



SUSTAINABLE VALUE ADDITION IN BANANA CAKE PRODUCTION AS ALTERNATIVE TO REDUCE BANANA WASTE

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ABSTRACT: *With the rising global demand for the baked goods market and the challenge of managing surplus ripe bananas, especially East African Highland bananas (Matooke), innovative approaches are essential to reduce food waste. The research focussed on using Apple (Sukari Ndizi), Gros Michel (Bogoya), and East African Highland (EAH) banana species in banana cake recipes. The objectives were to analyze the cake-making characteristics of the EAH, Apple, and Gros Michel banana varieties, to assess the sensory attributes of banana cakes made from these varieties, and to determine consumer preferences. The study involved 180 participants who rated the banana cakes using a 1-9 hedonic scale, focusing on color, flavor, texture, and overall acceptability. Results revealed that ripe EAH bananas possess unique qualities, notably a superior texture and blending efficiency, outperforming the Gros Michel and Apple banana varieties. Although EAH bananas are currently being used for food only and any ripe ones are discarded, this study found for the first time that these ripe bananas can be repurposed for cake, reduce waste, and increase the value of the bananas. Ripe EAH banana cakes were particularly favoured for their appealing appearance, satisfying mouthfeel, and subtly reduced sugar flavour, leading to a significantly expressed intent for repeat purchases.*

KEYWORDS: Sensory analysis, Consumer preferences, food waste, Sukari Ndizi, Matooke, Bogoya.



INTRODUCTION

Bananas, globally recognised as the fourth most crucial food crop, hold a preeminent position in production and consumption (Mordor Intelligence, 2023a; 2023b). In East Africa, particularly Uganda, bananas play a pivotal role, serving as a staple food source and contributing significantly to the country's economy (Bongers et al. 2012). Uganda stands as the second-largest banana producer globally, with bananas constituting approximately 20% of the nation's total export revenue (The Exchange, 2022). The demand for biofortified bananas in Uganda is substantial, reflecting a significant market potential and economic value (Kikulwe and Asindu, 2020). This demand is further exemplified by banana consumption per capita in East and Central Africa, which is higher than global and African averages, emphasizing bananas' integral role in the region (Madalla et al., 2023).

The diversity of banana varieties in Uganda, such as Bogoya (Gros Michel, *Musa acuminata* (AAA Group) 'Gros Michel'), and Sukari Ndizi (Apple banana, *Ney Poovan-AB*), contributes to the rich agricultural landscape (Tushemereirwe et al., 2004; PlantVillage, 2015). Among these, Matooke (East African Highland (EAH) banana), a starchy triploid banana cultivar (*Musa acuminata Colla* (AAA-EA)), stands out as a staple food in East Africa, supporting millions of smallholder farmers (Akankwasa et al., 2021). Despite its significance, postharvest losses remain a critical challenge, with approximately 14.9% of total production wasted in Uganda alone (Kikulwe et al., 2018). Efforts to minimize losses and enhance value addition include exploring the potential of banana cakes, an emerging trend in the global baked goods market.

Banana cakes, fueled by the surplus of ripe bananas, have gained popularity worldwide, contributing to the ever-growing global banana market valued at over USD 13,049 million in 2021 (Mordor Intelligence, 2023b). Ecuador is the largest banana exporter, comprising 26% of global exports, and the market is projected to reach USD 145.40 billion by 2028 (Mordor Intelligence, 2023b). In Uganda, however, the banana export industry faces challenges, with limited international market share and significant postharvest losses (The Exchange, 2022). The potential of banana cakes in Uganda's market remains largely untapped, with no current data on banana cake revenue, and therefore an area of future research. The intersection of banana cultivation and cake production presents economic growth and waste reduction opportunities.

Despite the promising prospects, the production and utilization of bananas, especially EAH bananas, have encountered challenges, primarily in minimizing postharvest losses (Gemechu et al., 2021). These losses, ranging from 23% to 43%, occur throughout the supply chain, with mechanical damage and improper handling identified as critical contributors (Nkwain et al., 2021). Addressing these losses is imperative, given the significant revenue of bananas and banana cakes. Transforming ripened bananas, both dessert varieties like Apple banana and cooking varieties like EAH banana, into cakes can serve as a solution to reduce waste and enhance product value.

Banana cake production, driven by consumer preferences and the need for sustainable solutions, aligns with global trends in baked goods consumption (Grand View Research, 2023). The study focuses on the characteristics and preferences of banana cakes made from three distinct varieties: EAH banana, Apple banana, and Gros Michel banana. By addressing the dual challenges of food waste reduction and economic empowerment, the research seeks to



contribute to sustainable agriculture and value addition, especially in developing countries. Understanding consumer behavior and market dynamics is crucial for the success of such value addition initiatives, providing information that can guide businesses and policymakers (Caleja et al., 2017). The study is at the intersection of global baking trends, cultural diversity, and sustainable practices, where locally available ingredients are incorporated into the global baking industry.

MATERIALS AND METHODS

Area of Study

The research was conducted at Nkumba University catering practical laboratory in the School of Sciences. With a targeted audience of university students and staff, a team of 180 participants divided into three 60 participants' replicates were randomly selected from the student body and staff using the Krejcie & Morgan (1970) reference table to determine the optimal sample size. Sensory evaluations were executed through a 1-9-point hedonic rating test, evaluating the color, flavor, texture, and overall acceptability of banana cakes crafted from different banana species. Plain cakes made without any banana flavors were used as control.

Collection of Ingredients

Ingredients for banana cake preparation were sourced from nearby markets and shops at Nkumba University. Three varieties of ripe bananas (Highland cooking bananas - EAH banana (Matooke), dessert bananas - Apple banana (Sukari Ndizi), and Gros Michel banana (Bogoya)) were used for the study in addition to wheat flour, baking powder, bicarbonate of soda, caster sugar, refined oil ("Fortune butto"), and eggs.

Banana Cake-making Process

The banana cake-making process involved the following ingredients:

- 600 grams of banana
- 600 grams of Azam baking flour
- 350 grams of sugar
- 7 eggs
- 5 teaspoons of sugar
- ½ teaspoon of baking soda
- 5 teaspoons of baking powder
- 3 tablespoons of water.



Procedure

The oven was preheated to 180 °C/160 °C Fan/Gas 4, and a 9x6 loaf tin was greased and lined with a baking loaf sheet. A mixture of flour, bicarbonate soda, and baking powder was prepared and added to peeled and mashed bananas, eggs, water, sugar, and oil and blended. The resultant mixture was poured into the prepared tin and baked for 40 minutes until well-risen, with a skewer inserted into the center. Following a 10-minute cooling period in the tin, the cake was turned out onto a wire rack, ready to be served warm or cold in slices. The commercial control cakes had vanilla flavors, one of the most liked flavours in the country, to assess the baseline sensory characteristics of cakes without the influence of banana flavor. The cakes were cut into equal portions and presented to the participating 180 judges.

Data Collection Methods

Primary data collection methods included questionnaires, interviews, document reviews, and observation techniques. The questionnaires incorporated both closed and open-ended queries. The cakes were randomly assigned to the participants in a blind taste test where participants evaluated samples without knowing which banana species each cake represented. Sensory characteristics were assessed using a 1-10 hedonic scale score analysis, including color, flavor, texture, appearance, and overall acceptance. An observation checklist focused on texture, aroma, appearance, and taste in banana cake samples.

Data Presentation and Analysis

Results were systematically categorized into banana cake-making characteristics, sensory evaluation outcomes, and customer preferences for banana cakes derived from three distinct banana species, with plain cakes as a control. The subsequent analysis involved the organization and presentation of data to extract meaningful conclusions from the study.

Statistical Analysis

The data used in the study were statistically analyzed using Minitab software (version 21). One-way analysis Of Variance (ANOVA) tests were conducted on all the parameters under study at a 95% confidence level. The post hoc test used was Tukey's, performed for multiple comparisons if the ANOVA results indicated significant differences between the groups.

RESULTS

Gender distribution

The cake study involved a cohort of 180 participants, and their gender distribution demonstrated a balanced representation, with 33% males and 67% females, as shown in Figure 1.

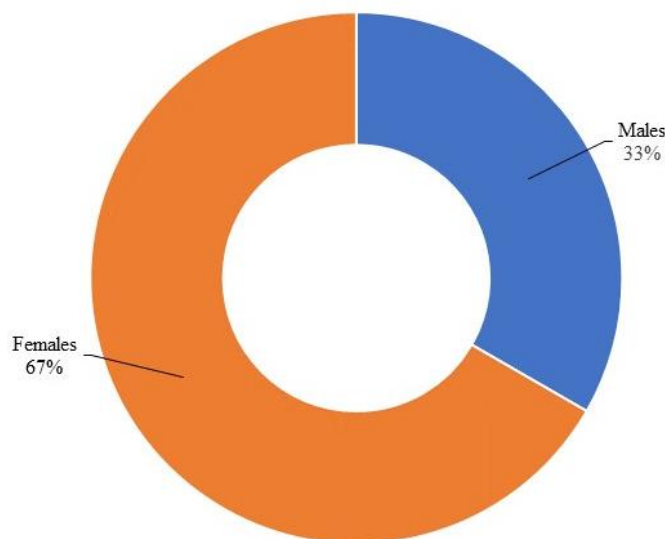


Figure 1: The gender of the participants

Education background

In the study, 45% were undergraduate students, 23% were diploma students, 13% were certificate students, and 11% were graduate students. Only 8% of the participants were University staff (Figure 2).

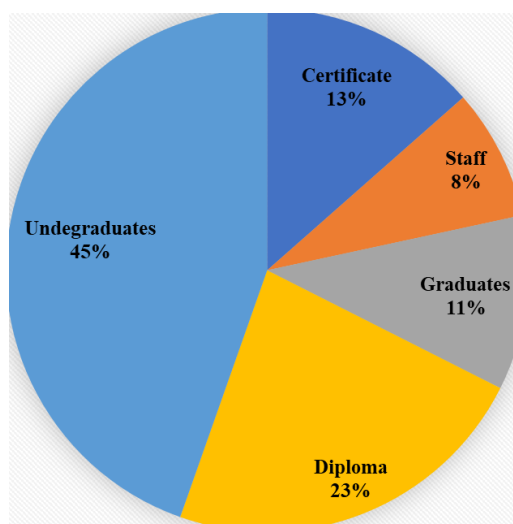


Figure 2: The educational background and occupation status of the participants

Age group of the participants

The age demographics of the participants in the cake experiment were as follows: aged 18 to 25, constituting 73% of the total sample, 25-35 age range, comprising 17%, while the age group of 35-50 constitutes 10%.



Cake Evaluation Survey Results

The following tables 1 - 4 summarize the responses from participants in the cake evaluation survey. Respondents were asked to rate their preferences for cakes made from different ingredients based on appearance, aroma, texture, and taste, using a Likert scale from 1 to 5 (SA: Strongly Agree, A: Agree, N: Neutral, DA: Disagree, SDA: Strongly Disagree).

Cake Appearance Assessment

The results from the appearance assessment of cakes in Table 1 show varying preferences among the participants in the cake experiment. Cakes made from EAH bananas received widespread approval, with 52% expressing a strong liking and 28% indicating a positive stance. In contrast, cakes made from Apple bananas exhibited mixed reactions, as 13% expressed a positive liking, 17% held a neutral stance, and 42% leaned towards dissatisfaction. Cakes crafted from Gros Michel bananas garnered substantial favor, with 70% expressing a positive liking and 30% showing a moderate preference. Commercial vanilla cakes emerged as the clear favorite, with a notable 62% expressing a strong liking and an additional 38% indicating a positive stance. These findings show variations influenced by the banana variety and commercial status, thereby contributing to understanding consumer perceptions of cake aesthetics.

Table 1. Appearance of the cakes

Question	SA	A	N	DA	SDA	Total (%)
I like the appearance of cakes made from EAH banana	52b	28c	-	-	-	100
I like the appearance of cakes made from Apple banana	13d	17d	42	-	-	100
I like the appearance of cakes made from Gros Michel banana	30c	70a	-	-	-	100
I like the appearance of commercial cakes	62a	38b	-	-	-	100

The numbers provided are average values.

Cake aroma assessment

The examination of participants' responses to the aroma of cakes, as presented in Table 2, shows that cakes made from EAH banana were most liked, with 73% expressing a strong liking for the aroma and an additional 27% indicating a positive stance. Similarly, cakes made from Apple banana and Gros Michel banana demonstrated favorable reactions, with 80% and 70% expressing a strong liking for their respective aromas, complemented by 20% and 30% indicating positive preferences. Commercial vanilla cakes emerged as a clear favorite in terms of aroma, with an overwhelming 85% expressing a strong liking and an additional 15% indicating a positive stance.

**Table 2. Aroma of cakes**

Question	SA	A	N	DA	SDA	Total (%)
I like the aroma of cakes made from EAH banana	73c	27b	-	-	-	100
I like the aroma of cakes made from Apple banana	80a	20c	-	-	-	100
I like the aroma of cakes made from Gros Michel banana	70c	30ab	-	-	-	100
I like the aroma of commercial cakes	85a	15d	-	-	-	100

The numbers provided are average values.

Cake textures

The examination of participants' responses to the texture of cakes, as illustrated in Table 3, reveals that cakes made from EAH banana demonstrated a balanced liking, with 53% expressing a strong preference for the texture and an additional 47% indicating a positive stance. Conversely, cakes made from Apple bananas displayed a clear preference, with 70% expressing a strong liking and 22% indicating a favorable preference, though 8% leaned towards dissatisfaction. Cakes made from Gros Michel bananas exhibited mixed reactions, with 25% expressing a strong liking, 8% holding a neutral stance, and 67% indicating dissatisfaction. Commercial vanilla cakes emerged as a clear favorite in terms of texture, with 66% expressing a strong liking, 28% indicating a positive stance, and a minor 6% leaning towards dissatisfaction.

Table 3. The texture of the cakes

Question	SA	A	N	DA	SDA	Total (%)
I like the texture of cakes made from EAH banana	53b	47b	-	-	-	100
I like the texture of cakes made from Apple banana	22c	70a	8	-	-	100
I like the texture of cakes made from Gros Michel banana	25c	-	8	-	67	100
I like the texture of commercial cakes	66a	28c	6	-	-	100

The numbers provided are average values.

Taste of the cakes

The analysis of participants' responses to the taste of cakes is presented in Table 4. Cakes made from EAH banana emerged as the overwhelming favorite, with an impressive 90% expressing a strong liking for the taste and 10% indicating a favorable preference. Cakes made from Apple bananas demonstrated a balanced preference, with 50% expressing a strong liking and an additional 50% indicating a positive stance. Gros Michel banana cakes generated favorable reactions, with 75% expressing a strong liking and 25% indicating a favorable preference. Commercial vanilla cakes stood out as the clear favorite in terms of taste, with an exceptional 93% expressing a strong liking and 7% indicating a favorable preference.

**Table 4. Taste of the cakes**

Question	SA	A	N	DA	SDA	Total (%)
I like the taste of cakes made from EAH banana	90a	10c	-	-	-	100
I like the taste of cakes made from Apple banana	50c	50a	-	-	-	100
I like the taste of cakes made from Gros Michel banana	75b	25b	-	-	-	100
I like the taste of commercial vanilla cakes	93a	07c	-	-	-	100

The numbers provided are average values.

Cake Purchase Preference

The evaluation of participants' preferences and purchase intent (Figure 3) for Apple banana, Gros Michel banana, EAH banana, and commercial vanilla cakes offers a detailed understanding of consumer behavior in the cake experiment. For Apple banana cakes, 66.67% of participants expressed a high purchase intent, indicating eagerness for frequent purchases. In comparison, 20% exhibited moderate intent, 8.33% were neutral, and 3.33% had low intent, revealing mixed sentiments and reluctance. Gros Michel banana cakes garnered positive responses, with 68.33% displaying a high purchase intent, 20% having a moderate intent, 11.67% expressing a neutral stance, and none indicating a low intent. EAH banana cakes emerged as a clear favorite, with 88.33% expressing a high purchase intent, 16.67% having a moderate intent, and 11.67% neutral. Commercial vanilla cakes showed strong appeal, with 93.33% exhibiting a high purchase intent, 6.67% indicating a moderate intent, and 1.67% each expressing a neutral and low intent.

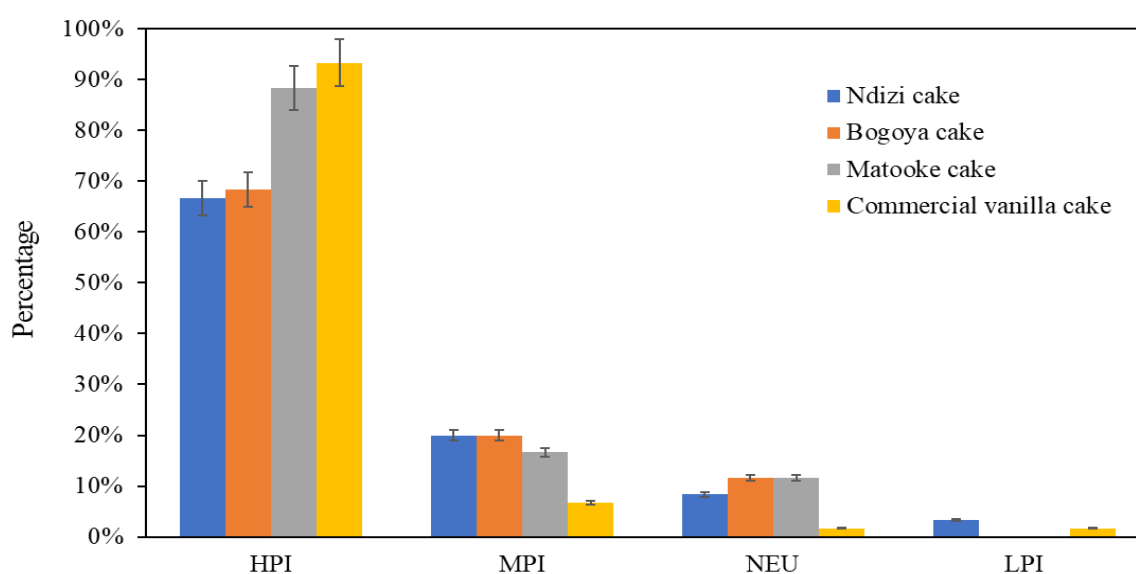


Figure 3: The participants' diverse purchase preferences are categorized into four groups based on their purchase intent (PI). The following are the meanings for each abbreviation: HPI: High



Purchase Intents shows Eager and Frequent Purchases; MPI: Moderate Purchase Intent shows Liked with Occasional Purchases; NUE: Neutral shows Would Buy if Available, but Not Actively Seeking; LPI: Low Purchase Intent shows Mixed Sentiments and Reluctance.

Overall cake preference

Upon analyzing the participants' preferences and purchase intent, EAH banana cakes emerged as the top choice banana cake, showcasing the highest overall preference, with 88.33% expressing a high purchase intent. Commercial vanilla cakes, although the reference point, also demonstrated strong appeal, with a high overall preference of 93.33%. Gros Michel banana cakes followed closely with an overall preference of 68.33%, expressing a high purchase intent. While positive in overall preference, Apple banana cakes showcased slightly lower figures, with 66.67% displaying a high purchase intent.

DISCUSSION

Distinctive consumer preferences have surfaced across various dimensions in the cake evaluation survey, shedding light on the potential for value addition to perishable goods, specifically EAH banana, Apple banana, and Gros Michel banana. The appearance assessment demonstrates that EAH banana and commercial vanilla cakes are leaders in eliciting positive reactions, emphasizing the pivotal role of visual appeal in consumer choices (Goto et al., 2019). These findings are relevant for strategic considerations of aesthetics in product development and marketing to compete effectively in the cake market. Positive reactions to EAH banana cakes show a future in reducing waste and increasing the value of this abundant resource, aligning with studies highlighting the positive impact of product aesthetics on usage behavior and consumer decision-making (Rössel et al., 2021; Solanki, 2018).

In the aroma assessment, positive reactions for EAH banana, Apple banana, and Gros Michel banana cakes underscore the significance of olfactory appeal in consumer preferences. Commercial banana cakes, as the preferred choice, emphasize the pivotal role of a pleasant aroma in influencing consumer choices. Aromatic elements can enhance consumer satisfaction and reduce waste (Goto et al., 2019). Texture preferences demonstrated liking patterns, with EAH banana and commercial vanilla cakes standing out as favorites. Understanding these preferences is crucial for achieving desired sensory experiences in cake products. In contrast, mixed reactions to Gros Michel banana and Apple banana cakes highlight the need for careful consideration of texture in product development. Opportunities for diversifying cake products, primarily through utilizing EAH banana, were identified, catering to different texture preferences and potentially increasing consumer acceptance (Kiswandono, 2019).

The taste analysis of EAH banana and commercial vanilla cakes emphasizes a strong correlation between taste satisfaction and overall preference (Guiné, 2022; Oludolapo et al., 2020). Making cakes with appealing tastes is paramount for market success, with the overwhelming preference for EAH banana and commercial vanilla cakes indicating the potential for value addition through flavorful products. EAH banana, an abundant and underutilized resource, can play a key role in developing cakes that cater to consumer taste preferences and contribute to waste reduction. Influenced by ingredient type and amount, baking methods, and sensory characteristics, taste analysis is crucial in determining consumer



satisfaction and repurchase decisions. Lastly, evaluating participants' purchase intent provided a comprehensive understanding of consumer behavior, aligning high purchase intent with the overall preference for commercial vanilla cakes and EAH banana cakes. Varying intent for Apple banana and Gros Michel banana cakes emphasizes the need for targeted marketing strategies, with high purchase intent for EAH banana cakes aligning with the study's objective of increasing value and reducing waste (Jack 2016; de Souza et al. 2018). These agree with other studies, suggesting that factors like functional potential, sugar reduction, and health benefit statements contribute to a high purchase intent for banana cakes.

CONCLUSION

Our research successfully addressed the pressing challenge of perishable bananas, specifically EAH banana, Apple banana, and Gros Michel banana, facing wastage in East Africa by investigating opportunities for value addition through cake production. This is the first paper in which EAH banana, originally known for food only, has been used for cake making, reducing EAH banana wastage. The encouraging responses from consumers regarding the appearance, aroma, texture, and taste of EAH banana cakes highlight their substantial potential for value addition. As the most abundant and economically viable resource among the studied fruits, the EAH banana stands out as an up-and-coming ingredient for cake production. The observed high purchase intent reflects a strategic market demand, positions EAH banana as a key player in waste reduction efforts, and augments the value of this readily available resource.

The findings derived from our study can serve as a foundation for future strategies aimed at transforming perishable goods into value-added products. This strategic shift has the potential to drive economic growth and alleviate the adverse impact of food waste. The focus on flavor profiles, textures, and aromatic qualities provides actionable insights for developing and marketing banana-based cakes. By capitalizing on these attributes, stakeholders can create products preferred by consumers, thus contributing to a sustainable and economically viable solution for reducing waste in the region.

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Statements and Declarations

Conflict of interest

No conflict of interest

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