfin catfish bone meal produced the best crackers. Chemical analysis showed a significant increase in ash content to 11.65% compared to the control of 3.25%. Protein and fat levels also increased to 11.44 and 15.63%, respectively, from the control of 11.21 and 13.55%. Calcium and phosphorus levels also increased significantly in the best crackers, to 4.37 and 2.64% compared to the control of 0.10 and 0.70%, respectively. These findings indicate that the crackers have the potential to be used as a food additive to address calcium and phosphorus deficiencies in growing children and the elderly.

INTRODUCTION

Osteoporosis is a disorder of bone metabolism brought on by a reduction in bone mass **(Annisa *et al.*, 2019)**. After heart disease, osteoporosis is the second most common health issue worldwide **(Joenputri, 2020)**. Right now, Indonesia has the fifth-highest proportion of old persons worldwide **(Sulistiawati *et al.*, 2022)**. Osteoporosis affects up to 3.6 million older persons, or 19.7% of the population **(Ebeling *et al.*, 2021)**.

Osteoporosis should be prevented as early as possible by eating foods high in calcium and nutrients **(Liu *et al.*, 2020)** and adopting healthy lifestyle practices

(Rustandi, 2023). Reduced bone density is the result of adolescent diets low in calcium **(Audiana *et al.*, 2022)**. This is due to the fact that nutritional needs are higher at age 18 than they are at other points in life, as 90% of peak bone mass development occurs at this age **(Kristiningrum, 2020)**. Additionally, 10% of bone mass is formed between the ages of 25 and 30 **(Watts *et al.*, 2019)**. Bone mass starts to decline with aging after the age of thirty **(Choirunnisa & Pudjianto, 2023)**.

Snacks are supplementary foods that can be consumed to satisfy calcium and phosphorus needs that are not satisfied by regular meals **(Hamil, 2020)**. Snacking is one of the customs of the Indonesian people **(Ningsih *et al.*, 2021)**. According to data on snack distribution in Indonesia in 2022, cookies and crackers accounted for the biggest snack consumption among the Indonesians (1.156 million kg).

One common and easily accessible food that is enjoyed by many is the crackers **(Abdullah *et al.*, 2023)**. Moreover, they are often ingested by people of different ages **(Ismawati *et al.*, 2020)**. However, the protein level of the various types of crackers on the market is quite low, ranging from 5- 8% of the recommended daily intake of protein per serving, because the primary ingredient in crackers is wheat flour **(Ernisti *et al.*, 2019)**. According to **Hodri *et al.* (2023)**, crackers require additional components to complete their nutritional composition since they are low-protein and low-calcium.

The sailfin catfish is a high-calcium, high-phosphorus food raw material **(Wei *et al.*, 2022)**. Like fish in general, the sailfin catfish have high-quality meat, but their bones are also rich in calcium and phosphorus **(Fonseka & Radampola, 2022)**. Based on research by **Hasrianti *et al.* (2022)**, the Ca (calcium) element content in *Pterygoplichthys pardalis* bones is 41.69%, and the P (phosphorus) element content is 7.69%.

The sailfin catfish specimens in Lake Tempe, Wajo Regency, are currently expanding at a very quick pace **(Tamsil *et al.*, 2022)**, their presence dominates the waters since they alter the ecosystem of the lake, causing harm to nets, decreasing the amount of fish that local fisherman catch, and endangering the existence of endemic fish **(Kasmiati *et al.*, 2023)**. The quantity of fish keeps rising daily as the locals don't eat it **(Yuniar, 2023)**. As per the findings of **Kasmiati *et al.* (2022)**, *Pterygoplichthys pardalis*, which is distinguished by its abdominal pattern, accounts for 70% of the sailfin catfish species found in Lake Tempe, Wajo Regency. An other source of calcium and phosphorus is the sailfin catfish, which has a high calcium and phosphorus contents **(Bechtel *et al.*, 2019)**. Therefore, this research aimed to increase the calcium and phosphorus contents in crackers by fortifying the sailfin catfish bone meal in crackers.

MATERIALS AND METHODS

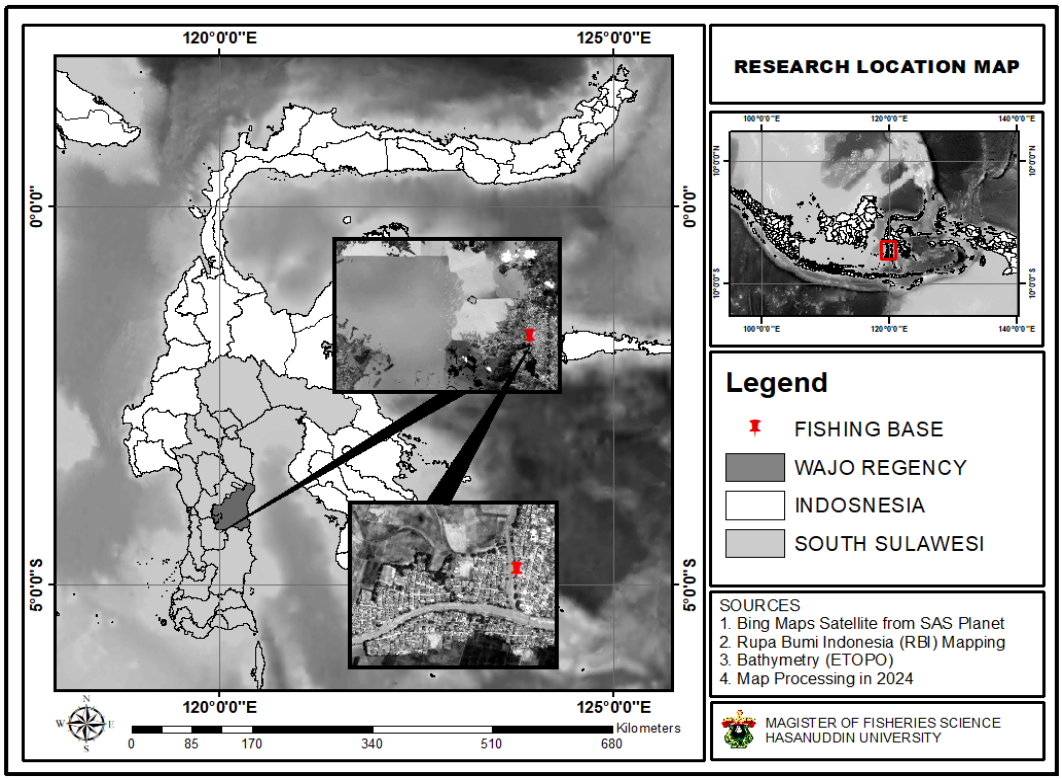

Fig. 1. A Map showing the sailfin catfish sampling sites in Tempe District, Wajo Regency, South Sulawesi Province, Indonesia

Samples of the sailfin catfish were taken from Tempe Lake in the Tempe District of the Wajo Regency in the Indonesian province of South Sulawesi. After that, the fish bones were grounded into flour (Fig. 1). The sampling point locations' coordinates were captured through the utilization of a global positioning system (GPS) device. Fishermen used the sampling location as one of their fishing grounds. The obtained samples fulfilled the requirements of having a consistent stomach pattern and a fairly consistent fish weight.

1. The sailfin catfish preparation

The samples of the sailfin catfish have been collected and then prepared. The sampling and preparation of the sailfin catfish in this study have received approval through animal ethics code letter number 5224092063. The sailfin catfish was cleaned with a brush under flowing water to get rid of any filth that has become lodged in between its scales. After that, the bones were taken out and the fish were separated from the meat. The bones were the first thing to be cleaned once the meat was removed. After being well cleaned, fish bones were cooked for 15 minutes at 80°C in water. The fish bones were boiled, drained, and then given one more wash before being weighed.

Subsequently, the fish bones underwent another 30-minute pressure cooker boil. Then, thirty lime leaves were added to the boiling water in this method. These lime leaves were meant to lessen the 65°C bones' fishy smell. Finally, the fish bones were dried for 48 hours.

2. Making the sailfin catfish bone meal

The dried fish bones were blended into fish meal and sieved using a flour sieve.

3. Making crackers

Crackers were made referring to the method of **Ramadhani *et al.* (2022)**, which has been modified. Preparing each ingredient was the first step in the process. After the ingredients were prepared, 30 grams of margarine were melted and combined with 40ml of liquid milk. Afterward, milk was added slowly with warm margarine to a mixture of wheat flour, yeast, sugar, and salt. Subsequently, the sailfin catfish bone meal was gradually incorporated and mixed until a smooth dough was formed. For sixty minutes, the dough was allowed to rest in a jar covered with a plastic wrap. After a half-hour rest, the dough was smoothed out with a rolling pin, molded into a uniform shape, and put onto a baking pan. For fifteen minutes, the cracker dough was baked at 150°C in the oven.

4. Crackers formulation

The formulation in this research was FO (100% wheat flour), F1 (added 10% sailfin catfish bone meal), F2 (added 20% sailfin catfish bone meal), and F3 (added 30% sailfin catfish bone meal).

5. Analysis of the level of liking

Analysis of the level of liking was carried out by testing the level of panelists liking for the characteristics of crackers, with the addition of the sailfin catfish bone meal, including appearance, texture, color, aroma, and taste. Untrained panelists totaled 100 people, consisting of teenagers, adults, and the elderly, on a scale of (1) really don't like, (2) don't like, (3) neutral, (4) like, and (5) really like. The hedonic test results show that the chosen cracker product was determined by selecting the sample that the panelists liked the most.

6. Chemical analysis

Chemical analysis was conducted on selected crackers (F2) and control crackers to determine their chemical characteristics, including moisture, ash, protein, fat, carbohydrate, calcium, and phosphorus content.

7. Data analysis

The hedonic test analysis for each treatment was averaged and then followed by a normality test to determine the distribution of the data. Hedonic test data were not

normally distributed, and thus it was continued with the Kruskall-Wallis test to determine if there was a significant difference between treatments. The test results showed that there was a significant difference ($P< 0.05$), so it was continued with the Mann-Whitney test to show which treatment had a significant difference. Meanwhile, laboratory data (chemical analysis) was not subjected to statistical tests because it was only selected based on the selected treatment.

RESULTS

1. Characteristics of crackers fortified with sailfin catfish bone flour

Crackers were made with four treatments, namely 0, 10, 20, and 30% addition of broom bone meal. The making of crackers dough was done by the all-in-one-dough method, where all ingredients were mixed at once into the dough and fermented together. After fermentation, the dough was flattened, molded, and baked.

Table 1. Characteristics of crackers fortified with sailfin catfish bone flour

Proportion Fish Bone Flour:Wheat Flour	Figure	Parameters				
		Appearance	Texture	Color	Aroma	Flavor
F0 (0:100)		Round, flat	Crispy	Brownish Yellow (+++)	Typical crackers	Savory
F1 (10:90)		Round, flat	Crispy	Brownish Yellow (++)	Typical Fish Crackers	Savory, fish (+)
F2 (20:80)		Round, flat	Crispy (+)	Brownish Yellow (+)	Typical Fish Crackers (+)	Savory, fish (+)
F3 (30:70)		Round, flat	Crispy (++)	Brownish Yellow	Typical Fish Crackers (++)	Savory, fish (++)

Description: The more (+), the more the browning color, fish aroma, crispy texture, and fish flavor increase.

2. Analysis of the level of liking

Results of the level of liking of 100 untrained panelists was conducted on a scale of (1) really don't like, (2) don't like, (3) neutral, (4) like, and (5) really like. This liking level test was carried out in November 2023. The parameters tested include appearance, color, texture, aroma, and taste. The hedonic test results showed that the chosen cracker product was determined by selecting the sample that the panelists liked the most. The following table displays the like level test results:

Table 2. Percentage of panelists' level of favorability

Sample	Favorite test results				
	Appearance	Texture	Color	Aroma	Flavor
F0	73,40%	70,40%	60,80%	81,00%	81,20%
F1	76,40%	78,80%	72,20%	76,00%	77,00%
F2	80,40%	87,40%	84,40%	76,40%	92,60%
F3	76,20%	87,20%	84,40%	60,60%	52,20%

Source : Primary data

With an average percentage of 80.40%, F2 had the highest percentage value based on the appearance qualities of the most favored crackers; similarly, F2 had the highest percentage value based on the texture characteristics of the most favored crackers. According to the cracker color preferences, F2 and F3 have an average percentage of 84.40%. F0 had the highest percentage value based on the most preferred flavor qualities of the crackers, with an average percentage of 92.60%, whereas F2 had the highest percentage value based on the scent characteristics of the most chosen crackers, with an average percentage of 81.00%. According to the percentage value of the four formulas that the panelists found most appealing in terms of appearance, texture, color, scent, and taste. Formula 2 (F2), containing 20% sailfin catfish bone meal, was the most popular choice.

Table 3. Average hedonic test value of samples

Treatment	Parameter				
	Appearance	Texture	Color	Aroma	Flavor
F0	$3,67 \pm 0,68^{a}$	$3,52 \pm 0,88^{a}$	$3,04 \pm 0,70^{a}$	$4,05 \pm 0,74^{a}$	$4,06 \pm 0,73^{a}$
F1	$3,82 \pm 0,64^{a}$	$3,94 \pm 0,90^{b}$	$3,61 \pm 0,77^{b}$	$3,80 \pm 0,65^{b}$	$3,85 \pm 0,76^{b}$
F2	$4,02 \pm 0,75^{b}$	$4,37 \pm 0,79^{c}$	$4,22 \pm 0,733^{c}$	$3,82 \pm 0,77^{b}$	$4,63 \pm 0,68^{c}$
F3	$3,81 \pm 0,73^{a}$	$4,36 \pm 0,77^{c}$	$4,22 \pm 0,73^{c}$	$3,03 \pm 0,73^{c}$	$2,61 \pm 0,72^{d}$

Description: 1 = strongly dislike; 2 = dislike; 3 = neutral; 4 = like; 5 = like very much. a, b = numbers followed by the same letter in the same column indicate no significant difference at the Mann-Whitney test level at the 95% confidence level. Source: Primary data

The normality test results showed that the hedonic test data were not normally distributed ($P< 0.05$), so it was continued with a non-parametric test using Kruskall-Wallis at a real level of 95%. The results of the analysis showed that each parameter showed a value of $\alpha < 0.05$, meaning that there were significant differences in treatment (F0, F1, F2, and F3) on the parameters of appearance, texture, color, aroma, and taste of crackers with the addition of the sailfin catfish bone meal. To check which groups were different, the Mann-Whitney test was conducted.

3. Chemical analysis of selected crackers

Chemical analysis was conducted on selected crackers (F2) and control crackers to determine their chemical characteristics, including moisture, ash, protein, fat, carbohydrate, calcium, and phosphorus content. The results of the chemical analysis can be seen in Table (4).

Table 4. Chemical characteristics of crackers F0 and F2

Parameter	Result	
	F0	F2
Moisture content	2,46%	2,14%
Ash	3,25%	11,65%
Protein	11,21%	11,44%
Fat	13,55%	15,63%
Carbohydrate	65,96%	52,65%
Calcium	0,10%	4,37%
Phosphorus	0,70%	2,64%

Source : **Makassar Health Laboratory Center, 2023**

DISCUSSION

1. Analysis of the level of liking

1.1 Appearance

The appearance of crackers produced in this study as a whole, including the size, thickness, shape of the mold, and shape of the cracker surface, received a favorable rating from the panelists. Although this assessment is subjective, it can give a fairly good idea of consumer acceptance of product appearance. The use of high-quality ingredients and proper production processes can affect the overall appearance of the product. Good-quality materials tend to produce more visually appealing products.

1.2 Texture

Food texture is also a component that helps determine the taste of food because the sensitivity of the sense of taste is influenced by the consistency of the food. Texture in food can be observed with the mouth or with fingers, which can be felt when biting, chewing, swallowing, or when held. Flour greatly affects the texture of baked products; the hardness will decrease and become easily crushed (not hard) **(Kohyama, 2020)**. Baking temperature and time can also affect the texture of the crackers produced. **(Stribitcaia *et al.*, 2020)**.

1.3 Color

The color appearance of a food item is the main factor assessed before other considerations such as taste and nutritional content **(Mihafu *et al.*, 2020)**. A food ingredient, even though it is considered delicious and has a very good texture but an unattractive color, will not be consumed **(Ege *et al.*, 2023)**. The level of panelists' liking for the color of crackers tends to increase along with the higher concentration of fish bone meal added in making crackers. Based on the results of this study, it is known that the color of crackers tends to get brighter with the addition of broomstick fish bone meal. Crackers without the addition of fish bone meal (F0) have a darker color when compared to crackers treated with the addition of the sailfin catfish bone meal.

1.4 Aroma

Aroma is one of the most important characteristics in determining the acceptability of a food product **(Umanahu *et al.*, 2023)**. The aroma spread by food is a very strong attraction and is able to stimulate the sense of smell, thus arousing appetite. The aroma of food is caused by the formation of volatile compounds as a result of a reaction due to the work of enzymes, or it can also be formed without enzyme reactions **(Surendran *et al.*, 2021)**. Aroma is not only determined by one component but also by several specific components that give rise to a characteristic odor, as well as the

comparison of the various components of the ingredients **(Starowicz, 2021)**. In the food industry, aroma testing is considered important since it can provide quick observation results. Not only can aroma be used as an indication of food viability, but it can also be used to detect whether food has a good taste or not **(Asmawati *et al.*, 2023)**.

1.5 Flavor

In general, the taste of crackers is the most supportive thing and will be considered in giving an assessment of a food **(Avery *et al.*, 2020)**. Generally, food does not only consist of one flavor but a combination of various flavors in an integrated manner, giving rise to a complete taste. Flavor is influenced by several factors: chemical compounds, temperature, concentration, and interaction with other flavor components **(Plasil *et al.*, 2022)**. The taste factor plays an important role in product selection for consumers, because even though the nutritional content is good but the taste is not acceptable to consumers, the target of improving public nutrition can be achieved, and the product does not sell well when sold in the market **(Suwarni *et al.*, 2023)**.

2. Chemical analysis

2.1 Moisture content

During baking, a lot of water is evaporated from the cracker dough. The baking conditions required for different crackers will not be the same because the way the structure is formed and the amount of water that must be removed depend on the richness of the formulation. During baking, there is also a loss of moisture from the surface of the product by evaporation, followed by moisture transfer to the surface, which is continuously lost to the oven environment. The desired moisture content of crackers is determined by two factors. If the moisture content value is too low, the crackers will have a burnt taste and the color will be too dark; if it is too high, the structure will not be crispy, can be broken (checking), and changes in flavor during storage will occur faster. Low water content in crackers can affect the shelf life of a product; the lower the water content, the less perishable the product, thus increasing its shelf life **(Nabilah & Kisnawaty, 2023)**.

2.2 Ash content

The ash content of the crackers produced increased along with the increasing amount of broom bone meal in the cracker formulation. The ash content shows a fairly high mineral content in a food ingredient; the higher the ash content value, the higher the minerals produced **(Syukroni & Santi, 2021)**. The ash content with the addition of fish bone meal shows a fairly high ash content value, so it can be concluded that crackers produced with the addition of fish bone meal have high minerals. This is because fish bones contain quite a few minerals, including calcium and phosphorus.

2.3 Protein content

The protein content of crackers increased with the addition of a proportion of fish bone meal. This is because the protein content of fish bone meal is higher than the protein content of wheat flour, so the higher the proportion of the sailfin catfish bone meal, the protein content of crackers also increases. Protein is the second-largest part of the human body after water **(Khotimah *et al.*, 2021)**. In general, protein consumption is recommended to be 10– 15% for adolescents and 15– 30% for adults **(Vitro & Kang, 2022)**. In the elderly, the need for protein per day is higher than the needs of adults because, in the elderly, the efficiency of using nitrogen compounds (protein) by the body has been reduced due to less efficient digestion and absorption **(Nishimura e*t al.*, 2023)**. Protein is necessary for the growth, maintenance, and repair of body tissues **(Utami *et al.*, 2020)**.

2.4 Fat level

The high fat content in crackers can be influenced by the processing of fish bone meal, which is due to the shorter boiling time of the bones and the less controlled temperature during the process of making fish bone meal. In addition, the use of margarine in the cracker-making process can also affect the high fat content of crackers **(Imra *et al.*, 2019)**. Appropriate heating in processing will remove the fat content of the ingredients **(Astiana *et al.*, 2023)**.

2.5 Carbohydrate levels

The carbohydrate levels in the control were quite high, probably because the control treatment used a large amount of wheat flour. Wheat flour contains sugar or carbohydrates, which are quite high. The higher the amount of bone meal added to the dough, the lower the carbohydrate content. Carbohydrates are the main source of energy for humans, providing 50– 60% of the total energy needed **(Twinomuhwezi *et al.*, 2020)**.

2.6 Calcium analysis

In this study, calcium levels increased with the addition of the fish bone meal since thr sailfin catfish bone meal is the highest source of minerals in the raw material for making crackers. Fortification of crackers with the sailfin catfish bone meal also produced higher calcium when compared to fortification using the mackerel fish meal, the cork fish bone meal, the catfish bone meal, and the tuna bone meal **(Yuliani *et al.*, 2018; Putri *et al.*, 2019; Mawwadah & Sulistiyati, 2021; Pangestika *et al.*, 2021)**. Fish bones contain the mineral calcium, which affects the calcium value of products made with fish bone meal **(Sholihin *et al.*, 2023)**.

2.7 Phosphorus analysis

Phosphorus levels increase with the addition of fish bone meal because broom bone meal is the highest source of minerals in crackers. Phosphorus is one of the most important minerals, as it ranks second only to calcium in total body mass **(Serna & Bergwitz, 2020)**. Phosphorus functions as a constituent of the structure of human teeth and bones **(Ford *et al.*, 2020)**. The sailfin catfish bone meal crackers are reported to have

a greater phosphorus content than cookie items made with crab shell flour, according to research by **Hapsoro *et al.* (2017)**, which showed a phosphorus content of 1.08% in cookies formulated with crab shell flour.

CONCLUSION

Based on the results of the study, it can be concluded that the fortification of the sailfin catfish bone meal can increase the nutritional value of crackers. Crackers fortified with the sailfin catfish bone meal have high calcium and phosphorus contents, so they can be an alternative healthy snack to overcome calcium and phosphorus deficiency for children in their growth period and the elderly.

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