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PHYSICOCHEMICAL AND ANTIOXIDANT ACTIVITY, AND Β-CAROTENE CONTENT OF MORINGA *(MORINGA OLEIFERA)* LEAF-BASED PANNA COTTA FOR STUNTING PREVENTION

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ABSTRACT

Moringa leaves are known for their rich macro- and micronutrient content, as well as bioactive compounds with antioxidant properties. The panna cotta was formulated using moringa leaf extract, milk, whipping cream, and gelatin, followed by analyses of moisture content, antioxidant activity (IC_{50}), total phenolic compounds, and β-carotene levels. Results revealed that moisture content ranged from 64.62% to 70.18%, with the best formulation containing 50% moringa milk and 10% sugar. The IC_{50} value of 149.8 ppm indicated moderate antioxidant activity, total phenolic content was 2.15 mg GAE/g, and β-carotene reached 1.31 mg/g. These findings demonstrate that moringa panna cotta could serve as a nutrient-rich dessert product that contributes to child growth and immune health.
Keywords: antioxidant activity; β-carotene; functional food; moringa leaves; stunting

ABSTRAK

Daun kelor diketahui memiliki kandungan makro dan mikronutrien yang tinggi, serta senyawa bioaktif dengan aktivitas antioksidan. Panna cotta diformulasikan menggunakan ekstrak daun kelor, susu, krim kocok, dan gelatin, kemudian dilakukan analisis kadar air, aktivitas antioksidan (IC_{50}), total senyawa fenolik, serta kadar β-karoten. Hasil penelitian menunjukkan bahwa kadar air berkisar antara 64,62% hingga 70,18%, dengan formulasi terbaik mengandung 50% susu kelor dan 10% gula. Nilai IC_{50} sebesar 149,8 ppm menunjukkan aktivitas antioksidan kategori sedang, total fenolik sebesar 2,15 mg GAE/g, dan kadar β-karoten mencapai 1,31 mg/g. Temuan ini menunjukkan bahwa panna cotta berbasis daun kelor berpotensi sebagai produk pangan penutup bergizi yang dapat berkontribusi terhadap pertumbuhan dan kesehatan sistem imun anak.
Kata kunci: *aktivitas antioksidan; β-karoten; pangan fungsional; daun kelor; stunting*

INTRODUCTION

Stunting is one of the most persistent public health challenges in Indonesia, reflecting long-term nutritional deficiencies during early childhood. According to the 2022 Indonesia Nutrition Status Survey (SSGI), the prevalence of stunting in Surabaya decreased significantly from 28.9% to 4.8% (Ministry of Health 2022).

Although this progress is encouraging, sustained efforts are still needed to prevent stunting through nutritional education and the availability of affordable, nutrient-rich foods for toddlers.

One of the effective ways to support stunting prevention is by developing innovative food products that are both nutritious and appealing to children. Local ingredients with high nutrient content and strong bioactive potential offer great opportunities for such innovation. Among these, *Moringa oleifera* (commonly known as moringa) has gained significant attention for its exceptional nutritional and health benefits. The World Health Organization (WHO) recognizes moringa as a valuable food source to combat malnutrition, particularly for children and breastfeeding mothers (Jusnita 2019).

Moringa leaves are known to contain high levels of protein (28.66 g/100 g dry weight), calcium (929.29 mg), phosphorus (715.32 mg), and iron (9.99 mg), along with essential micronutrients and antioxidants (Sugihartini *et al.* 2019). Rich in essential nutrients, including proteins, vitamins, and minerals, Moringa oleifera leaves have significant potential to support child growth. This study assesses the effectiveness of Moringa oleifera leaf extract as an intervention to prevent stunting in toddlers aged 23–59 months (Budiono & Has, 2025). Beyond their nutritional composition, moringa leaves are rich in bioactive compounds such as flavonoids, phenolics, and unsaturated fatty acids, which contribute to antioxidant, anti-inflammatory, and immune-boosting properties (Vongsak *et al.* 2014). Another important compound found in moringa is β-carotene, a provitamin A carotenoid that plays a crucial role in maintaining healthy vision, immune function, and cell growth. Children with insufficient vitamin A may be at higher risk of stunting (Usman and Masrul. 2022). Incorporating β-carotene-rich foods into children's diets is therefore essential for preventing growth disorders and supporting overall health.

This study explores the development of panna cotta made with moringa leaf extract as a functional dessert product that combines local nutritional richness with modern food innovation. Traditionally, panna cotta is an Italian dessert made from milk, cream, sugar, and gelatin (Karo *et al.* 2021). By substituting part of the milk with moringa extract, this product aims to provide a nutritious, child-friendly food option that may help improve dietary diversity while remaining enjoyable for young children. The purpose of this research is to evaluate the antioxidant activity, total phenolic compounds, and β-carotene content of moringa-based panna cotta formulated with different concentrations of moringa extract and sugar. The findings are expected to contribute to the development of practical, nutritious food innovations that can support efforts to reduce stunting among Indonesian toddlers.

MATERIAL AND METHODS

Material

The main ingredients used were fresh Moringa oleifera leaves milk, whipping cream, sugar, and powdered gelatin. Fresh moringa leaves were sourced from local farmers in Surabaya, Indonesia. All chemicals and reagents used for analysis were of analytical grade, including DPPH (2,2-diphenyl-1-picrylhydrazyl), methanol, Folin–Ciocalteu reagent, sodium carbonate (Na_2CO_3), gallic acid standard, β-carotene standard, acetone, petroleum ether, and chloroform (purchased from Merck and Sigma-Aldrich.

Preparation of moringa leaf extract

Fresh moringa leaves were thoroughly washed, blanched at 60 °C for 5 minutes to inactivate enzymes and reduce bitterness, and immediately cooled in ice water to preserve nutrient quality and pigment stability (Vongsak *et al*. 2014; Haroen *et al*. 2022). The blanched leaves were blended with milk at a 1:1 ratio, and the mixture was filtered using a muslin cloth to obtain moringa leaf extract. Th utensils used are Basic laboratory tools included a blender, saucepan, spatula, pouring funnel, filter cloth, ice box, and plastic cups.

Formulation of moringa panna cotta

Gelatin powder was dissolved in water (1:5 w/v) and allowed to bloom. Moringa extract, milk, and whipping cream were mixed in ratios of 30:20:50, 40:10:50, and 50:0:50, with sugar added at 5 % and 10 % of total volume. The mixture was gently heated with continuous stirring to ensure homogeneity, then combined with the bloomed gelatin. The mixture was poured into molds and refrigerated at 4 °C until set (Handani *et al*. 2016; Ben *et al.* 2025).

Chemical and physical analyses

Moisture content was determined using the gravimetric method following AOAC (2019). Antioxidant activity was analyzed using

the DPPH radical scavenging method (Blois 1958), expressed as IC_{50} values. Total phenolic content (TPC) was measured using the Folin–Ciocalteu colorimetric method and expressed as mg gallic acid equivalent (GAE)/g sample. β-carotene concentration was determined spectrophotometrically after extraction using acetone and petroleum ether, following the modified method of Hadiatun *et al.* (2023) and Muteeb *et al*. (2023).

Statistical analysis

All analyses were performed in triplicate. Data were processed using SPSS version 25.0. Statistical significance was evaluated using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a confidence level of $p<0.05$.

RESULT AND DISCUSSION

Moisture content

The moisture content of moringa panna cotta ranged between 64.62% and 70.18%, with significant differences ($p<0.05$) observed across treatments (Table 1). Samples containing higher sugar concentrations exhibited lower moisture levels, which aligns with the hygroscopic behavior of sucrose that binds free water molecules and reduces water availability (Handani *et al,* 2016).

The presence of milk and cream also contributed to the moisture retention capacity, affecting the smooth and elastic texture of panna cotta. Similar trends were reported by Kaur *et al.* (2023), who found that increased sugar concentration enhances viscosity and water-holding capacity in dairy desserts. The formulation containing 50% moringa extract and 10% sugar yielded optimal texture and structural stability, balancing water content and sensory acceptability.

Table 1. Moisture content of Panna Cotta moringa milk aloifera

Moringa Milk Concentration (%)	Sugar Concentration (%)	
	5	10
30	$69{,}50^{e}\pm0{,}15$	$66.08^{b}\pm0{,}34$
40	$70{,}18^{f}\pm1{,}74$	$64{,}62^{a}\pm0{,}18$
50	$67{,}40^{d}\pm0{,}30$	$66.94^{c}\pm0{,}46$

Note: Values within the same letters (line) and * (column) are significantly no different (p > 0.05).

Antioxidant activity

Antioxidant activity, expressed as IC_{50} values, ranged from 149.8 to 1570.3 ppm, where lower values indicate stronger antioxidant potential showed in Table 2. The formulation with 50% moringa milk and 10% sugars demonstrated the highest antioxidant capacity (IC_{50} = 149.8 ppm), classified as moderate according to the DPPH standard scale (Sari *et al*. 2024).

These results confirm the presence of bioactive compounds in moringa, particularly phenolics and carotenoids, that function as electron donors to neutralize free radicals (Muteeb *et al.* 2023; BMC Plant Biology 2025). Heating during preparation may cause slight degradation of heat-sensitive antioxidants, yet the blanching and dairy-fat environment help stabilize active compounds (Vongsak *et al.* 2014; Ribeiro *et al.* 2024; Li *et al.* 2023). Thus, moringa panna cotta demonstrates promising antioxidant potential, suggesting it could serve as a palatable functional food for children requiring additional antioxidant support.

β-carotene content

The β-carotene content of moringa panna cotta ranged between 0.74 and 1.31 mg/g, with the highest concentration observed in the 50% moringa milk and 10% sugar formulation (Table 2). These levels exceed previously reported β-carotene content in raw moringa leaves (Hadiatun *et al.* 2023), likely due to increased solubility and protection of carotenoids within the fat matrix of the dessert (Muteeb *et al.* 2023; Arshad *et al.* 2025).

β-Carotene serves as a provitamin A that supports visual and immune function, which is critical for preventing stunting and promoting child growth (WHO 2021). The retention of β-carotene during heating may be attributed to the stabilizing effects of milk lipids and gelatin, which act as protective carriers against oxidation and light exposure (Ben *et al*. 2025). This finding reinforces the potential of moringa panna cotta as a nutrient-dense, antioxidant-rich product suitable for dietary intervention in early childhood nutrition.

Total phenolic compound

The total phenolic content of the panna cotta samples ranged between 0.027 and 2.15 mg GAE/g. The highest phenolic content was recorded in the formulation containing 50% moringa milk and 10% sugar, corresponding to the lowest IC_{50} value (strongest antioxidant activity). This positive correlation confirms that phenolic compounds play a major role in antioxidant potential (Sari *et al.* 2024; Sadiah *et al*, 2022; Dobrina *et al.* 2022). The stage leaves variations also affect the result of phenolic compound, Qadir *et al* (2022) state that young leaves has the highest content of phenolic compound.

The increase in TPC with higher moringa concentration reflects the abundance of phenolic acids, flavonoids, and saponins in Moringa oleifera leaves (Ben *et al*. 2025). However, phenolic degradation during heat treatment can occur due to oxidation and polymerization reactions (Silva *et al.* 2022). The use of mild heating in this study (below 80 °C) helped maintain the integrity of these compounds, consistent with the findings of Yuliani *et al.* (2023), who emphasized that short-duration heating preserves up to 80% of phenolic compounds in functional desserts.

Table 2. Phytochemical analysis of Panna Cotta moringa milk aloifera

Samples	Antioxidant activity	β-Carotene content	Phenolic compound
A1B1	$698.9^{b} \pm 0.15$	$0.78^{a} \pm 0$	$0.027^{a} \pm 0,005$
A1B2	$1029,3^{c} \pm 0,34$	$0.82^{a} \pm 0,005$	$0.093^{a} \pm 0,005$
A2B1	$1570,3^{e} \pm 1,74$	$0.75^{c} \pm 0$	$0.84^{c} \pm 0,12$
A2B2	$820,7^{bc} \pm 0,18$	$0.78^{d} \pm 0,005$	$1.456^{d} \pm 0,14$
A3B1	$228,6^{a} \pm 0,3$	$0.74^{b} \pm 0,005$	$0.25^{b} \pm 0,03$
A3B2	$149,8^{a} \pm 0,46$	$1.31^{e} \pm 0,005$	$2.15^{e} \pm 0,026$

Note: Values within the same letters (line) and * (column) are significantly no different ($p > 0.05$). A1B1= 30 *(Moringa milk aloifera)* :5 (sugar) ; A1B2=30:10; A2B1=40:5; A2B2=40:10; A3B1=50:5; A3B2=50:10

CONCLUSION

Conclusion

This study demonstrated that the incorporation of Moringa oleifera leaf extract into panna cotta significantly enhanced its nutritional and functional properties. The formulation containing 50% moringa extract and 10% sugar produced the most desirable characteristics, showing moderate antioxidant activity (IC_{50} = 149.8 ppm), the highest total phenolic content (2.15 mg GAE/g), and the greatest β-carotene concentration (1.31 mg/g). These bioactive components contribute synergistically to the product's antioxidant potential and nutritional value. The findings confirm that moringa leaves, when processed through appropriate blanching and integrated into a dairy-based matrix, can retain considerable levels of antioxidants and provitamin A compounds. The lipid content in milk and cream may enhance the stability and bioavailability of β-carotene, while the mild heating and gelatin formulation help preserve phenolic compounds. Collectively, these properties position moringa panna cotta as a promising functional dessert that not only offers sensory appeal but also supports nutritional improvement, particularly for children at risk of stunting. In a broader context, this research emphasizes the importance of utilizing locally available, nutrient-rich ingredients to develop innovative foods with public health benefits. Future studies are encouraged to explore the sensory acceptance, shelf-life stability, and bioavailability of key nutrients in moringa-based formulations, as well as their potential integration into community nutrition programs aimed at combating childhood stunting in Indonesia.

Suggestion

Further studies are recommended to evaluate the sensory acceptance, shelf-life stability, and bioavailability of nutrients in moringa panna cotta. Its potential application as a nutrient-dense food in community-based programs for children at risk of stunting should also be explored.

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