ORIGINAL RESEARCH ARTICLE

Development and acceptability of mung beans and purple taro cookies as a supplementary food for pregnant women

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Abstract

Chronic Energy Deficiency (CED) in pregnancy remains a major public health problem associated with adverse maternal and neonatal outcomes. This Research and Development (R&D) study developed functional cookies using mung bean and purple taro as locally available nutrient-dense ingredients. Conducted from June to August 2025, the study involved cookie formulation, proximate analysis, antioxidant testing, and organoleptic and acceptability assessment. This laboratory-based R&D study did not include clinical outcome measurements. Three formulations were evaluated. Sensory testing by 30 trained panelists showed significant differences across all parameters ($p < 0.05$), with flavor receiving the highest score. Acceptability testing among 30 pregnant women revealed that 76.7% "liked" or "liked very much" the product. Proximate results showed moisture (8.18%), ash (4.96%), protein (9.65%), fat (14.90%), and crude fiber (10.20%). These findings suggest that cookies formulated from mung bean and purple taro are acceptable, nutritionally promising, and potentially useful as a supplementary functional food to support maternal nutrition and reduce CED risk.. *(Afr J Reprod Health 2026; 30 [3]: 161-169).*

Keywords: Pregnancy; Functional Food; Maternal Nutrition; Chronic Energy Deficiency

Résumé

La carence énergétique chronique (CEC) pendant la grossesse demeure un problème majeur de santé publique, associé à des issues maternelles et néonatales défavorables. Cette étude de Recherche et Développement (R&D) a élaboré des biscuits fonctionnels à base de haricot mungo et de taro violet, deux ingrédients locaux riches en nutriments. Réalisée de juin à août 2025, l'étude comprenait la formulation des biscuits, l'analyse proximale, l'évaluation de l'activité antioxydante, ainsi que les tests organoleptiques et d'acceptabilité. Cette étude de R&D, menée en laboratoire, n'incluait pas de mesures d'issues cliniques. Trois formulations ont été évaluées. Les tests sensoriels réalisés auprès de 30 panélistes formés ont montré des différences significatives pour tous les paramètres ($p < 0,05$), le goût obtenant le score le plus élevé. L'évaluation de l'acceptabilité auprès de 30 femmes enceintes a révélé que 76,7 % « aimaient » ou « aimaient beaucoup » le produit. Les résultats proximaux ont indiqué des teneurs en eau (8,18 %), cendres (4,96 %), protéines (9,65 %), lipides (14,90 %) et fibres brutes (10,20 %). Ces résultats suggèrent que les biscuits formulés à base de haricot mungo et de taro violet sont acceptables, prometteurs sur le plan nutritionnel et potentiellement utiles comme aliment fonctionnel complémentaire pour soutenir la nutrition maternelle et réduire le risque de CEC *(Afr J Reprod Health 2026; 30 [3]: 161-169).*

Mots-clés: Grossesse, Nutrition maternelle, Aliment fonctionnel, Carence énergétique chronique, Activité antioxydante

Introduction

Maternal undernutrition remains a persistent public health challenge in developing countries, contributing significantly to maternal and neonatal morbidity and mortality[1]. Global reports from the World Health Organization (WHO) and UNICEF indicate that maternal undernutrition—including Chronic Energy Deficiency (CED)—continues to affect millions of women worldwide, with several regions in Africa and Asia reporting prevalence rates exceeding 15%. Chronic Energy Deficiency (CED) among pregnant women reflects a long-term imbalance between energy intake and expenditure, leading to low body mass and poor nutritional reserves. In Indonesia, CED continues to hinder

national progress toward reducing maternal and infant mortality and preventing stunting. According to the 2018 Basic Health Research Survey (Riskesdas), the national prevalence of CED among pregnant women was 17.3%, with 14.91% reported in North Sumatra Province. Recent data from the 2023 Indonesian Health Survey (SKI), supported by UNICEF monitoring frameworks, further confirm that approximately 17% of pregnant women still experience chronic deficits in energy and protein intake. CED is commonly characterized by an upper-arm circumference of less than 23.5 cm, indicating low energy reserves.[2–4]

The implications of CED are extensive, affecting both maternal and fetal health. Pregnant women with CED face a higher risk of anemia, prolonged labor, gestational hypertension (preeclampsia), and other obstetric complications that may lead to maternal mortality[5,6]. For the fetus, CED is associated with intrauterine growth restriction, preterm birth, low birth weight, and impaired physical and cognitive development[7–9]. Collectively, these outcomes contribute to persistently high maternal mortality ratios (MMR) and infant mortality rates (IMR) in several regions of Indonesia.[10,11]

The causes of CED are multifactorial, involving limited access to nutritious foods, low socioeconomic status, and inadequate knowledge and awareness of maternal nutrition. Addressing CED therefore requires a comprehensive and preventive strategy based on evidence, affordability, and local resources. One promising approach is the development of functional food products made from locally available ingredients that are nutrient-dense, culturally acceptable, and sustainable as dietary interventions for pregnant women at risk of CED.[12,13]

In this context, mung bean (Vigna radiata) and purple taro (Colocasia esculenta) are two locally available food commodities with high nutritional and functional potential.[14,15] Mung beans are rich in plant-based proteins, iron, folate, and B-complex vitamins essential for hematopoiesis, fetal tissue growth, and energy metabolism during pregnancy. Purple taro, on the other hand, is high in complex carbohydrates and anthocyanins – potent antioxidants that help reduce oxidative stress, one of the contributing factors to pregnancy complications.[16,17] Combining these two ingredients offers complementary nutritional benefits that can be incorporated into a functional food product such as cookies, which are convenient, shelf-stable, and widely accepted across age groups, including pregnant women.[18–20]

Cookies were selected as the medium for intervention because they are practical, easy to store, and can be fortified with precise nutrient compositions. As a nutrient-rich snack, cookies can contribute additional energy and protein intake without disrupting regular meal patterns. Moreover, they can serve as an acceptable and scalable intervention for maternal nutrition improvement in community and health-service settings.[21]

Therefore, this study aimed to develop a functional food product—cookies made from mung bean and purple taro—as a locally based, evidence-informed supplementary food candidate for pregnant women at risk of Chronic Energy Deficiency.[16,22] The present work focused on product development and laboratory-based evaluation, including proximate composition, antioxidant activity, and sensory and acceptability profiles. The findings are expected to provide a scientific basis for future clinical and community-based trials to assess the effectiveness of this product in improving maternal nutritional status and pregnancy outcomes.[14,23]

Methods

Study design and setting

This study employed a Research and Development (R&D) design with a laboratory experimental approach. The research was conducted from June to August 2025 at the Sensory and Food Technology Laboratory, Institut Kesehatan Medistra Lubuk Pakam, North Sumatra, Indonesia.

The R&D procedure consisted of four main stages: (1) cookie formulation; (2) proximate analysis; (3) antioxidant activity assessment; and (4) organoleptic evaluation and acceptability testing. The sample sizes used in this study followed standard recommendations for preliminary product development trials, ensuring sufficient representativeness while maintaining feasibility for R&D-scale testing.

Stage 1: Cookie formulation

a. Preliminary assessment

The preliminary assessment was conducted through a literature review on Chronic Energy Deficiency (CED), functional foods, and the nutritional potential of mung bean (Vigna radiata) and purple taro (Colocasia esculenta). Coordination with the working areas of community health centers (Puskesmas) in Serdang Bedagai Regency, North Sumatra, Indonesia, was carried out to identify the nutritional needs and demographic characteristics of pregnant women with CED as potential beneficiaries of the intervention.

b. Preparation of ingredients

The ingredients used included mung bean flour, purple taro flour, wheat flour, tapioca flour, margarine, cocoa powder, sugar, eggs, and baking powder. All equipment (oven, mixer, sieve, weighing scale, baking trays) was cleaned and standardized prior to use.

c. Production of mung bean flour

Mung beans were selected and cleaned to remove impurities, then washed, dried, ground into flour, and sieved to obtain a uniform particle size suitable for cookie formulation.

d. Production of purple taro flour

Fresh purple taro tubers were peeled, sliced thinly (1–2 mm), and soaked at 80°C to reduce sap and maintain their natural color. The slices were oven-dried at 170°C for 50 minutes, then ground and sieved to obtain fine purple taro flour.

e. Cookie preparation process

All ingredients were weighed according to formulation standards. Margarine, powdered sugar, and eggs were mixed together, followed by the addition of wheat flour, mung bean flour, and purple taro flour. The dough was shaped and baked at 160–170°C for 20–35 minutes. The baked cookies were cooled, packaged, and prepared for laboratory testing, organoleptic evaluation, and acceptability assessment.

f. Cookie formulations

Three cookie formulations were developed by varying the proportions of mung bean flour and purple taro flour while keeping all other ingredients constant. The formulations were coded as F1, F2, and F3:
F1: highest proportion of mung bean flour
F2: balanced proportions of mung bean and purple taro flours
F3: highest proportion of purple taro flour
These formulation variations were used to compare sensory attributes assessed by trained panelists**.**

Stage 2: Proximate analysis

Proximate analysis was conducted based on the procedures of the Association of Official Analytical Chemists (AOAC), including measurements of moisture, ash, protein, fat, and crude fiber. Laboratory testing was carried out at the Industrial Standardization and Service Center (BSPJI) Medan, North Sumatra. Data were analyzed descriptively.

Stage 3: Antioxidant activity assessment

Antioxidant activity was measured using the DPPH (2,2-diphenyl-1-picrylhydrazyl) free-radical-scavenging assay. Cookie extracts at concentrations of 5, 10, 15, and 20 ppm were tested to determine free-radical inhibition. The IC_{50} value (the concentration required to achieve 50% inhibition) was calculated using linear regression ($y = 2.34x – 0.0576$; $R^2 = 0.9999$). Antioxidant activity was categorized as strong, moderate, or weak based on IC_{50} standards.

Stage 4: Organoleptic evaluation

A hedonic sensory test was conducted to evaluate color, aroma, flavor, texture, and overall acceptability. A total of 30 trained panelists rated each attribute using a five-point hedonic scale (1 = dislike very much; 5 = like very much). Samples were coded with three-digit random numbers to minimize bias, and panelists rinsed their palate between samples. A one-way Analysis of Variance (ANOVA) was used to determine significant differences among formulations. The sample size of

30 trained panelists follows standard sensory evaluation recommendations, which suggest 25–30 individuals for adequate statistical sensitivity. Inclusion criteria were: adults aged 18–55 years, non-smokers, no respiratory illness, no allergies to ingredients used, and prior experience with basic sensory evaluation. Panelists received brief training before participation.

Acceptability assessment

In addition to trained panelists, an acceptability test was conducted among 30 pregnant women in the study area to assess real-world consumer acceptance. Respondents evaluated color, flavor, texture, and overall preference using a structured questionnaire. Non-parametric statistical analysis was used to interpret the acceptability results.

The sample size of 30 pregnant women was based on minimum sample requirements for preliminary acceptability testing in functional food research. Inclusion criteria were: confirmed pregnancy, gestational age 12–36 weeks, ability to consume solid foods, absence of food allergies, and willingness to provide written informed consent. Exclusion criteria included hyperemesis gravidarum, medically restricted diets, or conditions requiring specialized nutrition.

Ethical considerations

Ethical approval for this study was obtained from the Institutional Ethics Committee of the Institut Kesehatan Medistra Lubuk Pakam, North Sumatera, Indonesia (Approval No.: 034.D/KEP-MLP/VI/2025). All procedures complied with institutional research standards and the ethical principles of the Declaration of Helsinki.

All panelists and pregnant women who participated in sensory and acceptability testing provided written informed consent prior to data collection. The study received funding from the Directorate General of Higher Education, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia through the Fundamental Research Grant 2025.

Results

Organoleptic evaluation was conducted on five sensory parameters—color, aroma, flavor, texture, and overall acceptability—using a five-point hedonic scale to compare preferences across the three cookie formulations (F1, F2, F3). ANOVA indicated that all parameters differed significantly ($p < 0.05$).

Flavor obtained the highest score (2.97), indicating that taste was the dominant factor influencing panelists' acceptance. These findings reflect the variation among formulations (F1, F2, F3), suggesting that differences in the proportions of mung bean and purple taro flours influenced sensory perceptions.The cookies demonstrated high acceptability among pregnant women, with 76.7% rating them as "liked" or "liked very much." Flavor received the highest score, indicating strong potential for the product as a functional food to support maternal nutrition.

Proximate analysis revealed that the cookies had a moisture content of 8.18%, classifying them as a dry, shelf-stable product suitable for storage. The ash content of 4.96% reflected adequate mineral levels derived from the raw ingredients. Protein content (9.65%) and fat content (14.90%) contributed substantially to total energy value, while the crude fiber level of 10.20% indicated that the cookies could serve as a good source of functional dietary fiber for maternal nutrition.Antioxidant testing using the DPPH method showed that inhibition increased with concentration: 11.84% (5 ppm), 23.13% (10 ppm), 34.86% (15 ppm), and 46.93% (20 ppm). The relationship between concentration and inhibition followed a linear trend ($y = 2.34x – 0.0576$; $R^2 = 0.9999$), indicating a very strong correlation. The IC_{50} value of 21.39 ppm classified the antioxidant activity as strong.

These findings confirm that the formulated cookies possess high antioxidant potential, in addition to their desirable nutritional and sensory characteristics, supporting their use as a functional food for pregnant women at risk of Chronic Energy Deficiency.

Table 1: Organoleptic evaluation of mung bean and purple taro cookies (n = 30)

Parameter	Mean ± SD	*p-Value*	Remarks
Color	2.53 ± 0.68b	0.000	Significant difference
Aroma	2.77 ± 0.57b	0.005	Significant difference
Flavor	2.97 ± 0.62b	0.000	Significant difference
Texture	2.77 ± 0.57b	0.000	Significant difference
Overall	2.90 ± 0.48b	0.000	Significant difference

Table 2: Acceptability Test Results Among Pregnant Women (n = 30)

Preference Category	Percentage (%)
Liked / Liked very much	76.7
Neutral	20.0
Dislike	3.3

Table 3: Proximate composition of mung bean and purple taro cookies

No	Parameter	Unit	Result
1.	Moisture	%	8.18
2.	Ash	%	4.96
3.	Protein	%	9.65
4.	Fat	%	14.9
5.	Crude Fiber	%	10.2

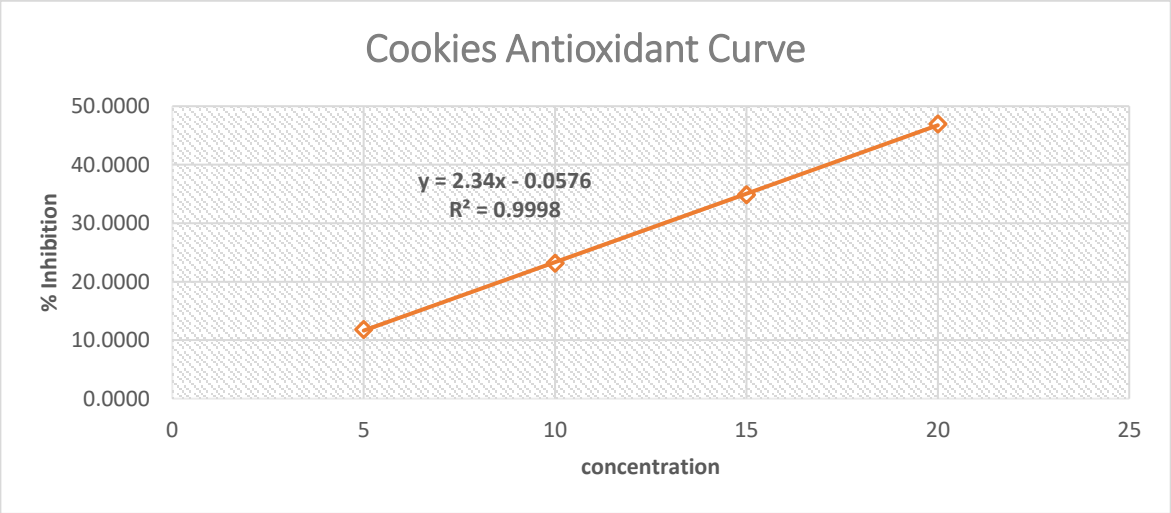

Figure 1: Antioxidant activity curve of mung bean and purple taro cookies using the DPPH assay

Discussion

This Research and Development (R&D) study successfully developed functional cookies using mung bean and purple taro as locally available nutrient-dense ingredients.[24,25] The integration of laboratory analysis, sensory evaluation, and acceptability testing allowed for a comprehensive assessment of the product's functional and organoleptic properties. The findings collectively demonstrate that the formulated cookies have strong potential as a supplementary food for pregnant women, particularly those at risk of Chronic Energy Deficiency (CED).[26,27]

The four-stage development process – cookie formulation, proximate analysis, antioxidant

evaluation, and sensory/acceptability assessment – ensured that the product was evaluated both scientifically and practically. The three formulations (F1, F2, F3), created by varying the proportions of mung bean and purple taro flour, provided a clear basis for comparing sensory outcomes. This method aligns with standard R&D protocols for the development of functional food products aimed at maternal nutrition support.[28,29]

The proximate results indicate that the cookies provide meaningful nutritional benefits. Protein (9.65%) and fat (14.90%) levels contribute significantly to the energy density required during pregnancy. The high crude fiber content (10.20%) enhances digestive health and may support glycemic control – important for preventing excessive weight gain or gestational diabetes. Meanwhile, the low moisture content (8.18%) ensures shelf stability and food safety, making the product practical for distribution in community health programs. Mung bean is well documented as a source of plant-based protein, folate, and essential minerals, while purple taro provides complex carbohydrates and anthocyanins. These components are relevant for addressing CED, which is characterized by prolonged insufficient energy and nutrient intake among pregnant women. From a nutritional perspective, pregnant women require increased intakes of energy, high-quality protein, essential fatty acids, and key micronutrients such as iron, folate, and B-complex vitamins to support fetal growth, maternal tissue expansion, and hematopoiesis. Within this context, the proximate profile of the mung bean–purple taro cookies indicates that the product can contribute additional energy through its fat and carbohydrate content, while the protein level (9.65%) and crude fiber (10.20%) provide complementary benefits for maintaining satiety, digestive health, and glycemic control. Although the present study did not directly measure changes in maternal nutritional status, these findings suggest that regular consumption of the cookies as a snack could help pregnant women move closer to meeting their daily energy and macronutrient requirements, particularly in settings where diet quality is suboptimal[30–32].

The strong antioxidant activity (IC_{50} = 21.39 ppm) observed in this study demonstrates the functional value of purple taro, which is rich in anthocyanins. Antioxidants play an essential role during pregnancy by reducing oxidative stress, which has been linked to complications such as preeclampsia, intrauterine growth restriction, and preterm birth. The linear relationship observed in the DPPH assay (R^2 = 0.9999) indicates a highly stable antioxidant response, further reinforcing the functional food profile of the cookies.

Organoleptic assessment showed significant differences across all parameters ($p < 0.05$). Flavor obtained the highest score, emphasizing its dominant role in acceptance. Differences among F1, F2, and F3 indicate that flour composition influences taste, aroma, color, and texture. Increased proportions of purple taro tend to enhance color due to natural pigmentation, while mung bean contributes to aroma and flavor stability. The overall sensory profile suggests that a balanced formulation (F2) may offer optimal acceptability. These findings validate the formulation approach described in the Methods section, demonstrating that systematic variation in ingredients results in measurable sensory differences, supporting evidence-based product optimization[33–35].

The acceptability test revealed that 76.7% of pregnant women “liked” or “liked very much” the cookies, while only 3.3% disliked them. This high acceptance level is crucial because palatability directly influences adherence to nutritional interventions. Products that are not well accepted – even if nutritionally beneficial – tend to have low compliance rates, reducing their effectiveness in improving maternal health outcomes.[31,32] The high scores for flavor and texture suggest that the cookies meet cultural taste preferences, an important factor in food-based interventions in community settings. This is consistent with literature showing that interventions based on locally familiar foods are more sustainable and more likely to be consumed consistently compared to synthetic supplements. Given that CED is prevalent in rural and low-resource areas, a locally produced, acceptable, and shelf-stable food product represents a promising strategy for maternal nutrition improvement.[14,35]

The findings support the feasibility of integrating mung bean – purple taro cookies into maternal nutrition programs at community health

centers (Puskesmas). The cookies' nutrient density, strong antioxidant capacity, high acceptability, and local ingredient composition make them suitable for antenatal supplementation initiatives, nutrition education sessions, food support for at-risk pregnant women, local food-based innovation programs. Scaling this product may contribute to reducing CED prevalence and improving overall maternal health indicators in Indonesia.

Overall, the integration of locally sourced ingredients, favorable sensory attributes, strong antioxidant activity, and high acceptability among pregnant women indicates that these cookies are a feasible candidate for inclusion in maternal nutrition programs. However, their role should currently be regarded as a supplementary food option rather than a proven therapeutic intervention. Further randomized controlled trials and longitudinal studies are needed to determine the extent to which regular consumption of these cookies can improve maternal nutritional status, reduce the incidence of CED, and positively influence pregnancy outcomes.

Limitations

The strength of this study lies in its comprehensive evaluation, including sensory acceptability, nutritional content, and antioxidant capacity. However, a limitation is that its assessment was laboratory-based and did not include direct clinical evaluation of maternal nutritional outcomes. Future research should include randomized controlled trials to determine the effectiveness of the cookies in improving maternal nutritional status, gestational weight gain, hemoglobin levels, and pregnancy outcomes.

Conclusion

The functional cookies formulated from mung bean and purple taro demonstrated good sensory acceptability, adequate nutritional content, and strong antioxidant activity. These findings indicate that the product has strong potential as a practical, locally sourced, and culturally acceptable supplementary food to support maternal nutrition and help reduce the risk of Chronic Energy Deficiency (CED) during pregnancy. At this stage, the evidence is limited to product development and laboratory-based evaluation; therefore, further clinical and community-based studies are recommended to evaluate the effectiveness of the cookies in improving maternal nutritional status and pregnancy outcomes. With sufficient clinical evidence in the future, this product may be integrated into maternal nutrition programs to support broader public health efforts.

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Conflict of interest

The authors declare that there is no conflict of interest.

Contribution of authors

Novita Br Ginting Munthe conceptualized the research, designed the study, supervised its implementation, interpreted the data, drafted the manuscript, and approved the final version. Raini Panjaitan developed the research methodology, collected the data, conducted laboratory analyses, and validated the findings. Iskandar Markus Sembiring performed the statistical analysis, processed the data, and critically revised the manuscript. Ika Nur Saputri coordinated the organoleptic assessment, curated the data, prepared tables and figures, and assisted in editing and refining the manuscript. Hesekiyel Ginting provided technical research support, documentation, and literature sourcing. All authors read and approved the final manuscript and accept responsibility for the integrity and accuracy of the work.

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