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Original Research Article

Proximate Composition, Sensory Properties, and Postprandial Glycemic Response of A Low-Sugar Composite Fruit Jam From Mango, Banana, Apple, And Orange

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ABSTRACT

Postprandial glycemic response is a key indicator used for assessing how carbohydrate-containing foods affect blood sugar response, most especially in individuals suffering from diabetes. Although fruits contain a significant amount of nutrients, their high perishability and seasonal availability make it essential for them to be processed to prolong their shelf life while preserving quality. This study aimed to evaluate the proximate composition, sensory attributes, and postprandial glycemic effect of jam formulated from mango, banana, apple, and orange. Fresh fruits were locally sourced, processed into pulp, and blended into four samples with ratios of 70:20:5:5, 60:30:5:5, 50:30:10:10, and 40:30:15:15. Standard analytical methods were used to analyze proximate and sensory characteristics. The postprandial blood glucose levels were monitored over 2 hours. The incremental area under the curve (iAUC) was subsequently calculated using the trapezoidal method. Data were analyzed using SPSS version 27.0, and mean differences were separated using Duncan's multiple range test. Results showed that moisture ranged from 31.19-34.83%, ash 0.44-0.53%, protein 0.81-0.95%, fat 0.21-0.29%, fiber 1.11-1.59%, and carbohydrate 61.90–66.24%. Sensory scores indicated good acceptability across all samples. The iAUC for glucose was 3688.5 mmol·min/L, while that of the jam was 1299 mmol·min/L, corresponding to a glycemic index of 35, which indicates a low glycemic response. In conclusion, the composite fruit jam exhibited good sensory acceptability and a low glycemic response, suggesting its potential as a healthier alternative to conventional jam products.

Keywords: Postprandial glycemic response, Composite fruit jam, Proximate composition, Glycemic index, Sensory evaluation

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Introduction

Postprandial blood glucose response refers to the changes in blood sugar levels following the consumption of food, particularly foods rich in carbohydrate. It is an important indicator used to assess carbohydrate metabolism and its effect on glycemic response.[1] Studies have shown that blood glucose rises after the consumption of food, then normally peaks within 30 – 60 minutes, before the gradual reduction in blood glucose as the body and tissues utilize the food. Several factors, including the type, quantity, and composition of carbohydrates, as well as dietary fibre, influence this response.[1-2]
Studies have shown that foods within the same group can produce different glycemic responses. This means that the glycemic effect of a food cannot be predicted accurately based on the quality and quantity of carbohydrate it contains.[2-4] The glycemic index (GI) is a ranking of the available carbohydrate portion of different foods based on how they increase blood glucose response after they have been consumed.[5] It is calculated using the incremental area under the curve (iAUC) of blood glucose response to a sample food, expressed as a percentage of the response to a reference food such as glucose.[5] With the development of the iAUC, each person acts as his or her own control, as the glycemic index of a food applies to everybody irrespective of their glucose tolerance level.[6]

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Fruits are widely consumed for their numerous benefits, ranging from high levels of vitamins, minerals, and antioxidants.[7] However, in developing countries, fruit availability depends on seasonality, which is constrained by improper storage facilities coupled with postharvest losses, significantly affecting fruit consumption.[8] Because of their moisture content, fruits are highly perishable and require processing to extend shelf life and ensure year-round availability.[9]
Recently, jam production has been used as a common method to increase the shelf life of fruits. It is produced by cooking the fruit pulp with sugar, and pectin is then added to obtain a thick, stable product. This processing extends the shelf life and improves the availability of the product.[10] However, conventional jams often contain high levels of added sugars, which may rapidly increase the blood glucose levels after consumption.
Apple (Malus domestica), banana, mango, and orange are widely consumed fruits known for their nutritional value. Apples are rich in phytonutrients, flavonoids, and polyphenols.[11-12] Banana provides easily digestible carbohydrates, vitamins, and minerals such as potassium and vitamin B6.[13] Mangoes are a good source of vitamins A and C and contain significant amounts of sugars.[14-15] Oranges are rich in vitamin C and help to contribute to antioxidant defense and immune function.[16] The combination of these fruits may influence both the nutritional composition and glycemic response of derived products.
Despite the nutritional benefits of fruits, there is increasing concern regarding the glycemic impact of processed fruit products such as jam, which often contain high levels of added sugars and altered food structure, which may contribute to fast increases in blood glucose levels.[17] Furthermore, there is limited evidence on the combined effects of multiple fruits in composite jam formulations on both proximate and postprandial blood glucose response. This gap is particularly relevant for dietary management among individuals at risk of metabolic disorders.
Therefore, this study aimed to evaluate the proximate composition, sensory properties, and postprandial blood glucose response of a

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composite jam produced from blends of mango, banana, apple, and orange.

Materials and Methods

Sample collection

Fresh bananas, apples, oranges, and mangoes were identified using standard identification procedures and verified by experts from the Department of Crop Production, Federal Polytechnic, Ilaro. The fruits were procured from Sayedero Market, Ilaro, Ogun State, Nigeria (6.8975° N, 3.0220° E), on 24th of February 2026 and subsequently transported to the Nutrition and Dietetics processing kitchen for jam production.

Sample preparation

The fruits were sorted to remove the bad ones, washed with clean water to remove dirt and contaminants. They were manually peeled with knives, sliced into smaller pieces, and blended into pulp.

Preparation of Mango Pulp

The mango pulp was produced using the method described by [18], with slight modifications. The mango was sorted, dirt and other impurities were removed manually from the mango, and then it was washed under clean water. The edible portion was sliced, and the pulp was extracted and blended to achieve a uniform consistency. The resulting pulp was then stored in an airtight container until further use.

Preparation of Apple Pulp

Apple pulp was prepared following the method described by [19], with slight modifications. Fresh apples were sorted to remove the bad ones and washed thoroughly with clean water to get rid of dirt and contaminants. The apples were peeled manually, cut into smaller pieces, and blended to obtain a uniform pulp.

Preparation of Banana Pulp

Banana pulp was produced following the method described by [20] with slight modifications. Fresh bananas were sorted to remove the bad ones and washed thoroughly with clean water to eliminate dirt and contaminants. The bananas were then peeled manually using a knife and blended to obtain a uniform pulp.

Preparation of Orange Pulp

Orange pulp was produced according to the method described by [21] with some modifications. The oranges were sorted to get rid of the bad ones, and then they were washed to get rid of dirt. Afterward, the oranges were hand-peeled with a stainless-steel knife, crushed, and blended into pulp using the electric blender. The orange pulp was then stored for use.

Ratio formulation for jam

Four different blends of jam were produced using the following ratio blend.

Preparation of jam from the various blends

The jams were produced according to the method described by [22]. The pulp of each fruit sample was measured, combined in a cooking pot, and heated at 105°C for 25 minutes, with temperature monitored using a thermometer. Pectin and sugar were dissolved in water and added to the boiling mixture while it was continuously being stirring to ensure uniform consistency. Citric acid was also added to the mixture while it was still boiling. The produced jam was then cool before it was then transferred into clean, labeled jars, leaving adequate space at the top to prevent contamination and enable proper sealing. The jams were then kept in a refrigerator until they were used.

Experimental methods

Participants selection

Ten healthy, non-diabetic volunteers consisting of 5 males and 5 females were recruited within the department of Nutrition and Dietetics after giving their informed consent. The inclusion criteria include participants aged 21 -35 years who were also from any illness, chronic condition, or allergy to fruits used in the study. The exclusion criteria were individual that are diabetic, suffering from chronic diseases or those who did not provide consent.

Anthropometric measurements (weight and height) were obtained using reference standards, and body mass index (BMI) was calculated to ensure that all participants were within the normal range. Ethical clearance for the study was obtained from the institution's Research and Ethics Committee with reference number FPI/RET/Vol. 1/13.

Test food and reference food

The test food selected for the glycemic response study was the jam sample with the lowest carbohydrate content, based on the proximate analysis of the formulated jams. The reference food was 50 g of anhydrous glucose (providing 50 g of available carbohydrate). Portions of the test food (jam) were calculated to provide an equivalent of 50 g of available carbohydrate. Both the glucose solution (dissolved in 50 mL of water) and the test food were consumed within 10 minutes, accompanied by 250 mL of water.

Blood glucose measurement

On each test day, participants were instructed to rest for 30 minutes before the procedure began. The tests were carried out on different days with a two-day interval between sessions for a wash-out period. Fasting blood samples were collected at baseline each day, following an overnight fast.

The test food (jam) and the reference food (glucose) were consumed by the participants within 10 minutes. Participants were asked to remain seated and reduce physical activity throughout the testing period. The postprandial blood glucose was then determined at 30, 60, 90, and 120 minutes.

Blood samples were obtained via finger prick, with each drop of blood placed on a disposable test strip and analyzed using an electronic Apucheck glucometer.

Calculation of glycemic index

The glycemic index was calculated following the procedures described by [23] Wolever (2004). For each participant, the incremental area under the curve (iAUC) was determined for both the test and reference foods, excluding baseline fasting blood glucose values, using the trapezoidal method as outlined by.[24] The mean and standard deviation (SD) of the iAUC values were then computed using the appropriate formula to calculate the glycemic index.

$$GI = \frac{iAUC\ for\ the\ test\ fruit}{Average\ iAUC\ for\ the\ reference\ food}\ x\ 100$$

Proximate composition

The proximate analysis of the formulated jam samples was determined using standard analytical procedures as described by.[25]

Sensory analysis

Sensory evaluation was determined using a semi-trained panel of 25 participants. The jam samples were assessed for the formulated jams for attributes including taste, color, flavor, appearance, consistency, aroma, and overall acceptability, using a 9-point hedonic scale

Statistical analysis

Statistical analyses were determined using the Statistical Product and Service Solutions (SPSS, version 27.0) to calculate the mean and standard deviation. Significant differences among means were determined using Duncan's Multiple Range Test at $p < 0.05$.

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Results and Discussion

The proximate evaluation of the formulated jams is presented in Table 1. Among the samples, sample D showed the highest moisture content (34.83%), while sample A had the lowest (31.19%). Sample D recorded the highest values for ash (0.53%), protein (0.95%), fat (0.29%), and crude fiber (1.59%). In contrast, carbohydrate content was highest in sample A (66.24%) and lowest in sample D (61.90%). Significant differences were observed among all the samples This study evaluated the nutritional composition, sensory properties, and postprandial glucose response of jam made from commonly consumed fruits. The proximate analysis showed that the moisture content of the formulated jams ranged from 31.19% to 34.83%, with sample D having the highest moisture level. This variation in moisture indicates different water activity and consistency. The moisture content found in this study was lower than the results reported by.[26], who evaluated the proximate composition and sensory qualities of jam made from pawpaw, apple, banana, and orange fruit, where they reported the moisture content ranging from 23.93% to 49.57%. [27,] however, reported a much lower moisture content of 15.31% to 27.60% in a similar study. The slightly high moisture content of the jam produced in this study could reduce the shelf life of the jam.

Ash content, indicative of mineral composition, ranged from 0.44% (sample A) to 0.53% (sample D), increasing with higher proportions of banana and orange. This is lower than values reported for jams from African bush mango (2.66%-3.19%) in a study conducted by [28], and pineapple, tomato, and pawpaw blends (2.00%-2.78%), according to.[29], but consistent with jams made from apple and banana blends (0.33%–0.53%),[30]

Table 1: Proximate analysis of the formulated jam

SAMPLES	MOISTURE %	ASH	PROTEIN	FAT	CRUDE FIBRE	CARBOHYDRATE
A	31.19±1.00^{d}	0.44±0.24^{b}	0.81±1.00^{d}	0.21±1.00^{d}	1.11±1.00^{d}	66.24±1.00^{a}
B	32.08±1.00^{c}	0.47±0.17^{ab}	0.86±1.00^{c}	0.24±1.00^{c}	1.26±1.00^{c}	65.31±1.00^{c}
C	33.38±1.00^{b}	0.53±0.10^{a}	0.91±1.00^{b}	0.26±1.00^{b}	1.41±1.00^{b}	63.58±1.00^{b}
D	34.83±1.00^{a}	0.53±0.10^{a}	0.95±1.00^{a}	0.29±1.00^{a}	1.59±1.00^{a}	61.90±1.00^{d}

Values are mean ± standard deviation of duplicate samples. A-D Means with different superscripts within the same column are significantly different ($p<0.05$).

KEY:

Sample A = (mango, apple, banana, and orange: (70:20:5:5)
Sample B = (mango, apple, banana, and orange (60:30:5:5)
Sample C = (mango, apple, banana, and orange (50:30:10:10)
Sample D = (mango, apple, banana, and orange (40:30:15:15)

The protein content of the jam samples ranged from 0.81% to 0.95%, which is slightly lower than the protein content reported by [31] for jams produced from African star apple and pineapple blends (1.14- 1.68%) and that reported by [32] for jams made from pineapple and pumpkin leaves (1.00%-1.54%). This low protein content can be attributed to the low protein content of the fruits used in the formulations. Additionally, processing methods such as heating, cooking, and blending usually result in some loss of protein, as reported in previous studies on processed fruit products.[33-34] Generally, fruits have low protein content, which could contribute to the jam's low protein content.

The fat content of the formulated jams ranged from 0.21% to 0.29%. Samples with a lower proportion of mango and apple tended to have slightly higher fat content. Sample D, which had the highest percentage of banana and orange, recorded the highest fat content. A significant difference ($p<0.05$) was observed in the fat content of the jam samples. Compared with previous reports, the fat content of these jams was lower than that of jams produced from black plum, which ranged from 2.83% to 3.81%. [35] The fat content of foods affects their overall attributes. Fat provides the body with essential fatty acids and is a major source of energy.[36]

Crude fibre ranged from 1.11% to 1.59%, increasing with higher banana and orange proportions. This aligns with findings by.[28] and.[37] Fiber contributes to reduced cardiovascular risk and cholesterol levels.[38] Carbohydrate content ranged from 61.90% to 66.24%, with the highest in sample A, and decreased with higher proportions of other fruits. This trend is consistent with.[31]

The carbohydrate content of the produced jam ranged from 61.90% to 66.24%, with sample A having the highest carbohydrate content. The results indicate an inverse relationship between the composite fruit content and carbohydrate levels in the jam: as the ratio of additional fruit pulp increased, the carbohydrate content decreased. A similar study conducted by.[31] reported carbohydrate content ranging from 73.65% to 83.55% in jam produced from African star apple, which is higher than the values observed in the present study. Carbohydrates play a vital role in providing the body with the energy necessary for physical activity and metabolic processes.[38] Statistical analysis showed that the significant differences ($p<0.05$) in carbohydrate content among the samples.

The sensory evaluation results of the jam samples are shown in Table 2. The highest mean score for colour (8.48) was observed in sample A, with sample D having the lowest (7.59). For taste, sample A also has the highest (8.11) mean score, followed by sample B (7.89). Both samples A and C had the highest mean score of 8.00 for aroma, while for overall acceptability, sample A had a mean score of 8.56, with samples B and C scoring 8.19 and 8.15, respectively. Significant differences ($p > 0.05$) were not observed among taste and aroma; however, significant differences ($p < 0.05$) were observed in color, appearance, and overall acceptability.

Table 2: Sensory analysis of the formulated jam

SAMPLES	Colour	Taste	Aroma	Appearance	Texture	Overall acceptability
A	8.48±1.00^{a}	8.11±0.21^{a}	8.00±0.12^{a}	8.56±0.07^{a}	8.44±0.06^{a}	8.56±0.12^{a}
B	7.93±0.24^{b}	7.89±0.21^{a}	7.70±0.12^{a}	8.04±0.16^{ab}	8.04±0.11^{ab}	8.19±0.15^{ab}
C	7.85±0.24^{b}	7.74±0.21^{a}	8.00±0.12^{a}	8.19±0.16^{ab}	7.93±0.11^{ab}	8.15±0.15^{ab}
D	7.59±0.24^{b}	7.74±0.21^{a}	7.60±0.12^{a}	7.85±0.26^{b}	7.70±0.16^{b}	7.81±0.19^{b}
Control (E)	7.93±0.24^{b}	7.81±0.21^{a}	7.50±0.12^{a}	7.89±0.26^{b}	7.63±0.16^{b}	8.11±0.15^{ab}

Values are mean ± standard deviation of duplicate samples. A-D Means with different superscripts within the same column are significantly different ($p<0.05$).

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KEY:
Sample A = (mango, apple, banana, and orange: (70:20:5:5)
Sample B = (mango, apple, banana, and orange (60:30:5:5)
Sample C = (mango, apple, banana, and orange (50:30:10:10)
Sample D = (mango, apple, banana, and orange (40:30:15:15)
Sample E = Commercial Jam (Control)

Table 3 shows the mean anthropometric measurements with respect to gender. The average weight and height for males were 56 kg and 1.63 m, respectively, with an average BMI of 20.50 kg/m², while females recorded 55 kg, 1.59 m, and 23.16 kg/m², respectively. There was a significant difference (p<0.05) in mean height by gender.
The sensory mean score for colour ranged from 8.48 to 7.93, with the commercial jam (Sample E) having the least mean value. The brighter colour observed in the formulated jam compared to the control may be attributed to the inclusion of multiple fruits. Significant differences (p<0.05) were observed among the samples. The colour difference could be attributed to enzymatic browning upon exposure to light, especially during processing.[39-40] One of the most important sensory attributes that determines if a product is accepted by consumers or not is the colour.

Table 3: Mean anthropometric by gender

Variables	Weight (Kg)	Height (m)	BMI (Kg/m^2)
Male	56.00 ± 4.32	1.63 ± 0.07	20.50 ± 0.57
Female	55.16 ± 8.40	1.59 ± 0.05	23.16 ± 5.15
Df	3.55	6.03	1.22
P-value	0.09	0.04*	0.35

*Significant difference between means (P – value <0.05)

The mean taste score ranged from 8.11 to 7.81. Sample A had the highest mean score for taste, while the control had the lowest (7.81). This taste preference could be attributed to the addition of multiple fruits in the formulated jam, compared to just one fruit in the control jam. All the composite fruits are known for their sweetness. This finding aligns with [37], who reported improved taste in composite jams made from banana, pineapple, and watermelon blends. The variation in the mean taste scores indicates the effect of different fruit proportions on the overall taste of the jams.
Aroma scores ranged from 8.00 to 7.50, with lower scores observed as the ratio of composite fruits increased. The control jam had the lowest mean score for aroma (7.50). This could be because the panelists prefer the aroma of the composite jam to that of the control. This preference could be due to the aromatic profile, which is a result of the fruit composition. The higher scores for sample A can be due to the bright orange color of the mango, which was present in the highest proportion. Appearance is critical in food acceptability, as it influences consumer perception and choice.[41-42]
For texture, the mean score ranged from 8.44 to 7.63, with a significant difference (p<0.05) observed between the samples. Sample A had the highest mean score for texture, with the control sample having the least texture. The score for the composite jam decreases with the inclusion of banana and orange. This could be as a result of the texture of the pulp of both banana and orange, especially the orange, which contains a fibrous structure, which would prevent a smooth pulp formation.[43-44] Overall acceptability scores ranged from 8.56 to 8.11, with sample A being the most preferred. The findings were similar to those reported by [27] and [45], where composite fruit jams received higher overall acceptability than control samples. Significant differences (p < 0.05) were observed among the samples for overall acceptability
Table 4 shows the weight of the test food. 50 g of glucose and 81 g of jam, with each providing 50 g of equivalent carbohydrate, were given to the participants

Table 4: Weight of test food

S/N	Samples	Carbohydrate content (g)	Available carbohydrate(g)	Sample Fed (g)
1	Glucose	50	50	50
2	Jam	61.90	50	81

The table shows the mean postprandial glucose response of participants over two hours. At baseline (0 minutes), the mean values were 86.50 mmol/L for glucose and 83.60 mmol/L for jam. Following jam consumption, the mean glucose levels were 106.30 mmol/L at 30 minutes, 94.70 mmol/L at 60 minutes, 91.40 mmol/L at 90 minutes, and 87.00 mmol/L at 120 minutes.
The reference food (glucose) and the test food (jam) mean postprandial glucose response was measured for over two hours. The incremental area under the curve (iAUC) was then calculated using the trapezoidal rule.
For glucose, the mean iAUC was 3688.5 mmol·min/L, while that of jam was 1299 mmol·min/L. Based on these values, the glycemic index (GI) of jam was calculated to be 35, classifying it as a low-GI food.
Postprandial blood glucose responses showed significant differences between the reference food (glucose) and the test food (jam). This can be linked to the jam's nutritional composition, particularly its fibre content.[46] Digestion and absorption of sugars is slowed down by dietary fibre, resulting in a moderated glycemic response. Blood glucose peaked 30 minutes after jam consumption, consistent with previous studies reporting maximum postprandial glucose levels within 30 minutes of carbohydrate intake.[47-49] The subsequent decrease in glucose levels supports the role of dietary fiber in attenuating sugar absorption. [48]
In contrast, consuming glucose resulted in a quick and higher increment in blood glucose due to the rapid digestion and absorption of simple sugars. This observation aligns with studies by [50] and [51]. Additionally, fruits rich in polyphenols may lower postprandial glucose responses and enhance insulin secretion and sensitivity.[52]
The average postprandial glucose response was lower for the jam compared to glucose. The jam-induced response peaked at 30 minutes, followed by gradual declines at 60, 90, and 120 minutes, indicating a slower and more moderate elevation of blood glucose with a faster return to baseline. This observation is consistent with [53], who reported significant differences between reference and test foods. The lower postprandial response of jam can also be attributed to its carbohydrate composition, which includes glucose, fructose, and sucrose. Studies have shown that fructose has a lower postprandial glucose response compared to glucose.[54]
The glycemic index of the jam was calculated to be 35 (Table 6), classifying it as a low glycemic index food. This finding supports the

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gradual increase and moderate decrease in postprandial glucose observed. Factors influencing the jam's low glycemic index likely include fruit composition, processing methods, and the presence of other constituents that slow glucose absorption.[2, 55-56] The incremental area under the curve (iAUC) for glucose was higher than that of the jam, consistent with previous reports indicating higher postprandial glycemic responses for reference foods compared to test foods.[23]

Table 5: Mean postprandial response of the respondents

Food sample	0 minutes (mmol/L)	30 minutes	60 minutes	90 minutes	120 minutes
Glucose	86.50±10.16	127.10±21.78	124.50±19.36	116.70±47.08	114.80±34.71
Jam	83.60±10.31	106.30±14.68	94.70±10.40	91.40±8.36	87.00±4.85

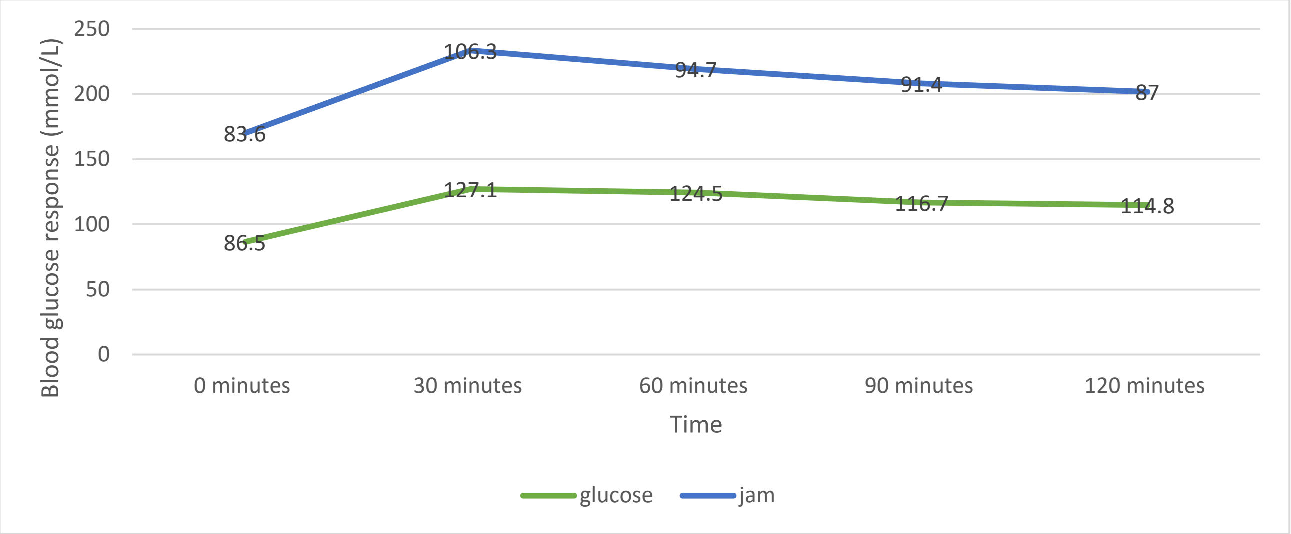

Fig 6: Mean postprandial glucose response curve of glucose and jam

Table 6: Glycemic index and iAUC for glucose and test food

S/N	Samples	iAUC (mmol·min/L)	GI
1	Glucose	3688.5	100
2	Jam	1,299	35

Conclusion

In conclusion, the results of this study showed that jam can be produced from mango, apple, banana, and orange without adverse effects on the nutritional and sensory properties of the jam when compared to commercial jam. Proximate results showed that sample D had the highest moisture, ash, protein, fat, and crude fiber content, whereas Sample A had the highest carbohydrate content. Sensory analysis indicated that sample A had the highest overall acceptability among the formulated jams. Furthermore, the glycemic index of the formulated jam was determined to be low, suggesting its suitability as a low glycemic index food.

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Conflict of Interest

The authors declare no conflict of interest.

Author's Declaration

The authors hereby state that the above-written paper is their own and that they take full responsibility for any liability arising from the contents of this paper.

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