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Formulation of Mineral Salt and Milk Fish Bone (*Chanos chanos*) Waste to Prevent Preeclamsia

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ABSTRACT: The high rate of maternal mortality remains a significant public health concern, highlighting the urgent need to improve maternal health, particularly during pregnancy. One of the major complications contributing to maternal morbidity and mortality is preeclampsia, a pregnancy-related disorder characterized by hypertension, proteinuria, and edema. Nutritional deficiencies, especially in essential minerals such as potassium, magnesium, and calcium, have been identified as contributing factors in the development of preeclampsia. Therefore, ensuring adequate intake of these micronutrients is crucial for prevention and maternal well-being. This study aimed to analyze the mineral content of a formulated mineral salt derived from milkfish (*Chanos chanos*) bone waste as a potential alternative source of essential nutrients. The research employed an experimental laboratory method, with mineral analysis conducted using an Atomic Absorption Spectrophotometer (AAS). The formulation was evaluated for its potassium, magnesium, and calcium content to determine its potential contribution to daily nutritional requirements. The results showed that a daily intake of 5 grams of the formulated product could provide approximately 1.49% of potassium, 45% of magnesium, and 65.26% of calcium requirements. These findings indicate that the mineral salt formulation derived from milkfish bone waste is particularly rich in calcium and magnesium, both of which play important roles in maintaining vascular function and reducing the risk of hypertensive disorders during pregnancy. In conclusion, the developed mineral salt formulation has promising potential as a non-pharmacological preventive strategy to support micronutrient intake in pregnant women. Its utilization may contribute to reducing the risk of preeclampsia and improving maternal health outcomes. Further studies are recommended to evaluate its safety, bioavailability, and clinical effectiveness.

KEYWORDS: Calsium; magnesium; mineral; preeclampsia; potassium.

1. INTRODUCTION

Mineral-rich salt is a type of edible salt obtained through the evaporation of contaminant-free seawater, in which the production process preserves the natural mineral content present in the seawater. Consequently, the mineral composition of mineral-rich salt is highly influenced by the quality of the seawater and the conditions of the evaporation process. These factors contribute to variations in taste, texture, and color. In addition to sodium chloride, which plays a role in regulating heart function and maintaining acid–base balance, mineral-rich salt contains essential minerals such as magnesium, potassium, iron, and sulfur. Magnesium is involved in numerous biochemical processes, particularly in metabolic and cardiovascular functions, while potassium is essential for proper nerve function. Iron and sulfur contribute to immune system support and overall physiological stability. The combination of these minerals helps maintain electrolyte balance, supports blood circulation, enhances muscle function, and contributes to overall physiological homeostasis (Kartika et al., 2019).

Magnesium and potassium are essential minerals that play critical roles in human physiology, particularly in cardiovascular health. Previous studies have indicated that mineral-rich salt may be beneficial for individuals with hypertension, especially due to its relatively lower sodium chloride (NaCl) content compared to conventional salt (Kartika et al., 2019). Potassium intake has a significant impact on blood pressure regulation; low potassium intake is associated with increased blood pressure, whereas higher potassium intake can contribute to blood pressure reduction. This effect is attributed to decreased vascular resistance through vasodilation, as well as enhanced excretion of sodium and water mediated by the sodium–potassium pump mechanism (Putri & Kartini, 2014; Maria et al., 2012).

Blood pressure is defined as the force exerted by circulating blood against the walls of blood vessels as the heart contracts and pumps blood through the arteries (Farapti & Sayogo, 2014). A person is classified as hypertensive if they have a systolic blood pressure of ≥140 mmHg and/or a diastolic blood pressure of ≥90 mmHg, based on repeated measurements. Hypertension is a major risk factor for cardiovascular diseases and remains a significant global health concern (Darussalam & Warseno, 2017). Epidemiological evidence supports the relationship between potassium intake and hypertension; for example, a study conducted in Cikarang Barat reported that hypertension was more prevalent among individuals with low potassium intake (51.7%) compared to those with adequate or high potassium intake (17.4%) (Anggara & Prayitno, 2013).

Calcium is an essential mineral required for numerous physiological functions in the human body, including skeletal development, cardiovascular regulation, neuromuscular activity, hormonal balance, and enzymatic processes. In many low- and middle-income countries, calcium intake during pregnancy is often inadequate, contributing to an increased risk of maternal mortality, particularly due to hypertensive disorders such as preeclampsia. During pregnancy, the fetus requires approximately 30 g of calcium, which is primarily supplied through increased intestinal absorption in the mother. This absorption rate can double from early to late pregnancy. Beyond its role in bone health, calcium is crucial in preventing preeclampsia, a condition characterized by hypertension that may lead to severe complications such as seizures, preterm birth, and maternal mortality. In cases of hypocalcemia, increased vasoconstriction may occur, leading to elevated blood pressure; therefore, adequate calcium intake is essential to promote vasodilation and maintain vascular stability (Hofmeyr et al., 2018).

Calcium supplementation has been shown to reduce the risk of hypertensive disorders during pregnancy by decreasing parathyroid hormone release and intracellular calcium levels, thereby reducing smooth muscle contraction and enhancing vasodilation (Irmayanti et al., 2021). Clinical studies have reported that calcium supplementation can reduce systolic and diastolic blood pressure by approximately 4.66 mmHg and 6.66 mmHg, respectively. Additionally, higher calcium levels have been observed in hypertensive pregnant women compared to normotensive individuals (Gomes et al., 2022; Lestariningsih & Budi Susila Duarsa, 2013). International guidelines from Europe, FAO/WHO, the United States, and Canada recommend a daily calcium intake of 1000–1300 mg for pregnant women, with an upper intake limit of 2500–3000 mg per day (Panel et al., 2015; Ross et al., 2011; Gomes et al., 2022).

Data from the South Sulawesi Provincial Health Office indicate that preeclampsia remains a leading cause of maternal mortality. In 2016, several cases of maternal death were attributed to this condition. Epidemiological data from multiple community health centers (Puskesmas), including Bara-Barayya, Kassi-Kassi, Jumpandang Baru, Mamajang, and Batua Raya, also revealed a relatively high prevalence of hypertension among pregnant women. For example, the incidence rates were reported as 2.31% (Kassi-Kassi), 2.87% (Bara-Barayya), 3.02% (Jumpandang Baru), 2.87% (Mamajang), and 2.45% (Batua Raya) (Maliang et al., 2019). These findings highlight the need for effective preventive strategies targeting nutritional deficiencies associated with hypertensive disorders in pregnancy.

Although milk and dairy products are widely recognized as primary sources of calcium, their consumption may be limited due to lactose intolerance or milk protein allergies, which are relatively common in certain populations, including Indonesians. Therefore, alternative calcium sources are needed. Fish bones, particularly from milkfish (*Chanos chanos*), represent a promising alternative due to their high calcium content and good bioavailability. Studies have shown that calcium derived from fish bones is well absorbed in both humans and animals and is comparable to commercial calcium supplements such as calcium carbonate (Panel et al., 2015). Nutritional analysis of milkfish bone flour indicates that it contains approximately 9.68% calcium, along with other nutrients such as protein, fat, and carbohydrates (Ilminingtyas & Fatarina, 2017).

Based on these considerations, this study aimed to analyze the mineral content of potassium, magnesium, and calcium in a formulation combining mineral-rich salt and milkfish bone (*Chanos chanos*) waste as an alternative source of micronutrients for the prevention of preeclampsia. The study employed an experimental laboratory design, utilizing Atomic Absorption Spectrophotometry (AAS) to quantify mineral content in seawater-derived salt (Fawwaz et al., 2019), milkfish bone flour, and their combined formulation. The results demonstrated that the formulation contained 14.01 mg/g of potassium, 30.15 mg/g of magnesium, and 182.74 mg/g of calcium. When consumed at a dosage of 5 g per day, the formulation could provide approximately 1.49% of the daily potassium requirement, 45% of magnesium, and 65.26% of calcium for pregnant women.

These findings suggest that the combination of mineral-rich salt and milkfish bone flour has strong potential as a non-pharmacological intervention to enhance micronutrient intake, particularly minerals involved in blood pressure regulation. Therefore, this formulation may serve as a promising preventive strategy to reduce the risk of preeclampsia and improve maternal health outcomes.

2. EXPERIMENTAL SECTION

2.1. Production of Rich Mineral Salt

Seawater samples were taken to be processed into rich mineral salt. Each seawater sample (1000 ml) was boiled using a hot plate (T = ± 500ºC) to form salt crystals (Kartika et al., 2019).

2.2. Processing of Milkfish Bone Waste

The milkfish bones are cleaned of any remaining flesh by boiling them for 30 minutes and then washing them thoroughly. The cleaned milkfish bones are then placed in a pressure cooker and boiled under high pressure for 30 minutes. After that. the milkfish bones are dried in a cabinet dryer at 50°C for 12 hours. The milkfish bones are then ground and sieved to a size of 20 mesh (Mulyani et al., 2021).

2.3. Magnesium Level Check

Magnesium content analysis was performed according to the Indonesian National Standard SNI 06-6989.12 (2004). A total of 50 g of the sample was dissolved in 200 mL of distilled water and subsequently filtered using filter paper to obtain a clear filtrate. An aliquot of 100 mL of the filtrate was then acidified by adding 2 mL of hydrochloric acid (HCl) and heated until dryness. After cooling, 1 mL of chloride solution was added to the residue. The preparation of standard magnesium solutions was carried out as follows: a 100 mg/L standard solution was prepared by pipetting 10 mL of a 1000 mg/L stock magnesium solution into a 100 mL volumetric flask and diluting it to the mark with distilled water. A 10 mg/L standard solution was then prepared by pipetting 1 mL of the 1000 mg/L stock solution into a 100 mL volumetric flask and diluting it to volume with distilled water. Subsequently, the working standard solution was prepared by pipetting 10 mL of the 10 mg/L standard solution into a 100 mL volumetric flask and diluting it to the mark with distilled water. The magnesium content in the sample was determined using Atomic Absorption Spectrophotometry (AAS) at a wavelength of 285.2 nm.

Magnesium levels are obtained from: Mg level (mg/l) = C × fp

Explanation: C: measured level fp: dilution factor nm (Ary Giri Dwi Kartika, Wiwit Sri Werdi Pratiwi, 2019)

2.4. Potassium Test

Potassium concentration analysis was conducted following the method described by Rochmawati et al. (2015). The sample solution was treated with nitric acid (HNO_3) and perchloric acid ($HClO_4$) to facilitate digestion until a clear solution was obtained. The resulting solution was then filtered using filter paper to remove any remaining particulates. Standard potassium solutions were prepared at concentrations of 0.5, 1.5, 2.0, and 3.0 ppm. The absorbance of each standard solution was measured using an Atomic Absorption Spectrophotometer (AAS), and a calibration curve was constructed to obtain the linear regression equation. For sample analysis, the salt sample was dissolved in distilled water, followed by the addition of HNO_3 to ensure complete dissolution and stabilization of the analyte. The solution was then filtered and its absorbance measured using AAS. The potassium concentration in the sample was determined by substituting the measured absorbance value into the linear regression equation obtained from the calibration curve (Kartika et al., 2019).

2.5. Calcium Test

Calcium levels using the Atomic Absorption Spectrometer (AAS) method. The data were analyzed using the SPPS computer program with the Analysis of Variance (ANOVA) method at a significance level of 0.05 (Mulyani et al., 2021).

3. RESULTS AND DISCUSSION

Based on **Table 1**. salt crystals from Barane contain 15,403.60 µg/g of potassium. equivalent to 15.4036 mg/g of salt. The potassium mineral content of milkfish bone (*Chanos chanos*) powder is relatively low at 229.58 µg/g. equivalent to 0.22958 mg/g. After combining the values, the potassium content is 14,010.08 µg/g. equivalent to 14.01008 mg/g. The daily potassium requirement for adult women. including pregnant women. is 4.700 mg/day (Ministry of Health Regulation, 2019). Based on this data. mineral-rich salt can meet an individual's potassium needs by 1.490% if consumed at 5 g/day.

Table 1. Potassium (K) content by AAS

Number	Samples	Level (µg/g)	Level (mg/g)
1.	Salt crystals	15,403.60	15.4036
2.	Milkfish bone powder	229.58	0.22958
3.	Milkfish bones mixed with seawater and then crystallized	14,010.08	14.01008

Based on **Table 2**, salt crystals from Barane contain 30,314.68 µg/g of magnesium. equivalent to 30.31468 mg/g of salt. The magnesium content of milkfish bone (*Chanos chanos*) powder is relatively low at 2,423.75 µg/g. equivalent to 2.42375 mg/g. After combining the values. the magnesium content is 30,148.34 µg/g. equivalent to 30.14834 mg/g. The daily magnesium requirement for adult women. including pregnant women. is 330 mg/day (Ministry of Health Regulation of the Republic of Indonesia, 2019). Based on this data. mineral-rich salt can meet 45% of an individual's magnesium requirement if consumed at a rate of 5 g/day.

Table 2. Magnesium (Mg) content by AAS

Number	Samples	Level (µg/g)	Level (mg/g)
1.	Salt crystals	30,314.68	30.31468
2.	Milkfish bone powder	2,423.75	2.42375
3.	Milkfish bone mixture mixed with seawater and then crystallized	30,148.34	30.14834

Based on **Table 3**. salt crystals from Barane contain 7,469.49 µg/g of calcium. equivalent to 7.46949 mg/g of salt. The calcium mineral content of milkfish bone (*Chanos chanos*) powder is relatively low at 39,033.65 µg/g. equivalent to 39.03365 mg/g. After combining the values, the calcium content is 182,737.06 µg/g. equivalent to 182.73706 mg/g. The daily calcium requirement for adult women. including pregnant women is 1.400 mg/day (Ministry of Health Regulation, 2019). Based on this data mineral-rich salt can meet 65.26% of an individual's calcium needs if consumed at 5 g/day.

Table 3. Calcium (Ca) content by AAS

Number	Samples	Level (µg/g)	Level (mg/g)
1.	Salt crystals	7,469.49	7.46949
2.	Milkfish bone powder	39,033.65	39.03365
3.	Milkfish bone mixture mixed with seawater and then crystallized	182,737.06	182.73706

The Health Development Program prioritizes efforts to improve the health status of mothers and children. particularly among the most vulnerable groups. namely pregnant women. postpartum women. and infants during the perinatal period. Preeclampsia is a condition characterized by hypertension. Proteinuria. and edema that occurs during pregnancy (Marfuah, 2021). Nutritional deficiencies play a role in the development of preeclampsia. Calcium and magnesium minerals are known to lower blood pressure. These minerals inhibit blood vessel constriction, reducing peripheral resistance and thereby lowering blood pressure (Marfuah, 2021). Potassium intake increases its concentration in intracellular fluid. leading to a tendency to draw fluid from the extracellular space and lower blood pressure. Potassium intake also protects individuals from hypertension (Marfuah, 2021).

Micronutrients such as magnesium. Potassium. and calcium in the blood can be optimally absorbed by the body when there is pro-vitamin D to aid the absorption process. Provitamin D is obtained through UV rays or sun exposure. The results of laboratory tests on pregnant women with preeclampsia regarding potassium. calcium. and magnesium levels following sun exposure intervention indicate that there is an effect of sun exposure intervention on increasing potassium. calcium. and magnesium levels in pregnant women with preeclampsia. with a P-value < 0.05. (P-value for potassium levels after intervention: 0.005; P-value for calcium levels after intervention: 0.016; P-value for magnesium levels after intervention: 0.007) (Marfuah, 2021).

Calcium requirements can be obtained from various food sources. Galih Purnasari found a significant relationship between the frequency of consumption of milk and its derivatives. animal-based side dishes. Vegetables. and snacks with the level of calcium adequacy in pregnant women (Purnasari et al., 2017). In addition to dietary diversification. calcium supplementation for pregnant women is an appropriate approach to meeting calcium needs in developing countries and as part of preventing hypertension during pregnancy (Purnasari et al., 2017).

Some recommended supplements include calcium. with each tablet containing 500 mg of the active ingredient calcium lactate. to be taken twice daily. Calcium supplementation in the form of calcium carbonate may be unpleasant for many pregnant women due to its large size and powdery texture. Additionally. if the tablet is administered three times daily. it increases the number of tablets that must be taken each day. for example. if the mother is also given iron tablets. folic acid. and calcium. This can affect the mother's compliance in taking calcium tablets (Tunçalp et al., 2017). Calcium should not be consumed together with iron because calcium can inhibit iron absorption (Adyani, 2020).

Based on the results of this study, the formulation of mineral salts and milkfish (*Chanos chanos*) bone waste shows significant potential as an alternative source of calcium, magnesium, and potassium. However, this study is still limited to mineral content analysis without evaluating bioavailability, consumption safety, and physiological effectiveness in preventing preeclampsia. Therefore, future research prospects can be directed towards testing mineral bioavailability through in vitro and in vivo methods to ensure the body's ability to absorb minerals. In addition, toxicity tests, organoleptic tests, and the development of functional food products that can be widely applied are needed. Subsequent research could also explore clinical intervention studies in pregnant women at risk of preeclampsia to assess the real benefits of this formulation on blood pressure regulation and body mineral status. Thus, the data obtained at this time can serve as a strong basis for the development of safe, economical, and effective natural mineral supplements as a preventive measure against preeclampsia.

4. CONCLUSION

Based on the results of laboratory analysis, the mineral-rich salt formulation derived from milkfish (*Chanos chanos*) bone waste meets the minimum threshold levels of potassium, magnesium, and calcium. Therefore, it has the potential to be utilized as a non-pharmacological alternative in the form of micronutrient supplementation to help prevent the development of preeclampsia.

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REFERENCES

Adyani, K. Calcium Diet for Pregnant Women. Embrio. 2020; 12(1), 31–42.

Anggara, F. H. D., & Prayitno, N. Factors Associated with Blood Pressure at Telaga Murni Health Center, Cikarang Barat in 2012. *Scientific Health Journal*. 2013; 5(1), 20–25.

Darussalam, M., & Warseno, A. Factors Associated with Uncontrolled Hypertension Patients at Community Health Centers. *Journal of Clinical and Community Nursing*. 2017;1(2), 72.

Fawwaz, M., Labasy, L., Saleh, A., Mandati, S. S., & Pratama, M. Determination of mercury (Hg) and lead (Pb) content in selected milkfish from fishponds around Pampang–Makassar River. *International Food Research Journal*, 2019; *26*(2).

Farapti, & Sayogo, S. Young Coconut Water - Its Effect on Blood Pressure. Cdk-223, 2014; 41(12), 896–900.

Gomes, F., Ashorn, P., Askari, S., Belizan, J. M., Boy, E., Cormick, G., Dickin, K. L., Neufeld, L. M., Weaver, C., & Bourassa, M. W. Calcium supplementation for the prevention of hypertensive disorders of pregnancy: current evidence and programmatic considerations. *Annals of the New York Academy of Sciences*, 2022; *1510*(1), 52–67. https://doi.org/10.1111/nyas.14733

Hofmeyr, G. J., Lawrie, T. A., Atallah, Á. N., & Torloni, M. R. Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. *The Cochrane Database of Systematic Reviews*, 2018, *10*(10), CD001059.

Ilminingtyas, D., & Fatarina, E. Addition of Milkfish (*Chanos chanos*) Bone Flour in the Production of Crackers as a By-product of the Milkfish Deboning Industry. Serat. *Acitya-Scientific Journal of UNTAG Semarang.* 2017; 6(2), 2302–2752.

Irmayanti, Tandiallo, D., & Ibrahim, F. Changes in Blood Pressure with Calcium Intake in Pregnant Women with a History of Preeclampsia. *Midwifery Scientific Journal*. 2021; 11(1), 12–16.

Kartika, A.G.D., Sri, W., Pratiwi, W.N. Analysis of Magnesium and Potassium Levels in Rich Minerals Salt. *Journal of Science and Technology*. 2019; 12(1), 1–4.

Lestariningsih, S., & Budi Susila Duarsa, A. The Relationship Between Preeclampsia in Pregnancy and the Occurrence of Low Birth Weight at Ahmad Yani General Hospital, Metro City, in 2011. *Andalas Public Health Journal*. 2013; 8(1), 34–39.

Maliang, M. I., Imran, A., & Alim, A. Medical Record Management System (Qualitative Study at Tamalate Health Center, Makassar. *Window of Health: Health Journal*. 2019; October, 315–328.

Marfuah, S. Analysis of Magnesium, Calcium, and Potassium Levels in Pregnant Women with Preeclampsia Following Sunlight Exposure Intervention. *Journal of Health Science and Technology*. 2021; 12(2),

Maria, G., Puspita, R. D., & Sulistyowati, Y. Relationship Between Sodium and Potassium Intake and Blood Pressure in Hypertensive Patients at the Dili Unit in Timor Leste. *Journal of Hypertension*. 2012; 4–15.

Mulyani, S., Rohmeita, D., & Legowo, A. M. Characteristics of calcium from milkfish (Chanos chanos) bones extracted using HCl solution. *Journal of Nutrition College*. 2021; 10(4), 321–327.

Ministry of Health of the Republic of Indonesia. Regulation of the Minister of Health of the Republic of Indonesia No. 28 of 2019. In Recommended Nutrient Intakes for the Indonesian Population. 2019; 11(1).

Panel, E., Nda, A., Vieille, S. La, Marchelli, R., Martin, A., Naska, A., Neuhäuser-berthold, M., Turck, D., & Correspondence, H. V. Scientific Opinion on Dietary Reference Values for calcium. *EFSA Journal*. 2015; 13(5).

Purnasari, G., Briawan, D., & Dwiriani, C. M. Calcium Intake and Calcium Adequacy Levels in Pregnant Women in Jember District. *Indonesian Public Health Journal*. 2017; 12(4), 261–268.

Putri, E. H. D., & Kartini, A. Relationship Between Potassium, Calcium, and Magnesium Intake and Hypertension Incidence in Postmenopausal Women in Bojongsalaman Village, Semarang. *Journal of Nutrition College*. 2014; 3(4), 580–586.

Ross, A. C., Manson, J. E., Abrams, S. A., Aloia, J. F., Brannon, P. M., Clinton, S. K., Durazo-Arvizu, R. A., Gallagher, J. C., Gallo, R. L., Jones, G., Kovacs, C. S., Mayne, S. T., Rosen, C. J., & Shapses, S. A. The 2011 Dietary Reference Intakes for Calcium and Vitamin D: What Dietetics Practitioners Need to Know. *Journal of the American Dietetic Association*. 2011; 111(4).

Tunçalp, Pena-Rosas, J. P., Lawrie, T., Bucagu, M., Oladapo, O. T., Portela, A., & Metin Gülmezoglu, A. WHO recommendations on antenatal care for a positive pregnancy experience—going beyond survival. BJOG: *An International Journal of Obstetrics and Gynaecology*. 2017; 124(6), 860–862.