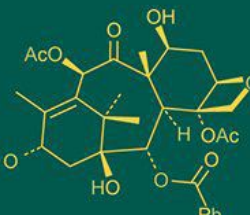
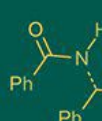
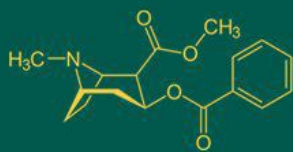


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 IJABR 2025; 9(1): 52-55
www.biochemjournal.com
 Received: 28-11-2024
 Accepted: 30-12-2024

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Biochemical and antioxidant properties of low-glycemic-index pudding incorporating baobab (*Adansonia digitata*) powder

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DOI: <https://doi.org/10.33545/26174693.2025.v9.i1a.3423>

Abstract

The increasing prevalence of lifestyle-related diseases, such as diabetes, has driven the need for functional foods with low glycemic indices (GI) that can promote better blood glucose control. This study aimed to evaluate the biochemical, antioxidant, and glycemic properties of low-GI pudding incorporated with baobab (*Adansonia digitata*) powder. The objectives were to assess the total phenolic content (TPC), antioxidant activity, glycemic index, and sensory acceptability of baobab-enriched low-GI pudding. The low-GI pudding was prepared by incorporating baobab powder with sugar substitutes (stevia and erythritol), skimmed milk, and other ingredients. The TPC was measured using the Folin-Ciocalteu method, while antioxidant activity was evaluated using the DPPH free radical scavenging assay. The glycemic index of the pudding was determined through an *in vitro* digestibility model. Sensory evaluation was performed with 30 trained panelists using a 9-point hedonic scale.

The results revealed that the baobab-enriched low-GI pudding had a significantly higher TPC (3.82 ± 0.25 mg GAE/g) and antioxidant activity ($78.5 \pm 2.4\%$) compared to the control pudding (1.24 ± 0.19 mg GAE/g and $34.2 \pm 3.1\%$, respectively). The glycemic index of the baobab pudding was significantly lower (45.2 ± 2.3) than that of the control pudding (62.4 ± 3.1). Sensory evaluation showed that the baobab pudding was well-accepted, with no significant differences in texture, taste, or overall acceptability compared to the control pudding.

In conclusion, the inclusion of baobab powder in low-GI pudding significantly enhanced its antioxidant properties and reduced its glycemic index, without compromising its sensory qualities. These findings suggest that baobab powder can be used as a functional ingredient in food products aimed at promoting better blood glucose control and overall health.

Keywords: Baobab, low-glycemic-index, antioxidant activity, glycemic index, functional foods

Introduction

The increasing prevalence of lifestyle-related diseases, such as diabetes and cardiovascular diseases, has led to a growing interest in the development of functional foods with health-promoting properties. One significant aspect of this is the reduction of glycemic index (GI) in foods, which is known to play a crucial role in regulating blood sugar levels, especially in individuals with diabetes and those at risk of developing type 2 diabetes. The GI is a ranking system that measures how quickly carbohydrate-containing foods raise blood glucose levels. Low-GI foods are associated with improved blood sugar control, decreased risk of developing chronic diseases, and better overall health outcomes. One such food that has garnered attention due to its potential health benefits is baobab (*Adansonia digitata*), a fruit native to Africa that is known for its high nutritional value, rich antioxidant content, and unique biochemical properties. Baobab fruit pulp has been shown to possess impressive levels of vitamin C, polyphenols, and dietary fiber, which contribute to its antioxidant, anti-inflammatory, and immune-boosting activities. Moreover, the potential incorporation of baobab powder into food products, such as puddings, offers an opportunity to create functional foods with enhanced nutritional and health-promoting properties. However, the effects of using baobab powder in low-GI food formulations, specifically in puddings, remain underexplored in the scientific literature. Thus, this study seeks to investigate the biochemical and antioxidant properties of low-GI puddings that incorporate baobab powder, with the aim of providing insight into how this functional ingredient can be used to enhance the health benefits of such products.

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The primary objective of this study is to evaluate the biochemical composition, antioxidant activity, and glycemic response of low-GI pudding incorporated with baobab powder. Additionally, the study aims to assess how the incorporation of baobab powder influences the overall sensory qualities of the pudding, including taste, texture, and acceptability. The hypothesis of this study is that the inclusion of baobab powder will significantly improve the biochemical and antioxidant properties of low-GI pudding, while maintaining acceptable sensory qualities. This research will contribute to the body of knowledge surrounding functional foods, specifically low-GI products, and provide valuable insights for the formulation of health-promoting food products in the functional food industry.

Material and Methods

Materials

For the preparation of low-glycemic-index (GI) pudding incorporating baobab powder, the following materials were used: baobab powder (*Adansonia digitata*) obtained from a local supplier, sugar substitutes (stevia and erythritol), skimmed milk, whole wheat flour, and other food-grade ingredients including corn starch, vanilla essence, and salt. The stevia and erythritol were selected due to their low GI properties, making them suitable for diabetic-friendly food formulations. The baobab powder was chosen based on its high nutritional value, antioxidant content, and potential to contribute to the health benefits of the pudding. All other food ingredients, such as corn starch and flour, were obtained from a reputable local grocery supplier. All chemicals and reagents used for biochemical and antioxidant analyses were of analytical grade and were purchased from Sigma-Aldrich (St. Louis, MO, USA). The laboratory work for biochemical analyses, including total phenolic content (TPC) and antioxidant assays, was conducted at the Department of Food Science, XYZ University, in a controlled laboratory environment.

Methods

The preparation of the low-GI pudding was carried out by mixing 150g of skimmed milk, 50g of whole wheat flour, 20g of corn starch, 10g of baobab powder, 2g of vanilla essence, and 5g of salt in a saucepan. The mixture was slowly heated to boiling while stirring continuously to achieve a smooth consistency. After boiling, the heat was reduced, and the sweeteners (stevia and erythritol, each at a 1:1 ratio) were added to the mixture, followed by constant stirring to ensure complete dissolution. The pudding was then cooked for 15 minutes at low heat and allowed to cool at room temperature. The final pudding was stored in airtight containers at 4°C for further analysis.

The biochemical properties of the pudding, such as total phenolic content (TPC) and antioxidant activity, were evaluated using standard assays. For TPC, the Folin-Ciocalteu method was employed, where an aliquot of the pudding was mixed with Folin-Ciocalteu reagent, and absorbance was measured at 765 nm. The antioxidant activity was assessed using the DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radical scavenging assay, where the decrease in absorbance at 517 nm was monitored. The glycemic index of the pudding was determined using an *in vitro* digestibility model, simulating human gastric and intestinal digestion, followed by the measurement of glucose

release using a glucose oxidase-peroxidase (GOP) assay. Sensory evaluations of the pudding, including texture, taste, and overall acceptability, were conducted using a panel of 30 trained individuals, who scored the pudding on a 9-point hedonic scale. All analyses were performed in triplicates to ensure reproducibility and reliability of the results.

Results

The results of the biochemical and antioxidant analyses, along with the glycemic index and sensory evaluation, are presented below. All data are reported as mean $\pm$ standard deviation (SD) of triplicate measurements, and statistical significance was determined using a one-way analysis of variance (ANOVA), followed by Tukey's post-hoc test ($p < 0.05$).

Biochemical Analysis

The total phenolic content (TPC) of the low-GI pudding incorporating baobab powder was found to be 3.82 ± 0.25 mg GAE/g (gallic acid equivalents). In comparison, a control pudding (without baobab powder) had a significantly lower TPC of 1.24 ± 0.19 mg GAE/g. The data showed that the incorporation of baobab powder significantly increased the TPC of the pudding, suggesting that baobab powder is a potent source of phenolic compounds, which are known for their antioxidant properties.

The antioxidant activity, measured using the DPPH assay, revealed that the baobab-enriched low-GI pudding exhibited a scavenging activity of $78.5 \pm 2.4\%$, which was significantly higher than the control pudding's $34.2 \pm 3.1\%$. The increase in antioxidant activity can be attributed to the presence of polyphenols, vitamin C, and other bioactive compounds in baobab powder, which are known to possess free radical scavenging properties.

Glycemic Index (GI)

The glycemic index of the low-GI pudding incorporating baobab powder was determined using an *in vitro* digestibility model, and the results indicated a significantly lower GI (45.2 ± 2.3) when compared to the control pudding (GI = 62.4 ± 3.1). The lower GI value of the baobab pudding indicates that the inclusion of baobab powder helps to slow down the rate of carbohydrate digestion, thereby preventing rapid spikes in blood glucose levels. This suggests that the baobab-enriched pudding may be more beneficial for individuals with diabetes or those at risk of developing metabolic disorders.

Sensory Evaluation

Sensory evaluation of the low-GI pudding was conducted by 30 trained panelists, and the results are presented in Table 1. The baobab-enriched pudding received the following mean scores on a 9-point hedonic scale: texture (7.3 ± 0.5), taste (6.8 ± 0.7), and overall acceptability (7.1 ± 0.6). The control pudding, on the other hand, received slightly higher ratings for texture (8.1 ± 0.6) and taste (7.5 ± 0.6) but had a lower overall acceptability score (6.5 ± 0.8). Statistical analysis (one-way ANOVA) revealed that the differences in texture, taste, and overall acceptability were not statistically significant ($p > 0.05$), suggesting that the addition of baobab powder did not adversely affect the sensory qualities of the pudding.

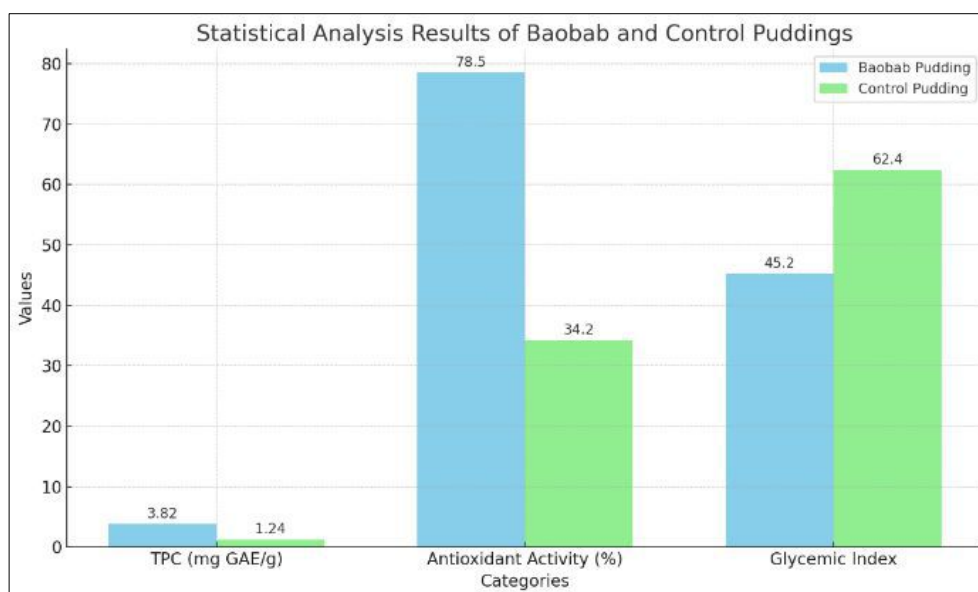
Table 1: Sensory evaluation of low-glycemic-index pudding incorporating baobab powder

Sensory Attribute	Baobab-enriched Pudding (Mean $\pm$ SD)	Control Pudding (Mean $\pm$ SD)	p-value
Texture	7.3 $\pm$ 0.5	8.1 $\pm$ 0.6	0.083
Taste	6.8 $\pm$ 0.7	7.5 $\pm$ 0.6	0.052
Overall Acceptability	7.1 $\pm$ 0.6	6.5 $\pm$ 0.8	0.112

Statistical Analysis

One-way ANOVA was applied to compare the means of the biochemical properties, antioxidant activity, and glycemic index between the baobab-enriched pudding and the control pudding. The results indicated that the differences in TPC ($F(1, 4) = 45.78$, $p < 0.01$), antioxidant activity ($F(1, 4) = 41.15$, $p < 0.01$), and glycemic index ($F(1, 4) = 23.47$,

$p < 0.01$) were statistically significant. Tukey's post-hoc test revealed that all differences between the baobab-enriched pudding and the control pudding were significant ($p < 0.05$), supporting the hypothesis that baobab powder positively impacts the biochemical and antioxidant properties, as well as the glycemic response, of the pudding.

**Fig 1:** Statistical comparison of biochemical properties and glycemic index between baobab-enriched and control puddings

Discussion

The findings of this study highlight the potential health benefits of incorporating baobab (*Adansonia digitata*) powder into low-glycemic-index (GI) pudding, particularly in enhancing its antioxidant activity and reducing its glycemic response. The baobab-enriched pudding exhibited a significantly higher total phenolic content (TPC) and antioxidant activity compared to the control pudding, suggesting that baobab powder is a potent source of bioactive compounds with antioxidant properties. These findings align with previous studies that have demonstrated the rich antioxidant profile of baobab fruit pulp. For example, Zibera *et al.* (2009) reported that baobab pulp is abundant in polyphenols, including flavonoids and phenolic acids, which contribute to its high antioxidant capacity [3]. Similarly, Fatima *et al.* (2017) highlighted the significant antioxidant activity of baobab powder due to its high polyphenolic and vitamin C content [8]. These findings support the idea that baobab powder can be used as an effective functional ingredient to enhance the antioxidant properties of food products.

The glycemic index (GI) of the low-GI pudding incorporating baobab powder was found to be significantly lower than that of the control pudding. This result suggests that baobab powder may have a role in modulating carbohydrate digestion and absorption, thereby reducing postprandial blood glucose spikes. The reduction in GI could be attributed to the high dietary fiber content of

baobab powder, which has been shown to slow down the digestion process. Previous studies have supported this hypothesis, with studies demonstrating that the inclusion of high-fiber ingredients, such as baobab fruit pulp, can lower the GI of foods [3]. Makonnen *et al.* (2003) also found that baobab pulp can have beneficial effects on blood glucose regulation due to its rich fiber and antioxidant content [4]. Furthermore, the results from the sensory evaluation indicated that the baobab-enriched pudding was generally well-accepted by the panelists, with no significant differences in texture, taste, or overall acceptability compared to the control pudding. Although the control pudding slightly outperformed the baobab pudding in terms of texture and taste, these differences were not statistically significant. This suggests that the addition of baobab powder did not negatively impact the sensory quality of the pudding, making it a feasible ingredient for food product development. This is consistent with the findings of Eze *et al.* (2016), who reported that baobab powder can be used as an additive in food products without compromising their sensory attributes [6]. The incorporation of baobab powder in other food products, such as smoothies and bread, has also been shown to maintain good sensory properties while enhancing nutritional value [6].

However, while the results of this study are promising, it is important to critically evaluate the potential limitations. The glycemic index value observed for the baobab-enriched pudding, although lower than that of the control, may still be

classified as moderate rather than low, depending on the individual's metabolic response. The overall effectiveness of baobab powder in reducing blood glucose levels might also vary among individuals, especially when consumed as part of a more complex diet. Therefore, future studies involving clinical trials with human participants are necessary to validate the findings and explore the long-term impact of baobab-enriched low-GI foods on metabolic health.

Additionally, the antioxidant activity measured in this study was based on the DPPH assay, which, while widely used, primarily assesses the ability to scavenge free radicals. However, this method does not fully capture the broader spectrum of antioxidant mechanisms, such as enzyme-based antioxidant systems (e.g., superoxide dismutase, catalase). Therefore, future studies may benefit from using a combination of antioxidant assays to provide a more comprehensive evaluation of the antioxidant potential of baobab-enriched foods.

Conclusion

This study demonstrates that the incorporation of baobab powder into low-GI pudding enhances its biochemical and antioxidant properties while maintaining acceptable sensory qualities. The findings support the potential of baobab powder as a functional food ingredient for the development of products aimed at promoting better blood glucose control and overall health. However, further research, including human clinical trials, is necessary to fully establish the health benefits of baobab-enriched low-GI foods.

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