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Nutrient Profiles and Glycemic Potentials of Noodles from Beneng Taro (*Xanthosoma undipes* K. Koch)

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ABSTRACT

This study explores the development of functional noodles made from modified beneng taro (Xanthosoma undipes K. Koch) flour, modified cassava flour (mocaf), and soy protein isolate (SPI) aiming to promote food diversification and offer a nutritious alternative for individuals with metabolic disorders. The research employed a completely randomized design (CRD) with three formulations as follows: F1 (50:40:10), F2 (50:35:15), and F3 (50:30:20) of modified beneng taro flour, mocaf flour, and SPI. The noodles was analyzed for dietary fiber, proximate composition, sensory evaluation, starch, and glycemic index. The modified beneng taro flour was produced through lactic acid fermentation using a commercially available mixed-culture starter (Bimo CF), followed by drying and milling. Dietary fiber analysis showed that formula F1 with 50% modified beneng taro flour, 40% mocaf flour, and 10% SPI had the highest fiber content (12.3 g/100 g). The sensory evaluation indicated that the formula F2 with 50% modified beneng taro flour, 35% mocaf flour, and 15% SPI was preferred for its color, texture, taste, and overall acceptance. Based on sensory preference, further nutritional, starch, and glycemic analyses were conducted on formula F2. The selected formula had a nutritional profile as follows: 13.2 g/100 g moisture, 2.6 g/100 g ash, 15.1 g/100 g protein, 1.2 g/100 g fat, 67.7 g/100 g carbohydrates, 64.1 g/100 g starch, 58.4 g/100 g in vitro starch digestibility, and 5.8 g/100 g resistant starch. The glycemic index was 43.6 (low) with a moderate glycemic load of 16.9. The postprandial glucose response showed better control than with pure glucose. The integration of modified beneng taro flour, mocaf flour, and SPI in formula F2 produced a nutritionally balanced noodle with good sensory qualities, high fiber and protein content, and a low glycemic index. This research highlights the potential of local ingredients for food diversification and the creation of healthier dietary options.

Keywords: *beneng taro, diabetes, dietary fiber, glycemic index, noodles*

INTRODUCTION

Food consumption patterns in Indonesia are dominated by grains, with a Food Consumption Pattern Score (*Pola Pangan Harapan* or PPH) of 56.7% in 2024, surpassing the ideal score of 50% (Bapanas, 2024). The Indonesian government, through Presidential Regulation (*Peraturan Presiden* or Perpres) Number 22 of 2009, encourages food diversification by utilizing local food ingredients. Tubers such as cassava, potatoes, and sago are common foods consumed by the community (BKP, 2020). The development of beneng taro as a functional food is one of the diversification efforts that have been carried out (Priyono and Aryana, 2016). The development of beneng taro-based products is an important step in supporting food diversification programs (Budiarto and Rahayuningsih, 2017). Beneng taro (*Xanthosoma undipes* K. Koch) grows abundantly around Mountain Karang, Pandeglang, and is estimated to yield 150 tons if harvested after 2 years (BPTP, 2021). The nutritional advantage of beneng taro lies in its fiber content of approximately 13.2 g/100 g (Nabiu *et al.,* 2023) and minerals such as iron (12.1 mg/100 g) and zinc (8.4 mg/100 g), making it an ideal candidate for food diversification (BPTP, 2021). Beneng taro contains high carbohydrates (72.8 g/100 g) with resistant starch, which helps lower postprandial glucose and improve gut health. It also has higher dietary fiber than cassava (1.8 g/100 g) and potato (2.2 g/100 g) (Kemenkes RI, 2020). Research on beneng taro is essential to maximize its functional value, develop innovative products like noodles, and support dietary strategies for managing diabetes.

The increasing trend towards a healthy lifestyle, particularly among millennials and Gen Z, stands in contrast to the rising health issues in Indonesia,

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where 27.3% of the population experiences health problems (BPS, 2024). According to Kemenkes RI (2018), the inadequate consumption of fruits and vegetables has increased from 93.5% to 95.5%, with intake falling below the recommended 400–600 g of fiber per day (DGA, 2020; Kemenkes RI, 2019). Processing beneng taro into high-fiber foods offers a viable strategy for enhancing daily fiber intake (Reynolds *et al.,* 2020). Furthermore, diabetes affects 10.6% of Indonesians aged 20–79 years, equating to approximately 1 in 9 individuals (IDF, 2021). Dietary fiber is associated with a reduced risk of diabetes (Basu *et al.,* 2021), with beneng taro emerging as a promising option for blood glucose management (Fitridewi *et al.,* 2023).

Instant noodles are globally popular due to their convenience, extended shelf life, variety of flavors, and affordability (Prerana and Anupama, 2020). According to the World Instant Noodles Association (2024), global consumption has reached 120.21 billion servings, with Indonesia ranking second at 14.5 billion servings. Beneng taro, which contains 13.2 g of fiber per 100 g (Nabiu *et al.,* 2023), presents a promising high-fiber ingredient for functional noodles. Previous developments have included beneng taro-based wet (Lestari and Susilawati, 2015) and dry noodles (Wulandari and Putri, 2022). Previous studies on beneng taro noodles mainly addressed feasibility and acceptability, without assessing nutritional quality or glycemic response. This study advances prior work by formulating noodles with modified beneng taro flour, soy protein isolate (90% protein), and mocaf flour (6 g/100 g dietary fiber) to improve protein and fiber content. The study further evaluates starch digestibility, resistant starch, and glycemic index, providing stronger evidence of its potential as a functional food for metabolic disorders.

The incorporation of soy protein isolate (90% protein) (Din *et al.,* 2021) and modified cassava flour (mocaf) (6 g/100 g fiber) (Kemenkes RI, 2020) in noodle development aims to enhance the protein and fiber content. Soy protein isolate serves as a functional plant-based protein suitable for diabetics (Detchewa *et al.,* 2016), whereas mocaf improves pasta texture and quality, offering beneficial functional properties (Riswanto *et al.,* 2019). Most previous studies improved either the nutritional profile or sensory quality of noodles without considering glycemic response. Limited research has examined the combined use of beneng taro, mocaf, and soy protein isolate (SPI) in functional noodles for diabetes, underscoring the need for formulations that deliver high protein and fiber while maintaining a low glycemic index. This study focuses on developing beneng taro-based noodles enriched with these ingredients and evaluating their nutritional and organoleptic characteristics to support food diversification, with high fiber content, a protein-rich source, and a low glycemic index.

MATERIALS AND METHOD

Materials

The main ingredients in this study were modified beneng taro flour (produced at Malang Jejeg, Indonesia), mocaf flour (PT Mocafina Sejahtera, Indonesia), SPI (Proteina, Indonesia), salt, glyceryl monostearate (GMS), and water. Analytical-grade chemicals included selenium powder, sulfuric acid (H_2SO_4), hydrochloric acid (HCl), sodium hydroxide (NaOH), hexane, ethanol (EtOH), methyl red and blue indicators, maltose, sodium phosphate buffer, 3,5-dinitrosalicylic acid (DNS), acetic acid, and pure glucose, all obtained from Brataco Chemical (Indonesia). Enzymes included α-amylase, protease, and amyloglucosidase (PT. Thermalindo Sarana Laboratoria, Indonesia).

Experimental design

This experimental study used a completely randomized design (CRD) with three treatments to evaluate noodles formulations of modified beneng taro flour, mocaf flour, and soy protein isolate (MBT:MF:SPI): F1 (50:40:10), F2 (50:35:15), and F3 (50:30:20). The formulations were adapted from Fitridewi (2023) and Nabiu *et al.* (2023), with porang flour replaced by soy protein isolate to improve protein content and functional properties. Analyses included fiber content, sensory evaluation, proximate composition, total starch, *in vitro* starch digestibility, resistant starch, and glycemic index. Ethical approval was granted by Poltekkes Kemenkes Jambi (No. 02.06/2/1312/2024).

Formulation

Noodle formulations were prepared using three different proportions of modified beneng taro flour, mocaf flour, and soy protein isolate. The ingredient ratios were designed to improve protein and dietary fiber content while maintaining a consistent percentage of modified beneng taro flour. The formulations used in this study are presented in Table 1.

Table 1. Formulation of noodles from beneng taro

Formula	Modified Beneng Taro Flour (%)	Mocaf Flour (%)	Soy Protein Isolate (%)
F1	50	40	10
F2	50	35	15
F3	50	30	20

The production of modified beneng taro flour

The production of modified beneng taro flour begins with selection and characterization of three-year-old tubers, followed by a dormancy period. The tubers are then peeled, washed, and thinly sliced before soaking in a salt solution to reduce oxalic acid. After a second wash, the slices were fermented for 18 h with a Bimo CF starter, a commercially available mixed-culture starter containing lactic acid bacteria, purchased from a local supplier. The fermented tubers are dried in a greenhouse for approximately three days, ground into flour, and then sieved. Finally, the flour was stored at 5 °C under airtight conditions (Nabiu *et al.,* 2023).

The production of noodles

The noodle-making process started with baking the modified beneng taro flour at 150 °C for 15 min to reduce moisture content, improve flour stability, and enhance its functional properties prior to mixing, followed by weighing the raw materials according to the formulation. The dry ingredients were mixed in a pin mixer, and then water (55% of the dry ingredients) was added slowly. The mixture was then fed into a twin-screw extruder (Berto BEX-DS-2256) with temperature settings of feed (T1) 60 °C, compressing (T2) 55 °C, metering (T3) 50 °C, auger speed 25.5 Hz, and screw speed 25.1 Hz. The noodles were dried using a cabinet dryer at 50 °C ±1.5 h (Fitridewi *et al.,* 2023). The total amount of dried noodles produced in this study was approximately 5 kg per formulation. To maintain product quality, particularly moisture stability and microbiological safety, low-density polyethylene (LDPE) or polypropylene (PP) packaging is recommended, as these materials have been widely used in instant noodle products for their low water vapor transmission rate (WVTR), good sealability, and extended shelf life of up to 6–12 months (Kumar *et al.,* 2022).

Dietary fiber analysis

Dietary fiber was analyzed using the enzymatic-gravimetric method according to AOAC 978.10 using a fiber analyzer (ANKOM 2000, USA), to determine the content of total dietary fiber, insoluble dietary fiber, and soluble dietary fiber. The procedure involves weighing the sample, dissolving it in a buffer solution, adding α-amylase, protease, and amyloglucosidase enzymes to hydrolyze starch and protein, heating, separating the insoluble residue by filtration, washing the residue with ethanol and acetone, drying, ashing, and calculating the fiber content after correction for ash and protein (AOAC, 2023).

Sensory analysis

Sensory analysis was conducted based on the Indonesian National Standard (SNI 01-2346-2015) for sensory testing. A total of 30 panelists participated in the evaluation, consisting of 12 males and 18 females, aged between 20–35 years. The sensory test was carried out in a controlled sensory room at a temperature of 25±1 °C with adequate lighting and individual booth separation to minimize bias. Samples were prepared according to standardized procedures and served to panelists at warm temperature (approximately 55–60 °C) to reflect typical consumption conditions.

Sensory analysis was conducted based on the guidelines of the Indonesian National Standard (*Standar Nasional Indonesia*/SNI) for sensory testing (SNI 01-2346-2015). The evaluation consisted of methods a quality intensity test. The quality intensity test assessed product attributes like tuber taste, nuttiness, bitterness, savoriness, aroma, texture, mouthfeel, and color (Civille *et al.,* 2024). This evaluation used a 0–9 scale for attributes color (strongly bright–strongly dark), aroma (typical taro and soybean) (strongly weak–strongly strong), texture (chewy) (strongly tough–strongly chewy), texture (elastic) (strongly brittle–strongly strong), mouthfeel (strongly smooth–strongly rough), tuber taste, nuttiness, savory taste, and bitter taste (mild–rich) (Stone *et al.,* 2020).

Nutrient content analysis

Proximate analysis of the noodles was conducted using standard AOAC methods. Moisture content determined using a hot-air oven (Memmert UN55, Germany) at 105 °C until constant weight (AOAC 925.10). Ash content measured by incineration in a muffle furnace (Nabertherm L5 / 11, Germany) at 550 °C (AOAC 942.05). Protein analyzed by the Kjeldahl method (AOAC 991.20) using a Kjeltec system (FOSS KT 200, Denmark), involving digestion, distillation, and titration, with a nitrogen-to-protein conversion factor of 6.25. Fat content determined by Soxhlet extraction (AOAC 922.06) using a Soxtec system (FOSS ST 243, Denmark). Carbohydrate content was calculated by subtracting total water, ash, protein, and fat from 100% (AOAC, 2023). Total starch and resistant starch were determined using the method by Giuberti and Gallo (2020), were analyzed following Megazyme (2022) assay procedures (K-TSTA and K-RSTAR, Megazyme Ltd., Ireland) using an enzymatic hydrolysis method. Absorbance was read at 510 nm with a UV-Vis spectrophotometer (Thermo Scientific Genesys 10S, USA). The *in vitro* starch digestibility test was performed according to Han *et al.* (2023). Samples were hydrolyzed using α-amylase (Sigma A3176) and amyloglucosidase (Sigma A7095). Glucose released during digestion was measured using the glucose oxidase–peroxidase (GOPOD) method and quantified at 510 nm using a UV-Vis spectrophotometer (Thermo Scientific Genesys 10S, USA). All analysis were performed on three independent noodle batches, with single laboratory analysis conducted for each batch.

Glycemic index test

Glycemic index (GI) testing was conducted on 12 screened participants in accordance with ISO 2010. Each participant consumed a portion of F2 noodles equivalent to 25 g of available carbohydrates, which corresponded to 44.8 g of dried noodles, and 25 g of glucose as the reference food. Formulations F1 and F3 were not subjected to glycemic index testing. Capillary blood samples were collected at 0, 15, 30, 45, 60, 90, and 120 min postprandially using sterile lancets. Blood glucose was measured using an Accu-Chek Instant meter and test strips (Roche Diabetes Care, Indonesia). Foods were administered on separate days, with a three-day washout period. The incre-mental area under the curve (iAUC) was calculated using the trapezoidal method, excluding areas below the fasting baseline. The glycemic index (GI) was calculated using Equation 1, while the glycemic load (GL) was calculated according to Equation 2.

$$\text{Glycemic Index} = \frac{\text{IAUC test food}}{\text{IAUC reference food}} \times 100 \text{ g} \ldots. (1)$$

$$\text{Glycemic Load} = \frac{\text{GI} \times \text{available carbohydrate (g)}}{100} \;.. (2)$$

Data analysis

Data analysis was performed using IBM SPSS Version 25 and Microsoft Excel 2016, with results expressed as mean ± standard deviation (mean ± SD). Each noodle formulation was produced in triplicate from independent batches (n= 3). Chemical, starch, and dietary fiber analyses were performed once for each independent batch. Thus, the reported values represent independent production replicates rather than repeated analytical measurements. Statistical tests included one-way analysis of variance (ANOVA) with a significance level of $p<0.05$. Duncan's multiple range test was applied to identify mean differences between groups when ANOVA indicated significance. Additionally, a paired *t*-test was used to compare the postprandial blood glucose levels.

RESULTS AND DISCUSSION

Dietary fiber content

The analysis of dietary fiber, which included total, soluble, and insoluble fractions, revealed notable variations among the three noodle formulations containing modified beneng taro flour, mocaf flour, and SPI. These differences indicate that the composition of raw materials and the proportion of soy protein isolate significantly influenced the fiber profile of the noodles. The detailed results of dietary fiber content for each formulation are summarized in Table 2, highlighting the distinct nutritional characteristics of the developed products.

The analysis revealed that variations in formulation significantly affected the fiber content. The highest total dietary fiber was observed in F1 (12.3±0.1 g/100 g), followed by F2 (11.9±0.1 g/100 g), with the lowest in F3 (11.0±0.1 g/100 g). The increase in mocaf flour and the corresponding reduction in soy protein isolate contributed to the decrease in fiber content. Nonetheless, all formulations maintained a high fiber level owing to the intrinsic fiber richness of beneng taro flour (13.2 g/100 g) (Nabiu *et al.,* 2023).

Mocaf flour is recognized for its enhanced nutritional profile and lower glycemic index, attributable to its fiber content (Utami and Farida, 2023). Comparative studies indicate that noodles with purple sweet potato flour contain 13.3–14.6 g/100 g of total fiber (Monica *et al.,* 2018), while dry noodles with 20% taro flour and 20% gembus flour substitution had 11.4 g/100 g fiber (Febiyani, 2024). Taro flour also offers functional benefits for glycemic control (Bintanah *et al.,* 2021). The combination of high-fiber flour with soy protein isolate enhances protein content while preserving the benefits of dietary fiber (Mahendrayana *et al.,* 2023). These findings support the use of beneng taro-based formulations as promising functional foods for diabetes.

Table 2. Dietary fiber content

Fiber Type	Formula (Modified Beneng Taro Flour:Mocaf Flour:Soy Protein Isolate)		
	F1 (50:40:10)	F2 (50:35:15)	F3 (50:30:20)
Total fiber (g)	12.3±0.1^{c}	11.9±0.1^{b}	11.0±0.0^{a}
Soluble fiber (g)	3.1±0.1^{c}	3.0±0.1^{b}	2.8±0.4^{a}
Insoluble fiber (g)	9.3±0.1^{c}	8.9±0.0^{b}	8.2±0.0^{a}

Notes: Values are expressed as mean ± standard deviation (n= 3 independent production batches per formulation). Each batch was analyzed once for dietary fiber. Different superscript letters (a–c) within the same row indicate significant differences (one-way ANOVA followed by Duncan's multiple range test, $p<0.05$)

Sensory characteristics

A sensory quality intensity test is used to determine how strong a sensory attribute, such as sweetness, sourness, bitterness, saltiness, aroma, texture, or color, is perceived in a product (Garnida, 2020). A sensory liking test was conducted to evaluate various sensory aspects of the noodles, including color, aroma, taste, texture, aftertaste, and overall acceptance, by 30 panelists. Table 3 shows the results of the quality intensity test, which differed significantly in terms of color, soy aroma, and texture. Sensory liking showed significantly different results for color, texture, taste, and overall acceptability.

The formulation of noodles using varying proportions of modified beneng taro flour, mocaf flour, and soy protein isolate showed significant differences in sensory characteristics, including color, soy aroma, and texture. F1 produced noodles with desirable color, slightly less bright than F2, with mild soy aroma and less chewy texture. F2 exhibited superior sensory attributes, with brightness (5.6±1.3). The optimized balance of ingredients enhanced overall noodle quality (Ratnawati *et al.,* 2019). F2 soy aroma was strong, while its chewiness (7.3±1.2) and elasticity (6.7±1.2) were highest, attributed to soy protein isolate (Asysyifa *et al.,* 2024; Rahmawati *et al.,* 2021).

F3 showed good but less vibrant color than F2, with pronounced soy aroma (7.2±1.7), indicating higher soy protein isolate enhanced soy aroma (Apriliani *et al.,* 2024; Aslim *et al.,* 2023). However, its texture was less chewy than F2. Mouthfeel remained consistent across formulations, as mocaf flour contributed to smooth texture (Zaki *et al.,* 2024). The savory taste linked to glutamic acid from soy protein (Sari and Mardhiyyah, 2020), while taro, soy, and bitter tastes remained consistent. F2 demonstrated the best performance in sensory quality, particularly in color and texture.

Nutritional content of noodles

Table 4 presents the nutritional composition of noodles made from modified beneng taro flour, mocaf flour, and soy protein isolate. The analysis included moisture, ash, protein, fat, carbohydrates, total starch, *in vitro* starch digestibility, and resistant starch. These data offer a comprehensive overview of the nutritional profile and health benefits of noodles.

Table 3. Sensory characteristics of noodles

Attribute	Formula (Modified Beneng Taro Flour:Mocaf Flour:Soy Protein Isolate)		
	F1 (50:40:10)	F2 (50:35:15)	F3 (50:30:20)
Sensory quality intensity			
Apperance (color)	6.6±1.6^{b}	5.6±1.3^{a}	6.0±1.6^{ab}
Aroma (taro)	6.2±2.0^{a}	5.9±1.9^{a}	6.3±2.2^{a}
Aroma (soy)	6.1±2.0^{a}	6.7±1.9^{ab}	7.2±1.7^{b}
Texture (chewy)	6.0±1.3^{a}	7.3±1.2^{b}	5.6±1.2^{a}
Texture (elastic)	5.8±1.3^{a}	6.7±1.2^{b}	5.4±1.8^{a}
Mouthfeel grittiness	6.0±2.0^{a}	6.0±2.2^{a}	6.8±1.9^{a}
Tuber taste (taro)	6.3±2.2^{a}	5.9±1.7^{a}	6.0±1.9^{a}
Unpleasant taste (soy)	5.5±2.1^{a}	5.6±1.5^{a}	6.0±1.8^{a}
Savory taste (umami)	5.1±2.1^{a}	6.1±1.9^{a}	5.2±2.1^{a}
Bitter taste	3.8±1.9^{a}	3.6±1.8^{a}	3.9±1.9^{a}

Notes: Values are expressed as mean ± standard deviation (n= 30 panelists). Sensory evaluation was conducted using a 9-point intensity scale (1= very weak, 9= very strong). Each panelist evaluated all three formulations (within-subject design) in a single session. Data were analyzed using one-way ANOVA followed by Duncan's multiple range test. Different superscript letters (a–b) within the same row indicate significant differences ($p<0.05$)

Table 4. Nutritional content of noodles

Component	Formula (Modified Beneng Taro Flour:Mocaf Flour:Soy Protein Isolate)
	F2 (50:35:15)
Moisture (g)	13.2±0.0
Ash (g)	2.6±0.0
Protein (g)	15.1±0.0
Lipid (g)	1.2±0.0
Carbohydrate (g)	67.7±0.0
Total starch (g)	64.1±1.3
In vitro starch digestibility (g)	58.4±0.0
Resistant starch (g)	5.8±0.0

Note: Values are expressed as mean ± standard deviation (n= 3 independent production batches). The selected formulation was F2 (modified beneng taro flour:mocaf flour:soy protein isolate = 50:35:15). Each independent batch was analyzed once for nutritional composition. The reported values represent independent production replicates rather than repeated analytical measurements

Noodles from beneng taro exhibited a moisture content of 13.2 g/100 g, complying with the SNI 2018 standard (maximum limit of 14 g/100 g for dry noodles). Replacing wheat flour with mocaf flour influences the moisture content (Wulandari and Putri, 2022). Maintaining low moisture levels enhances product stability, with values below 14 g/100 g contributing to a prolonged shelf life (Zhang *et al.,* 2021). Noodles with 13.2 g/100 g moisture are considered stable and likely possess desirable organoleptic properties (Yani *et al.,* 2022). The ash content was recorded at 2.6 g/100 g, increasing with the proportion of beneng taro flour, which is rich in minerals such as iron and zinc (BPTP, 2021). An increase in ash content signifies an elevation in essential minerals such as potassium, magnesium, and calcium, enhancing the nutritional value of the product (Maryam, 2022). The protein content reached 15.1 g/100 g, significantly surpassing the SNI 3551:2018 standard, which requires a minimum of 4 g/100 g for non-wheat instant noodles. An increase in the proportion of soy protein isolate correlates directly with a higher protein content (Agus and Ismawati, 2018), and the combination of local ingredients with soy protein isolate yields nutritionally superior instant noodles (Ratnasari and Rahmawati, 2022).

The noodles have a low-fat content of 1.2 g/100 g (lower than 3 g/100 g) according to BPOM No. 1 of 2022. Reduced fat content enhances oxidation resistance (Tan *et al.,* 2020) and lowers the risk of heart disease (Eris *et al.,* 2022). The carbohydrate content was measured to be 67.7 g/100 g. The inclusion of mocaf flour and protein isolate resulted in a decrease in the carbohydrate content (Shivaani, 2020). Mocaf contributes complex carbohydrates and dietary fiber (Utami and Farida, 2023), whereas beneng taro retains a high carbohydrate level (Avilia, 2023). Soy protein isolate, processed to remove non-protein components such as carbohydrates and fats, contains protein concentrations exceeding 90%, highlighting its protein dominance (Thrane *et al.,* 2017).

The starch content of 64.1 g/100 g highlights carbohydrate richness, crucial for glycemic regulation (Drewnowski *et al.,* 2022). Beneng taro, with high amylose content has an amylose ratio over 30%, ideal for low-glycemic foods (Yuliani and Herawati, 2022). *In vitro* starch digestibility of 58.4 g/100 g suggests moderate digestibility, with levels below 60% linked to a lower glycemic index, beneficial for diabetics (Wiruch *et al.,* 2019). Beneng taro flour and mocaf affect starch composition and digestibility, reducing the glycemic index and aiding in managing postprandial blood glucose (Jenkins and Willett, 2024). Thermal processing in noodle production changes starch structure and digestibility (Yu *et al.,* 2023). The resistant starch (RS) content of 5.8 g/100 g offers health benefits through colonic fermentation (Junejo *et al.,* 2022). RS slows glucose release and enhances insulin sensitivity (Anal, 2023). RS over 5%, the noodles qualify as functional food, supporting metabolic health (Li and Hu*,* 2023).

Glycemic index and glycemic load

A comparative analysis of postprandial blood glucose levels between standard food (pure glucose) and test food (noodle) is illustrated in Figure 1, measured at various time intervals. Significant differences ($p<0.05$) were observed at 15, 30, and 45 min, with the test food showing lower glucose levels. No significant differences ($p>0.05$) were observed at 0, 60, 90, and 120 min. The standard food induced a sharp glucose spike within 15 min, peaking at 30 min, followed by a rapid decline. The test food exhibited a more controlled glucose response, with a lower peak at 30 min. This attenuated response is attributed to the high dietary fiber content of the test food, which slows glucose absorption in the small intestine, preventing postprandial glucose spikes. This mechanism involves water-soluble fibers gel-forming properties, which increase gastric content viscosity, delay gastric emptying, and slow carbohydrate digestion and absorption, leading to more stable postprandial glucose levels (Jaelani *et al.,* 2024).

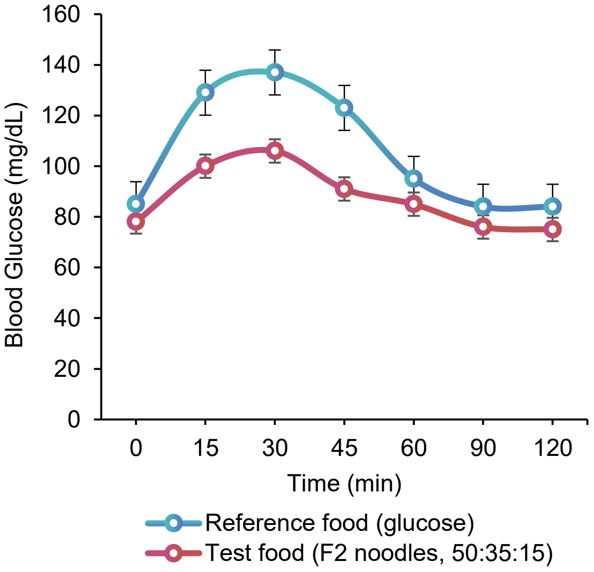

Figure 1. Postprandial blood glucose response of subjects (n= 12) after consumption of reference food (glucose, 25 g available carbohydrate) and test food (F2 noodle: modified beneng taro flour:mocaf flour:soy protein isolate=50:35:15, equivalent to 25 g available carbohydrate) measured over 120 min. Values are expressed as mean ± standard error (SE)

Adequate fiber intake has been significantly associated with reduced postprandial blood glucose levels in individuals with normal glucose tolerance, prediabetes, and diabetes mellitus type 2 (Zhang *et al.,* 2024). The glycemic index (GI) value of noodle from beneng taro was calculated based on the ratio of the incremental area under the curve (iAUC) of the test food compared with pure glucose as the reference, multiplied by 100 for each subject, and then averaged. The glycemic index value of noodle from beneng taro was 43.6±14.8, which is categorized as low according to ISO 26642:2010 (GI value ≤55). This result suggests that beneng taro noodles have a slower impact on postprandial blood glucose compared to the GI of beneng taro noodles previously which was 51.50 (Fitridewi *et al.,* 2023).

Foods with low GI help control blood glucose levels and reduce the risk of metabolic diseases (Slavin, 2005). The decrease in GI is due to the high dietary fiber content in beneng taro, which slows the digestion and absorption of carbohydrates (Fitridewi *et al.,* 2023). In addition to fiber, resistant starch, protein, and fat can also slow down the digestion and absorption of carbohydrates. Resistant starch is a type of starch that is not digested in the small intestine; therefore, it does not increase blood glucose levels. Proteins and fats also slow down the gastric emptying process, resulting in slower carbohydrate absorption and contributing to a low GI (Di Cairano *et al.,* 2022). Noodles have a moderate glycemic load (GL) of 16.9±5.9, indicating a moderate effect on blood glucose levels (Jenkins *et al.,* 2024), meaning that noodles will cause an increase in blood sugar levels that is not too fast and not too slow (Atkinson *et al.,* 2021).

CONCLUSION

The formulation of 50% modified beneng taro flour, 35% mocaf flour, and 15% soy protein isolate produced noodles with the best sensory characteristics. The noodles had color, aroma, and chewy texture highly preferred by panelists. This formulation was chosen for its optimal ingredient combination and nutritional profile, namely high dietary fiber (11.9 g/100 g), source of protein (15.1 g/100 g), low fat (1.2 g/100 g), moisture content meeting SNI standards (13.2 g/100 g), low glycemic index (43.6), and moderate glycemic load (16.9). This study shows noodles made with modified beneng taro flour, mocaf flour, and soy protein isolate have potential as a healthy alternative. High fiber content, high protein, and low glycemic indices provide food alternatives for people with metabolic problems like prediabetes and diabetes. The use of local ingredients supports agriculture and food diversification. Further improvements are needed, including optimizing extrusion and drying conditions, using smaller die diameters, and applying starch modification example autoclaving–cooling to enhance resistant starch. Sodium and gluten analysis should be conducted for safety, and *in vivo* trials in prediabetic or diabetic subjects are recommended to validate glycemic response and acceptance.

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