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Glycemic Index Diversity Among Seven Banggai Yams: Evidence from the Incremental Area Under the Curve Method

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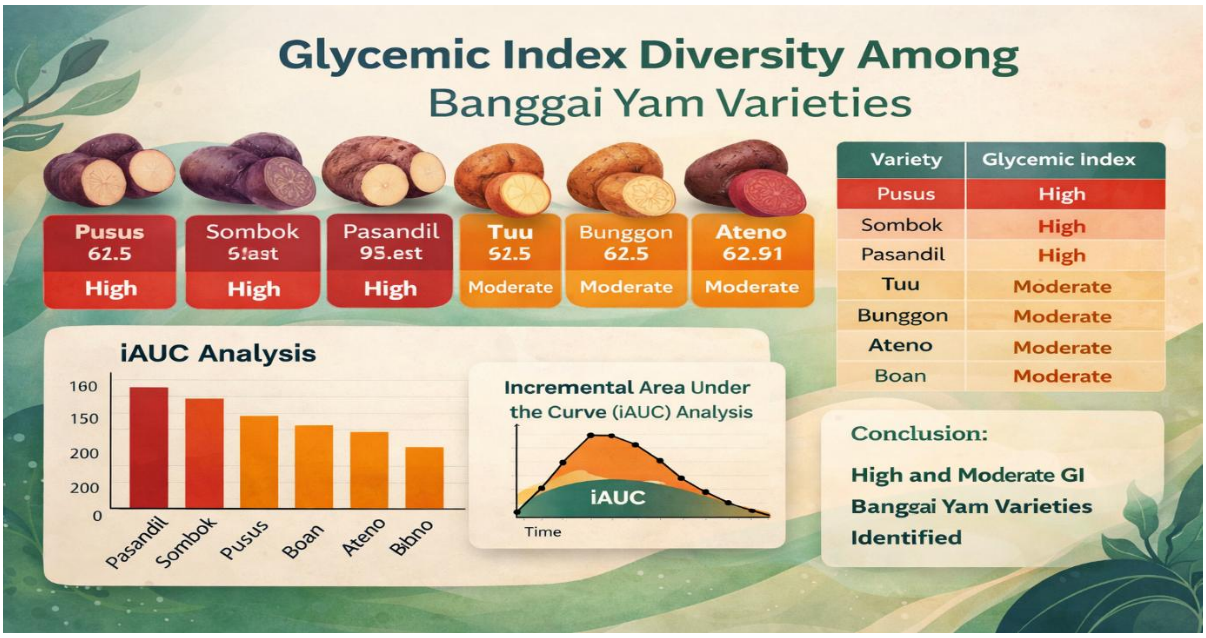
ABSTRACT

Banggai yam (Dioscorea sp.) is an indigenous carbohydrate source in Central Sulawesi with potential value for functional-food development. However, comparative glycemic index (GI) data for local Banggai yam varieties remain limited. This study aimed to determine the GI of seven Banggai yam varieties using the incremental area under the curve (iAUC) approach based on ISO 26642:2010 principles. The study used a parallel-group design with paired reference-food testing. Seventy healthy adults were allocated to seven groups (n=10 per variety). Each participant completed two test sessions after an overnight fast: a glucose reference food equivalent to 50 g anhydrous glucose and one assigned steamed yam portion containing 50 g available carbohydrate. Capillary blood glucose was measured at 0, 15, 30, 60, and 120 minutes. The calculated GI values showed clear variation across varieties. Bunggon (61.5), Ateno (63.91), Boan (67.7), and Tuu (67.8) were classified as moderate-GI varieties, whereas Pusus (87.3), Sombok (94.4), and Pasandil (95.44) were classified as high-GI varieties. The consolidated glucose-response curves also indicated more attenuated postprandial responses for Ateno and Tuu than for the high-GI varieties. These findings indicate that Banggai yam exhibits substantial inter-varietal diversity in glycemic response. Moderate-GI varieties, particularly Bunggon and Ateno, are promising raw materials for Banggai yam–based food products intended to provide a lower glycemic impact than the high-GI varieties.

Key Messages:

- Glycemic index; iAUC; Banggai yam; local varieties; functional food
- This study is the first to assess the glycemic index of seven *Dioscorea* (Banggai yam) varieties from Sulawesi, identifying Bunggon and Ateno as promising low-glycemic functional foods. The findings support the use of Banggai yams as alternative carbohydrate sources for natural diabetes prevention and improved metabolic health in island communities.

GRAPHICAL ABSTRACT



INTRODUCTION

The glycemic index (GI) is widely used to describe the postprandial blood glucose effect of carbohydrate-containing foods. By ranking foods according to the speed and magnitude of glucose release after ingestion, GI provides a practical indicator of carbohydrate quality for public health nutrition and clinical dietetics [1-3]. This concept is increasingly relevant in Indonesia, where diabetes and related metabolic disorders continue to contribute substantially to the national disease burden, and where current clinical guidance highlights the importance of dietary carbohydrate quality in prevention and long-term management [4,5].

Within this context, tuber-based foods remain important because they are still consumed in many rural and island communities as staple or supplementary carbohydrate sources. In Banggai Kepulauan Regency, Banggai yam is recognized as a local tuber commodity and continues to appear in official regional statistics, including market-price reporting for tuber crops, which indicates that it remains part of the local food system [6,7]. Other studies from the region have also documented considerable diversity among Banggai yam accessions and growing environments, including differences in phenotypic characters, soil conditions, land suitability, and farming potential across production areas in the archipelago [8-12].

Its nutritional and technological relevance is further supported by studies describing the starch and flour characteristics of Banggai yam. Previous work has reported distinctive physicochemical properties, including differences in starch composition, functional behavior, and modification response that may influence digestibility and performance in processed foods [13,14,27]. Related studies have shown that Banggai yam flour can be used in analog rice and starch-based noodle products, and that soaking or other processing treatments may alter chemical composition, solubility, swelling power, and sensory quality [15-19].

These findings have encouraged wider food-product development using Banggai yam as a local raw material. Studies on biscuits, cookies, and analog rice suggest that Banggai yam has practical potential for value-added and health-oriented food innovation [20-23]. Its nutritional relevance is also supported by reports on vitamin C and zinc content, while more recent work has shown that Banggai yam analog rice lowered blood sugar levels in prediabetic participants and that Banggai yam flour extract did not produce acute oral toxicity in mice under the tested conditions [24-26].

Even so, glycemic response cannot be inferred solely from food identity or local reputation because it is influenced by starch characteristics, cultivar differences, and processing conditions. Available evidence on tuber foods shows that glycemic responses may vary widely, and studies on yam from different settings

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have confirmed that cultivar and preparation method can substantially influence GI values [28-30]. Direct comparative GI data for Banggai yam varieties, however, remain limited. Therefore, the present study evaluated the GI of seven Banggai yam varieties using the incremental area under the curve approach and compared their postprandial blood glucose responses over 120 minutes.

METHODS

Study design

This analytical experimental study used a parallel-group design with paired reference-food testing. A total of 70 healthy adults were assigned to one of seven yam-specific groups (n=10 per variety: Pusus, Sombok, Tuu, Bunggon, Boan, Pasandil, and Ateno). Within each group, participants completed two separate test sessions: one reference-food session and one test-food session for the assigned yam variety. This design was selected to ensure that each yam variety was tested on at least 10 individuals, consistent with minimum subject recommendations for GI testing.

Participants

The participants were healthy adults aged 20–35 years recruited from the Banggai Islands. Inclusion criteria were body mass index 18.5–24.9 kg/m^2, no history of diabetes mellitus or other metabolic disorders, no current use of medication affecting glucose metabolism, and willingness to provide written informed consent. Exclusion criteria included pregnancy, breastfeeding, smoking, and participation in another clinical trial within the previous three months.

Test foods and reference food

Seven Banggai yam varieties—Pusus, Sombok, Tuu, Bunggon, Boan, Pasandil, and Ateno—were obtained from local farmers in the Banggai Islands, Central Sulawesi, Indonesia. The yam tubers were steamed without additives until fully cooked, then served in portions equivalent to 50 g of available carbohydrate. The reference food was a glucose solution containing 50 g of anhydrous glucose dissolved in 250 mL of water. In this manuscript, the term reference food is used consistently in accordance with GI-testing terminology.

Test procedure

All tests were conducted in the morning after an overnight fast of approximately 10–12 hours. The reference-food and test-food sessions were separated by a washout interval of at least two days. At each session, fasting capillary blood glucose was measured at baseline (0 minutes), after which the participant consumed the assigned food within 10–15 minutes. Capillary blood glucose was subsequently measured at 15, 30, 60, and 120 minutes using a calibrated glucometer.

Glycemic index calculation

The incremental area under the blood glucose response curve (iAUC) from 0 to 120 minutes was calculated using the trapezoidal rule, excluding areas below baseline. The glycemic index of each Banggai yam variety was calculated relative to the glucose reference food using the standard equation GI = (iAUC test food / iAUC reference food) × 100. GI values were interpreted using conventional categories: low (<55), moderate [56-69], and high (≥70).

CODE OF HEALTH ETHICS

The study was conducted in accordance with the Declaration of Helsinki and the Code of Health Ethics. Ethical approval was granted by the Health Research Ethics Committee of Universitas Muhammadiyah Purwokerto under registration number KEPK/UMP/206/VII/2025.

RESULTS

The blood glucose response measured at 0, 15, 30, 60, and 120 minutes showed different patterns between the Banggai yam varieties and their corresponding standard foods. In general, the standard foods

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tended to produce higher glucose values than the yam samples at most observation points, particularly at 30 and 60 minutes. Among the tested varieties, Pasandil and Sombok showed relatively high glucose responses across the measurement period, while Bunggon and Ateno tended to show lower responses, especially at 120 minutes. Bunggon exhibited a marked increase at 30 minutes followed by a decline at 60 and 120 minutes, whereas Ateno showed a progressive decrease after 15 minutes. Tuu and Boan showed moderate fluctuations, while Pusus generally remained lower than its standard comparator after 30 minutes. Overall, these findings indicate that the glycemic responses of Banggai yam varieties varied over time, with several varieties showing lower postprandial blood glucose responses than the corresponding standard foods.

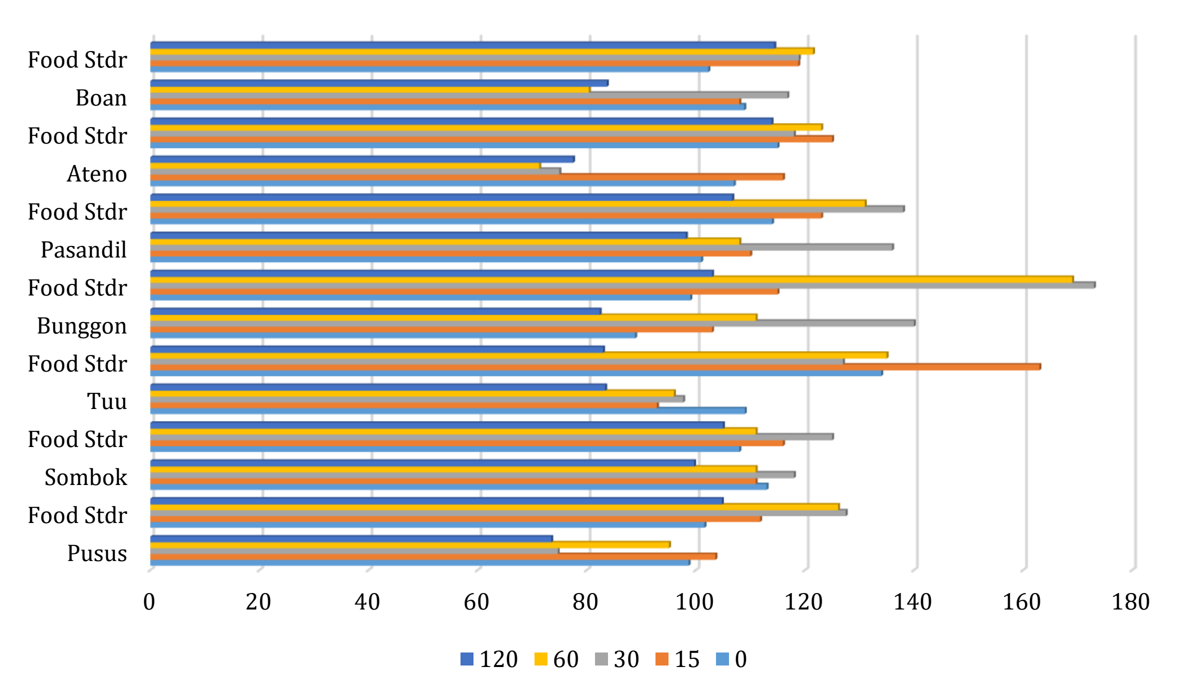

Figure 1. Comparison Of Blood Glucose Levels In Volunteers After Consumption Of Several Banggai Yam Varieties And A Standard Food At Five Observation Time Points

Table 1 presents the mean blood glucose concentrations used for descriptive comparison across time points. Table 2 summarizes the final GI values and their classification categories. Based on the calculated GI values, four varieties were classified as moderate GI (Bunggon, Ateno, Boan, and Tuu), whereas three varieties were classified as high GI (Pusus, Sombok, and Pasandil). No Banggai yam variety fell into the low-GI category.

Table 1. Mean blood glucose concentrations (mg/dL) at five observation time points

Variety	0 min	15 min	30 min	60 min	120 min
Reference food (pooled mean)	110.6	124.7	132.5	130.9	104.4
Pusus	98.7	103.6	74.7	95.1	73.5
Sombok	113.0	111.0	118.0	111.0	99.7
Tuu	109.0	92.9	97.7	96.0	83.4
Bunggon	88.9	103.0	140.0	111.0	82.4
Pasandil	101.0	110.0	136.0	108.0	98.2
Ateno	107.0	116.0	75.0	71.3	77.5
Boan	108.9	108.0	116.8	80.4	83.7

Note: The pooled reference-food curve was derived from the mean of the seven group-specific reference-food measurements available in the working dataset.

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Table 2. Classification of the glycemic index of several Banggai yam varieties

Variety	Glycemic Index	Classification
Pusus	87.3	High
Sombok	94.4	High
Pasandil	95.44	High
Tuu	67.8	Moderate
Bunggon	61.5	Moderate
Ateno	63.91	Moderate
Boan	67.7	Moderate

Note: Glycemic index classification was defined as low (<55), moderate [56-69], and high (≥70).

DISCUSSION

This study demonstrated that the seven Banggai yam varieties did not produce a uniform glycemic response. The calculated glycemic index values ranged from moderate to high, indicating substantial inter-varietal diversity in postprandial glucose behavior. Bunggon, Ateno, Boan, and Tuu were classified as moderate-GI varieties, whereas Pusus, Sombok, and Pasandil were classified as high-GI varieties. These findings suggest that Banggai yam should not be treated as a single nutritional category because each variety appears to have a distinct metabolic profile when consumed as a carbohydrate source. This interpretation is consistent with earlier reports showing that Banggai yam itself is biologically diverse at the phenotypic and physicochemical levels [8,13,27].

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The temporal blood glucose patterns also supported this distinction. The glucose-response curves showed that some varieties produced a sharper rise and a more sustained elevation, whereas others showed a more attenuated response over the 120-minute observation period. Pasandil and Sombok tended to maintain relatively higher glucose values across time points, while Ateno and Tuu showed lower responses at later measurements. Bunggon displayed a marked increase at 30 minutes followed by a decline toward 120 minutes, indicating that the overall glycemic response is better understood from the full postprandial curve than from a single time-point value alone. This interpretation is in line with the original GI concept and with later methodological refinements that emphasize the use of the complete postprandial response profile [1-3,28-30].

The present findings are also consistent with previous studies showing that yam glycemic responses may vary considerably across cultivars and processing conditions. Earlier work on Banggai yam has demonstrated that its starch and flour properties are not uniform, while studies from other yam-producing settings indicate that boiling, roasting, frying, and cultivar differences can alter glycemic outcomes [13-19,29,30]. In this context, the variation observed among Banggai yam varieties is biologically plausible and supports the view that local tubers should be evaluated on a variety-specific basis before broader nutritional claims are made.

One plausible explanation for the observed differences lies in variation in starch composition and digestibility. Earlier work on Banggai yam starch described differences in physicochemical characteristics, functional behavior, and modification response that may influence digestion rate and glucose release [13,14,27]. However, this explanation should be interpreted cautiously because starch fractions were not directly measured in the present study. For that reason, the mechanistic interpretation remains inferential and should be viewed as a hypothesis supported by previous evidence rather than a direct finding of this experiment.

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The moderate-GI classification of Bunggon and Ateno is particularly noteworthy. Although Bunggon showed a transient increase at 30 minutes, its overall glycemic response relative to the reference food remained within the moderate range. Ateno, in contrast, showed a more consistent downward trend after 15 minutes and ended with one of the lower glucose values at 120 minutes. This suggests that moderate-GI behavior may arise through different response patterns: one variety may show an early peak followed by faster normalization, whereas another may show a more subdued response throughout the observation period. From an applied perspective, these varieties appear promising for further product development, particularly because previous work has already shown the feasibility of Banggai yam in analog rice, starch-based noodle products, and lower-GI cookie formulations [15-17,22,23,25].

The high-GI values identified for Pusus, Sombok, and Pasandil also deserve attention. These results indicate that not all traditional tubers can automatically be assumed to provide a slow glucose release simply because they are locally cultivated or minimally processed. In practice, foods categorized as high GI may contribute to greater postprandial glycemic excursions when consumed alone, especially in populations already at risk of impaired glucose tolerance or type 2 diabetes. This point is particularly relevant in settings where metabolic disease remains an important public health problem and where dietary management is central to prevention and care [4,5,28].

From a public health perspective, the identification of moderate-GI Banggai yam varieties offers a useful starting point for local food diversification and functional-food development. Bunggon, Ateno, Boan, and Tuu may be more suitable candidates for products intended to provide a lower glycemic impact than Pusus, Sombok, and Pasandil. This is relevant not only for individual food choices, but also for broader strategies aimed at strengthening the use of indigenous carbohydrate sources in island areas. Because Banggai yam is culturally familiar, agriculturally recognized, and still represented in regional statistical and land-use studies, its selective use based on glycemic characteristics could support more context-specific nutrition interventions in Banggai Kepulauan [6-12,24-26].

At the same time, the high-GI varieties should not necessarily be excluded from future food innovation efforts. Previous studies on Banggai yam have shown that flour processing, starch modification, composite formulation, and product redesign can substantially alter functional and sensory properties [14-23,27]. This means that varietal selection may be combined with technological approaches to improve product quality and potentially moderate glycemic performance. In practical terms, high-GI varieties may still be useful as raw materials when incorporated into more complex food matrices or processed using approaches that improve starch functionality.

This study also contributes methodologically by applying the incremental area under the curve approach based on established GI principles and by using paired testing against a reference food within each yam-specific group [1,2]. Nevertheless, several limitations should be acknowledged. The revised manuscript was prepared from the archived analytical file, which retained the mean glucose values at each time point and the final GI estimates, but did not preserve full participant-level dispersion data. As a result, the manuscript could not provide error bars, iAUC mean plus or minus standard deviation values, or post-hoc comparisons between varieties. These omissions do not invalidate the descriptive and comparative findings, but they do limit the statistical depth of interpretation.

Overall, the findings of this study underline that Banggai yam has meaningful nutritional diversity that should be recognized in both research and practice. Some varieties appear more promising for lower-glycemic applications, whereas others may require reformulation or alternative processing to improve their metabolic profile. Future studies should integrate direct starch characterization, broader physicochemical profiling, fuller participant-level glycemic data, and downstream food-development trials so that the biochemical and physiological basis of GI variation can be explained more precisely. This direction is consistent with the expanding evidence base on Banggai yam, including work on agronomic suitability, nutrient composition, starch functionality, analog rice, cookies, biscuits, and preclinical and clinical evaluation [8-27].

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CONCLUSION

The seven Banggai yam varieties examined in this study showed clear diversity in glycemic index, ranging from moderate to high. Bunggon, Ateno, Boan, and Tuu were classified as moderate-GI varieties, whereas Pusus, Sombok, and Pasandil were classified as high-GI varieties. These findings support selecting specific Banggai yam varieties for lower-glycemic food development rather than treating all varieties as nutritionally equivalent. Future work should incorporate direct starch characterization, full iAUC summary statistics, and error-bar reporting to strengthen the translational value of Banggai yam research.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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