Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

# Fortification of Mangrove Crab Shell Flour (*Scylla serrata*) as a Mineral Source in Functional Cookie Formulation

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Received: October 28, 2024. Accepted: November 27, 2024. Published: November 30, 2024

**Abstract:** The importance of calcium and magnesium intake for health, especially bones, teeth, and the nervous system, encourages the development of functional food products rich in minerals. Mangrove crab shell (*Scylla serrata*) is a waste with calcium-magnesium content that is beneficial for health. This study aims to determine the potential calcium and magnesium content in cookies fortified with mud crab shell flour. The research design used a complete randomised design (CRD). Crab shell flour fortification concentration was 0%, 3%, 6%, 9%, 12%, 15%. Repetition was done 4 times. Data were analysed using the variance analysis (ANOVA) method. The results significantly affected increased calcium and magnesium levels of cookies fortified with mud crab shell flour. The calcium content of cookies ranged from 65.325 – 1,802.773 mg/kg, and magnesium in cookies ranged from 82.719 – 188.553 mg/kg, so cookies with the fortification of mangrove crab shell flour can be used as an alternative functional food product for calcium and magnesium mineral sources.

**Keywords:** Calcium; Cookies; Mangrove Crab Shell; Magnesium; Minerals.

## Introduction

Awareness of the importance of mineral intake, such as calcium and magnesium, to support body metabolic processes is increasing. The nutritional adequacy level (NAC) of calcium intake for women is 1,200 mg/day, and magnesium is 230 mg/day. For men, calcium is 1,000 mg/day, and magnesium is 360 mg/day [1]. Calcium and magnesium work together in bone formation. Magnesium plays a role in calcium metabolism by increasing calcium absorption [2]. Magnesium also plays a role in the synthesis of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), which can increase the risk of stunting [3]. The balance of calcium and magnesium is essential in blood pressure regulation [4]. Cell division, cell growth, and tissue repair can be disrupted without a deficiency. Calcium intake is lower in stunted than in non-stunted toddlers [5].

The mangrove ecosystem in Indonesia has many mineral sources, including mangrove crab shells *(Scylla serrata)*. Crab shells are rich in minerals such as calcium 14.06%, carbohydrate 11.34%, fat 0.17%, ash content 74%, moisture content 4.49%, and magnesium 150.95 mg/kg [6] [7]. The calcium component in crab shells is very high, characterised by the hard texture of the shell [8]. Only 20% of crab parts can be consumed, while 80% are shell waste [9]. Crab shell waste increases the calcium content of cheese stick snacks by 1.83-3.58% [10]. Fortification of crab shell flour in wheat bread contains calcium 317.48-319.56 mg/L and magnesium 51.05-51.10 mg/L [11].

Mangrove crab shells can be processed into flour. Fortification of mangrove crab shell flour is essential, considering that mangrove crab shell waste has yet to be widely processed and optimally utilised, even though it contains many bioactive compounds that are beneficial to the human body's metabolism, such as mineral content. Mangrove crab shells can be applied for ready-to-eat food products such as cookies as a material for mineral sources such as calcium and magnesium. Fortification of mangrove crab shell flour in cookies is expected to help fulfil calcium and magnesium intake and reduce the risk of deficiency, considering that cookie products are snacks widely favoured by the public.

## Research Methods

The research design was completely randomised, with the variation factor in the addition (fortification) of mangrove crab flour 0%, 3%, 6%, 9%, 12%, and 15%. The data obtained were processed using the variance analysis (ANOVA) statistical method. If there is a significant difference of $P \leq 0,05$, it will continue with the Duncan Test.

The process of making mangrove crab shell flour is done by cutting the crab shell into parts (shells and claws) 2-3 cm, then washing thoroughly 2-3 cm. The crab shells were boiled at $100^0$C for 30 minutes and then rinsed thoroughly. The crab shells were oven-dried at $65^0$C for 12 hours. The dried shell is ground using the flouring machine. The flour is sieved using an 80-mesh sieve.

Fortified cookies are made by mixing margarine, butter, and palm sugar, adding an egg yolk, and homogenising. Add baking powder, vanilla extract, and mangrove crab shell flour according to concentration. Homogenise the dough until smooth. Bake the dough at 100 for 20 minutes. Cool it on a cooling rack [12]. Calcium Testing is done by 10 grams of sample diluted with 90 ml of distilled water shaken until homogenous, then filtered using filter paper. Take 1 ml filtrate using filter paper. Take 1 ml filtrate, enter into a 50 ml volumetric flask, and add 1 ml murked solution, 2 ml NaOH 0.1 N and distilled water until the limit mark. The solution is homogenised and put into the

**How to Cite:**
Widnyani, I. A. P. A., & Putra, A. A. N. D. A. W. (2024). Fortification of Mangrove Crab Shell Flour (Scylla serrata) as a Mineral Source in Functional Cookie Formulation. *Jurnal Pijar Mipa*, *19*(6), 1037–1040. https://doi.org/10.29303/jpm.v19i6.7931

cuvette read at a wavelength absorbance of 507 nm [13]. Magnesium testing is done by a 50-gram sample dissolved into 200 ml of distilled water. The sample solution was filtered using filter paper. A total of 100 ml of the sample solution that has been filtered added 2 ml of Hcl and heated until the solution dries, then 1 ml of chloride solution. Measured using spectrophotometry at a wavelength of 285.2 [14]

## Results and Discussion

### Calcium Content

Based on the ANOVA analysis, the fortification treatments of mangrove crab shell flour in cookies significantly affected the calcium parameter. The Duncan test results showed that the interaction between treatments was significantly different. The average calcium content of cookies with mangrove crab shell flour fortification is presented in Table 1.

**Table 1.** Average Calcium Content of Cookies With Mangrove Crab Shell Flour Fortification

| Treatment | Calcium Content (mg/kg) |
|---|---|
| TCK | 1,911.217±0.13 |
| TCK 1st (0%) | 65.325±0.07 |
| TCK 2nd (3%) | 727.617±0.18 |
| TCK 3rd (6%) | 979.836±0.13 |
| TCK 4th (9%) | 1,095.201±0.03 |
| TCK 5th (12%) | 1,106,157±0.02 |
| TCK 6th (15%) | 1,802,773±0.05 |

Description: Data are presented as mean ± standard deviation (SD) of 4 replications

Table 1. shows the lowest calcium level was the sample of TCK 1st (0% mangrove crab shell flour fortification), and the highest calcium level was the TCKth 6 (15% mangrove crab shell flour fortification). Calcium levels increased as the concentration of mangrove crab shell flour added to the samples increased.

In blue swimming crab shell flour fortified to cookie products, the result of the concentration treatment of crab shell flour produced calcium levels of cookies (0%, 2.5%, 5%, and 7.5%) with significant differences, where the value of calcium levels increased up to 2 times from the control to the highest concentration at 7.5%. These values were obtained because blue swimming crab shell flour contains higher calcium levels than the control (0%). The value of calcium content is 1.38%, 2.48%, 2.83%, and 3.31%, respectively. This value is obtained because blue swimming crab shell flour contains a higher calcium content than the control, so the calcium content will increase the concentration of clue swimming crab shell flour added [12].

Calcium increases in wet noodles products fortified with blue swimming crab shell flour. The lowest calcium content was in wet noodles that were given 0% blue swimming crab shell flour at 14.19% mg/100g, and the highest calcium content was obtained at a concentration of 20%, which was 31.34 mg/100 gram [15].

In cheese stick products fortified using blue swimming crab shell flour, there were significant differences between concentrations of 3%, 5%, and 7%, resulting in calcium levels of 1.86%, 2.39%, and 3.58%, respectively [10]. Crustacean shells contain calcium, chitin, protein, CaCO3, $MgCO_3$, $Ca(PO_4)_2$, and astaxanthin pigment. In cracker products fortified with blue swimming crab shell flour, the texture produced is less crunchy and tends to be hard; this is thought to be because the enzymes in yeast cannot work optimally due to the content of $CaCO_3$ and $Ca(PO4)_2$ [16].

Calcium is an essential micronutrient that prevents stunting in children. In the growth process, calcium is required to increase bone mineralisation. Insufficient calcium intake during this growth process results in osteoblast dysfunction. Mineralisation of the deposit matrix in new bones is reduced, and if the calcium content in the bone is less than 50%, it can affect linear growth [17]. In snack bar products modified using the addition of plantain and soybeans, the average value is 1.360-2.660 mg. An increase will follow an increase in calcium content in ash content. This is because ash content can indicate mineral content in food [18]. The higher the heating temperature, the higher the calcium content in food [19]. A person will be at risk of renal colic hypercalciuria if they consume more than 3.000 mg of calcium per day. Excess calcium intake will be excreted through urine. In product, it is not a problem to consume because it is within the upper limit of calcium, which is 1.500 mg per day [20]. Calcium plays a role in growth where calcium contributes to the formation of osteoblasts and bone mineralisation [21]

### Magnesium Content

Based on the results of the ANOVA test, the fortification treatment of mangrove crab shell flour in cookies had a very significant effect on the magnesium parameter. The result of the Duncan test showed the interaction between treatments was significantly different. The average value of magnesium content of cookies with mangrove crab shell flour fortification is presented in Table 2.

**Table 2.** Average Magnesium Content of Cookies With Mangrove Crab Shell Flour Fortification

| Treatment | Magnesium Content (mg/kg) |
|---|---|
| TCK | 696.490±0,03 |
| TCK 1st (0%) | 82.719±0.01 |
| TCK 2nd (3%) | 130.699±0.04 |
| TCK 3rd (6%) | 133.045±0.03 |
| TCK 4th (9%) | 135.633±0.33 |
| TCK 5th (12%) | 154.133±0.04 |
| TCK 6th (15%) | 188.553±0.03 |

Description: Data are presented as mean ± standard deviation (SD) of 4 replication

Table 2. shows that the lowest magnesium content was in the TCK 1 treatment (0% mangrove crab shell flour fortification) at 82.719 mg/kg, and the highest magnesium content was in the TCK 6 treatment (15% mangrove crab shell flour fortification) at 188.553 mg/kg. Magnesium levels increased with an increasing concentration of mangrove crab shell flour. In bread products fortified using a ratio of crab shell flour and wheat flour concentration, the lowest magnesium content was 13.69 mg/kg in the 10%: 90% treatment and the highest was 51.10 mg/kg in the 30%: 70%

comparison ratio treatment [11]. The magnesium content in mangrove crab shells that have been demineralised and deproteinized and transformed chitin into chitosan obtained a magnesium level of 1,1245 mg/kg [22].

Magnesium functions in more than 600 enzymatic reactions in protein synthesis, mitochondrial function, neuromuscular activity, bone formation, and the immune system. Magnesium plays an essential role in calcium metabolism by increasing calcium absorption and synthesis of Deoxyribonucleic Acid (DNA), Ribonucleic Acid (RNA), and proteins that can affect individual growth and development [3]. The balance of magnesium and calcium levels plays a role in blood pressure regulation because blood vessels need sufficient calcium to contract and magnesium to relax. Magnesium deficiency causes a decrease in the function and activity of the enzyme superoxide dismutase, causing an increase in lipid peroxide that accumulates in the lumen of the blood vessels and can trigger an increase in blood pressure [23]. Calcium and magnesium are minerals of bone formulation that work complementary to the process of matrix formation, deposits in the formation of bone tissue. If calcium and magnesium are deficient, it will inhibit cell division growth and tissue repair it will affect weight and height [24].

## Conclusion

Mangrove crab shell flour fortification treatment significantly affected calcium and magnesium parameters in cookie products. Calcium levels in the product ranged from 65.325 to 1,802.773 mg/kg. Magnesium levels ranged from 82.719 to 188.553 mg/kg. From the results obtained, cookies fortified with mangrove crab shell flour can be used as an alternative functional food product to fulfil calcium and magnesium mineral sources. Further research must test other mineral components, such as iron and phosphorus, and sensory testing to determine consumer acceptance of the product.

**Acknowledgements**
The authors would like to thank the Ministry of Education, Culture, Research and Technology for supporting and funding this research.

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