

FORMULATION OF EGGSHELL AND BANGUN-BANGUN BOOSTER (EGGSBOS) CANDY TO SUPPORT CALCIUM REQUIREMENTS IN BREASTFEEDING MOTHERS

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ABSTRACT

*Calcium requirements increase during lactation due to the daily excretion of approximately 200-300 mg of calcium through breast milk. However, calcium intake among women of reproductive age in Indonesia remains at only 60-70% of the recommended dietary allowance. Eggshells contain about 95% calcium carbonate and have potential as a natural calcium fortification source, while bangun-bangun (*Coleus amboinicus*) is traditionally used as a galactagogue and reported to enhance breast milk production. This study aimed to formulate Eggsbos Candy as a calcium-fortified product based on duck eggshell powder and bangun-bangun leaves and to determine its calcium content. This study employed a Laboratory Experimental Descriptive Design using three different formulations (A, B, and C) containing 9 g, 7 g, and 5 g of eggshell powder, each with three replications. Calcium levels were analyzed using Atomic Absorption Spectrophotometry (AAS). Formula A showed the highest calcium content (190.28 mg), followed by Formula B (190.00 mg) and Formula C (179.37 mg). One candy contains approximately 190 mg of calcium; consuming six candies per day would provide about 1,141.68 mg (≈95% of the 1,200 mg daily requirement). These findings indicate that Eggsbos Candy has potential as a natural calcium fortified product with laboratory verified mineral content and warrants further investigation to evaluate its bioavailability, safety, and physiological effectiveness.*

Keywords: Eggsbos Candy; calcium; breastfeeding mothers; duck eggshell; bangun-bangun.

INTRODUCTION

Calcium is a major mineral that plays an essential role in maintaining bone and dental health, as well as nerve and muscle function. For breastfeeding mothers, calcium is not only needed to preserve bone density but also to support the secretion of breast milk (BM). During lactation, approximately 200-300 mg of calcium is excreted daily through breast milk, thereby increasing the calcium requirement to about 1,200 mg per day (Sutiari, 2017).

During the breastfeeding period, the mother's body undergoes metabolic changes in calcium to ensure sufficient calcium availability to support the bone development of the newborn. The calcium present in breast milk is largely derived from the mother's bones through a mechanism believed to involve parathyroid hormone related protein (PTHrP), which works in conjunction with decreased estrogen levels in the bloodstream (Augustine et al., 2023).

If calcium intake in breastfeeding mothers is inadequate, the body will draw calcium reserves from the bones, which over time may lead to bone demineralization, joint pain, and an increased risk of osteoporosis. Breastfeeding mothers are therefore advised to consume animal-based foods that are the primary sources of vitamin D in the form of cholecalciferol, such as egg yolks, liver, cream, butter, and cod liver oil. Calcium absorption can be further enhanced through morning sunlight exposure (Kemenkes, 2018).

In fact, most breastfeeding mothers in Indonesia still fail to meet their daily calcium requirements. According to Kemenkes (2021), milk and calcium source consumption among women of reproductive age and breastfeeding mothers remains low, averaging only 60–70% of the recommended daily intake. This situation is further exacerbated by monotonous diets and limited access to commercial calcium supplements, which tend to be relatively expensive. Therefore, there is a need for alternative natural calcium sources that are easily accessible, safe, affordable, and nutritionally valuable.

One promising natural ingredient is duck eggshell, which contains approximately 95% calcium carbonate (CaCO_3) and can serve as a natural calcium source after undergoing drying and sterilization processes. Previous research by Azis et al., (2018) revealed that duck eggshells contain higher calcium levels than chicken eggshells; however, their use in food products remains very limited. On the other hand, bangun-bangun is widely recognized in North Sumatra as a traditional galactagogue plant that promotes lactation due to its flavonoid and phytochemical content, which stimulates oxytocin and prolactin hormones (Rahmawati et al., 2021).

Eggshells have been reported as a natural source of calcium with a high calcium carbonate content and good potential bioavailability after undergoing sterilization and grinding processes

(Waheed et al., 2019; Bartter et al., 2018). Recent studies have also demonstrated that the utilization of agroindustrial waste as a mineral source can support the concept of a circular economy in functional food development (García, Segovia et al., 2020). Most existing research remains limited to chemical characterization or applications in bakery products and fortified beverages, whereas their incorporation into confectionery products, which possess distinct textural and stability characteristics, has rarely been reported. Several previous studies have discussed the effects of bangun-bangun on increasing breast milk production (Husna et al., 2021; Ariescha & Tryningsih, 2023), as well as the potential of eggshells as calcium sources (Rahayu & Shofia, 2017; Ainiyah, 2019).

Coleus amboinicus has been extensively investigated over the past decade for its bioactive potential and traditional use among breastfeeding mothers. Nevertheless, the integration of this herbal plant with alternative calcium sources derived from agroindustrial waste into a single standardized functional food product has not been widely explored scientifically. Furthermore, studies that specifically combine varying concentrations of mineral fortificants and quantitatively measure calcium content using instrumental methods such as Atomic Absorption Spectrophotometry (AAS) in confectionery products remain very limited in the current literature. Therefore, a research gap exists in the development of calcium fortified confectionery products based on eggshell waste combined with traditional herbal plants and evaluated under controlled laboratory conditions.

However, no study has yet combined these two natural ingredients into a functional food product that is easy to consume and acceptable to the public, particularly breastfeeding mothers. This research therefore seeks to fill that gap by developing an innovative product that provides both nutritional and functional benefits. Based on these observations, the author was motivated to develop a bangun-bangun leaf-based product combined with duck eggshell in the form of candy.

The bangun-bangun plant is a traditional medicinal herb widely used by the community in North Sumatra. This plant is commonly found across various regions in North Sumatra, including Karo, Tapanuli, Medan, Lake Toba, Deli Serdang, and surrounding areas (Pane, 2023). The local population has long used bangun-bangun leaves as a natural galactagogue to stimulate breast milk production. Among the Batak ethnic group, the average daily consumption of bangun-bangun leaves ranges from 120–150 g (Januarti & Putri, 2021). Consumption of bangun-bangun leaves has been shown to significantly increase the concentration of several minerals such as iron, potassium, zinc, and magnesium in breast milk, thereby contributing to infant weight gain

(Rahmawati et al., 2021). Providing bangun-bangun leaves for 14 days at a dosage of 150 g per day was found to increase breast milk production by 47.4% (Ariescha & Tryningsih, 2019).

Eggshells are the hard, outermost protective layer of an egg. They are composed of approximately 95% calcium carbonate, with the remainder consisting of minerals such as magnesium, phosphorus, sodium, potassium, zinc, iron, manganese, and copper (Widyantara et al., 2017). Researchers from the University of Tokyo, Japan, studied the combination of vitamin D and eggshell powder in animals with osteoporosis. Their findings indicated that eggshell powder containing vitamin D not only increased bone mineral density but also improved blood calcium levels (Fuadi & Arianingrum, 2018). The addition of a single duck eggshell can increase calcium levels by up to 6% (Ainiyah, 2019).

The ingredients used in this study are derived from natural sources, and previous studies have confirmed their safety for consumption. Experimental and field studies by Sihotang (2024) at the Mera Midwife Clinic showed that consuming bangun-bangun leaves as a tea infusion or decoction significantly improved breast milk production, with a p-value of 0.001 (<0.05), and no serious side effects were reported during the intervention. These findings are consistent with those of Rambe (2023) in Batang Pane II Village, which involved breastfeeding mothers with infants aged 0-6 months.

The results demonstrated an increase in breast milk volume after participants regularly consumed bangun-bangun leaf decoction, without side effects such as nausea or digestive disturbances. Similar outcomes were also reported in a study involving postpartum mothers, where bangun-bangun leaf consumption effectively promoted breast milk production, supported by statistically significant results (Simanjuntak et al., 2023). Therefore, it can be concluded that consuming bangun-bangun leaves in moderate doses is relatively safe and beneficial for supporting lactation.

Based on this gap, the present study proposes an innovative approach to sustainable functional food development by utilizing duck eggshell waste as a natural calcium fortification source. Unlike previous studies that primarily employed synthetic calcium or focused on non confectionery products (Waheed et al., 2019; García, Segovia et al., 2020), this study integrates an alternative mineral source with the traditional herbal plant bangun-bangun into a single confectionery matrix formulated under controlled conditions.

Moreover, this research not only develops formulation but also quantitatively determines calcium content across different concentration variations using AAS to obtain specific numerical data per unit product. This approach may contribute additional insights into the food fortification

literature by expanding the application of waste based calcium sources into a practical confectionery product that may enhance consumption compliance among the target population, particularly breastfeeding mothers.

A review of the existing literature indicates that the combined application of these two natural ingredients in a single standardized product has not yet been systematically examined. Thus, the present study introduces an innovative formulation *Eggsbos Candy* (Eggshell and bangun-bangun Booster Candy) a functional confectionery combining duck eggshell and bangun-bangun leaves.

METHOD

1. Research Method

This study employed an experimental laboratory design with a descriptive quantitative approach (data were analyzed descriptively without inferential statistical testing), aiming to analyze the calcium content of several formulations of *Eggsbos Candy*, a product made from duck eggshell and bangun-bangun leaves (*Coleus amboinicus*) and to determine the calcium content of each formulation and to estimate its potential contribution to the Recommended Dietary Allowance (RDA) for breastfeeding mothers. The independent variable in this study was the proportion of duck eggshell powder used in each formulation (9 g, 7 g, and 5 g), while the dependent variable was the calcium content of *Eggsbos Candy* measured using AAS. The measured calcium content was then compared descriptively with the Recommended Dietary Allowance (RDA) of 1200 mg/day for breastfeeding mothers. The calcium concentration (mg/dL) obtained from AAS analysis was converted into milligrams per serving based on the dilution volume and total mass of the candy sample analyzed.

2. Research Location and Period

The study was conducted at the Public Health Laboratory Center (Balai Laboratorium Kesehatan Masyarakat), Medan. The experimental tests were carried out from April 29 to May 15, 2025.

3. Population and Sample

The study population consisted of all *Eggsbos Candy* formulations produced from combinations of duck eggshell powder and bangun-bangun leaf powder. The samples comprised three formulations Formula A, Formula B, and Formula C, which differed in the proportion of

duck eggshell powder to other ingredients. Each formulation was prepared in triplicate (three replications) to ensure the reliability of measurement results.

4. Materials and Equipment

The main ingredients used were duck eggshells, bangun-bangun leaves, palm sugar, gelatin, and citric acid. Duck eggshells served as the calcium source, while bangun-bangun leaves acted as a functional and flavor enhancing component. The instruments used included an Atomic Absorption Spectrophotometer (AAS) for calcium analysis, an analytical balance, an air fryer, a blender, standard laboratory glassware, and silicone molds for candy shaping.

5. Research Procedures

a. Material preparation

Five duck eggshells (± 4 g per shell) were washed thoroughly, boiled at 100°C for 15 minutes to remove residual protein and bacteria, then dried. The shells were ground into a fine powder and sieved through a 100 mesh screen. Bangun-bangun leaves (200 g) were dried using an air fryer at a low temperature (20-40°C) for 15-20 minutes, then blended and sieved through a 100 mesh filter.

b. Formulation preparation

Three formulations were prepared with varying amounts of duck eggshell powder: Formula A (highest proportion), Formula B (medium), and Formula C (lowest). All ingredients were mixed with palm sugar, gelatin, and citric acid until homogeneous, then heated until thickened and molded into jelly candies (*Eggsbos Candy*).

c. Calcium content analysis

Each sample was weighed, dissolved in concentrated nitric acid (HNO₃), filtered, and analyzed using an Atomic Absorption Spectrophotometer (AAS). The results were expressed in mg/dL and converted into calcium content per candy piece.

d. Daily requirement contribution calculation

The calcium content per candy piece was multiplied by the recommended daily consumption amount to calculate the percentage contribution toward the calcium requirement of breastfeeding mothers, based on the RDA of 1200 mg/day.

6. Data Analysis Technique

The calcium content data were analyzed descriptively and quantitatively, including the calculation of mean values and percentage contributions to daily requirements. The results were presented in tables and graphs to visually illustrate comparisons among formulations.

7. Research Implementation and Ethical Considerations

All research activities were carried out by the primary researcher under the supervision of an academic advisor. Laboratory analyses were performed by qualified chemical analysts at the laboratory.

RESULTS AND DISCUSSION.

1. Product Formulation

The product was developed into three variants of candies, each designed as Formula A, B, and C, with different proportions of duck eggshell and Bangun-bangun leaf powder, as presented in the following table:

Table 1. Formulation of *Eggsbos Candy* Made from Duck Eggshell and Bangun-bangun (*Coleus amboinicus*) to Enhance Calcium and Breast Milk Production

Composition	A	B	C
Duck eggshell	9 g	7 g	5 g
Bangun-bangun leaves	80 g	60 g	40 g
Gelatin	7 g	7 g	7 g
Palm sugar	70 g	70 g	70 g
Citric acid	0,5 g	0,5 g	0,5 g
Water	200 mL	200 mL	200 mL

Note: Values in bold indicate the varied components.

As shown in Table 1, the three formulas (A, B, and C) were differentiated based on the proportions of duck eggshell powder and bangun-bangun leaf powder. Formula A contained 9 g of duck eggshell powder and 80 g of bangun-bangun leaves; Formula B contained 7 g and 60 g, respectively; and Formula C contained 5 g and 40 g, respectively. All formulations were processed into *Eggsbos Candy* products.

2. Calcium Content in Each Formula

The calcium content of the three *Eggsbos Candy* formulations was analyzed using an Atomic Absorption Spectrophotometer (AAS).

Table 2. Calcium Content of *Eggsbos Candy* Formulations

Formula	Calcium Content (mg/dL)	Calcium per Candy (mg)	Remarks
A	1902,77	190,28	Highest content
B	1900,04	190,00	Slightly lower
C	1793,68	179,37	Lowest content

As shown in Table 2, Formula A had the highest calcium content (1902,77 mg/dL), followed by Formula B (1900,04 mg/dL) and Formula C (1793,68 mg/dL). These differences are influenced by the varying proportions of duck eggshell powder used, with Formula A containing the largest amount.

According to Ainiyah (2019), a higher proportion of eggshell powder in the formulation results in a higher calcium concentration in the final product. This is due to the high calcium carbonate (CaCO₃) content in eggshells, which can reach 95-97%. These findings are consistent with Rahayu and Shofia (2017), who reported that substituting eggshell powder in food products significantly increases calcium levels.

3. Contribution of *Eggsbos Candy* to the Calcium Requirements of Breastfeeding Mothers

The contribution of each formula to the calcium needs of breastfeeding mothers was calculated by converting the calcium content per candy into the percentage of the Recommended Dietary Allowance (RDA) for lactating women (1200 mg/day).

Table 3. Contribution of *Eggsbos Candy* to the Daily Calcium Requirement of Breastfeeding Mothers

Formula	Calcium per Candy (mg)	Daily Consumption (pieces)	Total Calcium Intake (mg/day)	% RDA Fulfilled
A	190,28	6	1141,68	95,1%
B	190,00	6	1140,00	95,0%
C	179,37	6	1076,22	89,7%

As shown in Table 3, consuming six pieces of *Eggsbos Candy* Formula A per day can meet approximately 95% of the daily calcium requirement for breastfeeding mothers. Thus, Formula A shows the greatest potential as a natural, practical calcium supplement that can substitute synthetic alternatives. The absorption of calcium in the human body is highly influenced by its chemical form and bioavailability. Duck eggshells contain calcium carbonate, which is known to dissolve in gastric acid and may be absorbed under appropriate physiological conditions. The inclusion of citric acid in the formulation may improve calcium solubility, which could potentially support its

bioavailability in the body (Suyatma et al., 2020). However, bioavailability was not directly assessed in this study.

4. Theoretical Discussion and Implications

The present study demonstrated that increasing the concentration of duck eggshell powder proportionally increased the calcium content of *Eggsbos Candy*. This finding is consistent with previous reports indicating that eggshells contain approximately 95% calcium carbonate (Widyantara et al., 2017; Ainiyah, 2019), suggesting that higher inclusion levels logically result in greater calcium contribution per unit product. However, although descriptive data indicate variation among Formulas A, B, and C, this study did not perform inferential statistical analysis to determine whether these differences were statistically significant. Therefore, the interpretation of an “optimal formulation” should be limited to descriptive comparison rather than confirmed statistical superiority. Future research applying appropriate statistical tests is necessary to validate comparative differences among formulations.

The processing method involved drying, sterilization, and heating during candy preparation. Calcium carbonate is generally recognized as thermally stable under moderate food-processing temperatures (Ainiyah, 2019). The measurable calcium levels detected after processing indicate that calcium remained present in the final product, although mineral stability was not directly evaluated. Nevertheless, no direct pre–post thermal comparison was conducted to specifically evaluate mineral degradation or stability. Thus, conclusions regarding processing stability remain theoretical and should be confirmed through controlled mineral retention studies.

In previous studies, duck eggshell powder has been proposed as a potential calcium fortificant due to its high mineral content and availability as food-processing waste (Azis et al., 2018; Rahayu & Shofia, 2017). Compared with synthetic calcium sources, natural eggshell-derived calcium offers advantages such as lower production cost and support for waste valorization. However, while these theoretical advantages exist, the present study did not conduct economic feasibility analysis, microbial testing, or sensory evaluation. Therefore, claims regarding safety, affordability, and consumer acceptance must be interpreted cautiously and require further laboratory and consumer-based validation.

The inclusion of bangun-bangun leaves in this formulation was based on its traditional use as a galactagogue and its reported phytochemical activity in stimulating lactation related hormones (Rahmawati et al., 2021); Husna et al., 2021; Ariescha & Tryningsih, 2023). Experimental studies have shown that bangun-bangun leaf consumption may increase breast milk

production (Simanjuntak et al., 2023; Sihotang, 2024). However, the present study did not evaluate lactation outcomes, hormonal levels, or physiological effects. Thus, *Eggsbos Candy* should not be interpreted as a clinically validated lactation-supporting product, but rather as a calcium-enriched confectionery prototype incorporating traditionally used herbal ingredients.

Although the combination of bangun-bangun leaves and eggshell powder suggests a conceptual dual functional product, no pharmacological interaction or synergistic mechanism between phytochemical compounds and calcium metabolism was investigated. Therefore, the assumption of synergistic action remains hypothetical. Further biochemical and clinical research is needed to determine whether any interactive or additive physiological effects occur.

Importantly, calcium concentration alone does not determine physiological benefit. The effectiveness of calcium fortification depends not only on total content but also on bioavailability, solubility, and absorption efficiency. Calcium carbonate (CaCO_3), the primary form present in eggshells (Widyantara et al., 2017), requires adequate gastric acidity for optimal dissolution. This study did not evaluate in vitro dissolution, gastrointestinal simulation, or bioavailability assessment. Consequently, although the measured calcium levels were substantial, the actual absorbed calcium fraction cannot be determined from the present data. Future studies employing in vitro digestion models or clinical bioavailability testing are necessary to confirm physiological efficacy.

Overall, this study provides preliminary laboratory evidence that duck eggshell powder can effectively increase calcium content in a confectionery matrix. However, further investigations incorporating statistical validation, mineral stability analysis, bioavailability assessment, safety evaluation, and clinical testing are required before definitive functional claims can be established.

5. Interpretation of Research Findings

The findings indicate that increasing the concentration of duck eggshell powder proportionally increased the calcium content of *Eggsbos Candy*. This result is consistent with previous reports stating that eggshells are predominantly composed of calcium carbonate (Widyantara et al., 2017; Ainiyah, 2019). The successful quantification using AAS confirms that eggshell derived calcium can be incorporated into a confectionery matrix without complete mineral loss during processing. However, as no inferential statistical analysis was performed, differences among formulations should be interpreted descriptively rather than as statistically confirmed superiority.

Although the formulation integrates bangun-bangun, which has been traditionally associated with lactation support (Rahmawati et al., 2021; Husna et al., 2021), this study did not assess biological outcomes such as milk production or calcium bioavailability. Therefore, the results should be understood as preliminary laboratory evidence of calcium enrichment rather than confirmation of functional or clinical efficacy. Further investigations involving statistical validation, bioavailability testing, safety assessment, and clinical evaluation are necessary to determine the actual physiological benefits of the product.

CONCLUSION

This study confirmed that *Eggsbos Candy* Formula A, made from duck eggshell and bangun-bangun (*Coleus amboinicus*), contained the highest calcium level (1902,77 mg/dL) among all formulations. Each piece of Formula A candy contained approximately 190 mg of calcium, meaning that consuming six pieces per day can meet about 95% of the daily calcium requirement for breastfeeding mothers (1200 mg/day).

Eggsbos Candy Formula A has the potential to serve as a locally based calcium-enriched functional food product for breastfeeding mothers while utilizing eggshell waste as a nutritionally valuable material. Practically, this study implies that the use of natural local ingredients, such as duck eggshells can provide an innovative and sustainable solution to improve calcium intake in the community.

Further research is recommended to assess the bioavailability of calcium and its biological effectiveness on calcium status and breast milk production in breastfeeding mothers directly. This study demonstrates that duck eggshell powder can be successfully incorporated into a confectionery matrix, resulting in increased calcium content proportional to the concentration used in the formulation. Quantitative analysis using AAS confirmed measurable calcium levels in each formulation, indicating the technical feasibility of utilizing eggshell waste as a mineral fortification source.

However, the findings are limited to laboratory based calcium quantification. The study did not evaluate calcium bioavailability, absorption efficiency, maternal calcium status, breast milk composition, or clinical lactation outcomes. Therefore, although the product contains a substantial amount of calcium, no conclusion can be drawn regarding its physiological effectiveness or its ability to improve calcium intake in vivo. Additionally, no comparative analysis was conducted with commercial calcium supplements or other natural calcium sources.

In conclusion, *Eggsbos Candy* should be regarded as a preliminary prototype of a calcium-enriched confectionery product derived from sustainable raw materials. Further research involving statistical validation, bioavailability testing, safety assessment, sensory evaluation, and controlled clinical studies is necessary to determine its nutritional efficacy and potential application as a functional food.

ACKNOWLEDGEMENT

The researcher expresses sincere gratitude to Poltekkes Kemenkes Medan and the Bachelor of Applied Midwifery Program, Medan, for their support in developing innovation throughout this study. Special thanks are also extended to the technical staff of the Public Health Laboratory Center, Medan, for their assistance in calcium analysis using the Atomic Absorption Spectrophotometer (AAS). The highest appreciation is given to the academic supervisors and fellow students for their valuable guidance, technical support, and constructive input throughout the research process and the preparation of this article.

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