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Hybrid Banana Palatability and Preference Analysis in the Major Banana Production South Western Agro-Ecological Zone, Uganda

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Abstract

Both agronomic and palatability traits influence acceptance of banana varieties by the farmer, the market and the consumer in the major banana production and consumption South Western Agro-Ecological Zone (SWAEZ) of Uganda, where depending on use, the variety that yields the most "output" is preferred. Continuous decline in banana productivity, which results from the current climate change-triggered stresses of insufficient soil moisture, soil infertility, prolonged dry spells resulting from unfavourable high temperatures, severe pest and disease pressure has been documented. Because, most well adopted banana cultivars and/or landraces are not resistant to the prevailing abiotic and biotic stresses, research has been compelled to focus on breeding banana varieties, which are highly resistant to such stresses. The cooking hybrid banana was developed through joint research by the National Agricultural Research Organisation (NARO) and International Institute of Tropical Agriculture (IITA) in Uganda, to increase banana productivity (yield) and improve its resistance to the major pests and diseases. This study focused on the key consumer preference attributes, which determine the farmers' and consumers' acceptability and adoption of hybrids. The local *Mbwazirume*, an East African Highland Banana (EAHB) cooking cultivar was the most preferred based on its high probability of acceptance (PoA) as steamed finger pulp and steamed-mashed-pulp, whereas the hybrids were mostly preferred as juices. Apple Banana (locally known as *Kabaragara*), NARITA 4, NARITA 22, NARITA 24 and NAROBAN 4 (NARITA 27) had higher sugar contents (Brix) than the rest of the cooking and dessert varieties. The moderate to high probabilities of acceptance of hybrids: NAROBAN 5, NARITA 22, NARITA 17 and NARITA 4 as food and juices were close to *Mbwazirume* and FHIA 25 or *Kabaragara,* respectively. The cooking hybrids had higher Brix or sugar contents than the local varieties, which indicated that probably some of their parent plants were from the sweet types. Therefore, both the local and hybrid banana varieties can serve as food (fresh and processed), and when properly ripened, they can be used in sweet banana-based product development. Consumer preference has been found to be a key determinant of the banana varieties that the farmer and the market should supply, which also, indirectly affects the profitability and sustainability of banana-trade. Therefore, breeders need to prioritize the consumer preferred banana attributes when developing varietal technologies that they expect farmers to adopt.

Subject Areas

Agricultural Science

Keywords

Banana Hybrids, Palatability, Food and Juice, Consumer Preference

1. Introduction

Globally banana (*Musa* spp.), is a multipurpose tropical plant produced mainly for human nutrition, health benefits and industrial processing [1]-[3]. In Sub-Saharan Africa, *Musa* banana is also a major livestock feed [4], soil fertilizer [5] [6], like elsewhere, a resource for building shelters in rural areas [7] [8] and making hand crafts [9].

A perennial crop that reproduces through overlapping cycles, with a yielding potential of 100 t/ha, a banana plant has a very high soil water utilization rate of ≥5 litres per day during early plant establishment and ≥25 litres per day for reproductive plants. Banana macro-nutrient (Nitrogen-N, Potassium-K, Phosphorus-P, Calcium-Ca, Magnesium-Mg and Sulphur-S) and micro-nutrient (Boron-B, Copper-Cu, Iron-Fe, Manganese-Mn and Zinc-Zn) requirement for optimal growth, fruit development, carbohydrate synthesis and translocation in its above and below ground tissues (leaves, stems, fruits, corms and roots) have been documented [10]. A balanced amount of both macro- and micro-nutrients supplemented with sufficient water supply all year around ensures enhanced banana productivity [11]. The key mineral nutrients required by banana include potassium, nitrogen, magnesium, sulphur, boron, copper, iron, manganese, molybdenum, and zinc, but the level of consumption of these nutrients varies with cultivar, phenology and environment [10], which significantly affect banana palatability [12]. Because of its high nutrient demand, various recommendations have been made of which application of 7 - 8 Kg N, 0.7 - 1.5 Kg P and 17 - 20 Kg K per metric tonne per yield was found ideal, and based on a study carried out in

Uganda, a single blanket rate of 100N-30P-100K-25Mg kg per hectare per year was recommended [11].

The East Africa Highland Banana cooking type exists in numerous varieties of which more than 50 cultivars are grown in the South Western Agro-Ecological Zone of Uganda. Marketability or consumer preference influences the level of variety adoption by farmers, where varieties that are high yielding, produce big bunches, highly abiotic stress tolerant and possess preferred sensory qualities are priority. Also, for dessert banana/plantain *Musa* species (spp.), farmers and end users prefer varieties with appealing and good agronomic attributes. Farmers' and end-users' most desired traits are high yields, good cooking qualities [13] and climate resilience [14]. Previously, Mulugo *et al.*, revealed that gender influences banana cultivar adoption, where men preferred high-yielding varieties with desirable traits like bunch and finger size, while women preferred early-maturing cultivars with specific organoleptic banana food attributes: pulp colour, food colour, texture, aroma and taste [15]. Even if new cultivars have better agronomic traits and better response to biotic and abiotic stresses, research has shown that farmers still prefer local cultivars because of their superior consumption attributes (good taste, soft food texture, good aroma, and good/yellow colour) [16]-[18].

Out the numerous (~130) banana varieties grown in Uganda among the banana growers and consumers in both rural and urban areas, the local cultivars and landraces are the most common [19] [20], and preferred compared to the improved cultivars. Even when the improved cultivars have been developed to address major problems associated with agronomic traits, abiotic and biotic stresses, the rate of improved or hybrid banana adoption by farmers has remained very low in the South Western Uganda [21] [22]. In a study to assess farmers' choice among developed hybrid banana varieties in Uganda, the local *Mbwazirume*, was the most preferred by farmers because it had large bunch sizes, good food taste, soft texture and good flavour. While for years, banana improvement research has been focused on developing varieties with superior agronomic traits, a study found out that quality characteristics were rated higher than the agronomic performance among the farmers, the market (traders) and end users/consumers. In the above study, five (*Nakitembe, Mbwazirume, Kibuzi, Musakala* and *Mpologoma*) of the following varieties (*Nakitembe/Entaragaza, Kibuzi, Enyeru, Mbwazirume, Musakala, Mpologoma, Enjagata, Muvubo, Kisansa, Embururu, Rwamigongo, Nakyetengu, Majaga, Butobe, Enzirabushera, Entukura*, FHIA, *Kabana, Lusumba, Nakawere* and *Nakinyika*), were identified for making good banana food as the most preferred because of their softness, taste, good yellow colour, big finger size and big bunch size [21].

The vulnerability of the local banana cultivars to climate change, which continues to negatively affect the plant phenology and productivity due to the changing unfavourable rainfall patterns and higher temperatures, negatively impact banana production and farmers' returns to investment in Uganda. Under climate change, increasing unfavourable weather characterised by prolonged dry spells and erratic rains leading to water stress have become common and create favourable conditions for increased pest and disease prevalences, which further threatens banana cultivation by escalating crop damage and yield losses. These impacts create significant challenges for food security and farmer livelihoods, necessitating adaptation strategies such as developing abiotic and biotic-stress resistant cultivars [23].

Cooking hybrid varieties were developed to improve banana productivity and production in Uganda. With evidence, the hybrids are high yielding, and produce big banana bunches even under severely unfavourable conditions under which the local cultivars totally fail [13] [16]. Hybrids produce and maintain many green leaves that are disease-free, which support development of big fruit bunches. However, limited research attention has been paid to the quality attributes based on hybrid banana palatability/sensory analysis by consumers in the South Western Uganda. The primary aim of this research was to analyse the consumers' acceptability of new cooking banana hybrids in comparison with local cultivars/landraces, utilizing matrix scores and preference ranking based on the four key culinary attributes. The study evaluated the palatability of East African Highland Banana cooking varieties (hybrid and local cultivars/landraces) through sensory evaluation of unpeeled steamed fingers (*Empogora*), peeled steamed-mashed pulps (*Emibumba* commonly known as *matooke* in Uganda) and fresh juices, using the matrix scores and logistic preference ranking analysis [24].

2. Materials and Methods

The palatability analysis and preference ranking were carried out using seven hybrid banana lines (NARITA 4, NARITA 17, NARITA 18, NARITA 22, NARITA 24, NAROBAN 4/NARITA 27 and NAROBAN 5/NARITA 30), described in **Table 1**. These varieties were developed by the National Agricultural Research Organization (NARO) in collaboration with the International Institute of Tropical Agriculture (IITA). The tissue culture plantlets were provided by Dr. Ivan Kabiita Arinaitwe a Plant breeder formally based at the Banana Programme of the National Agricultural Research Laboratories Kawanda of the National Agricultural Research Organisation, Kampala, Uganda. Ninety-five tissue culture plantlets of the improved banana hybrids and 15 plantlets of a local variety (*Enzirabahima*) were planted on the 12th December 2022 in a randomized complete block designed experiment, with eight 21 m × 12 m plots replicated three times in the field at the Mbarara Zonal Agricultural Research and Development Institute (MbaZARDI). For sensory evaluation, three fully mature bunches were harvested from each of the five plants of the seven hybrids, in each replication. The test samples of the two desserts (FHIA 25 and Apple banana/*Kabaragara*) and the local market preferred cooking cultivar (*Mbwazirume*) (**Table 2**) were similarly collected from a similar trial that was established for the non-hybrid types in the same period, environment and grown under the same agronomic management system and cycle. Three fully mature banana fruit bunches were harvested from each of the five mother plants per cultivar per replication, and the middle fingers from the

Table 1. East African highland banana cooking hybrid, dessert and the local cultivars tested for palatability in the South Western Agro-Ecological zone of Uganda.

Variety name	Pedigree	Year of release	Owners and seed source in Uganda	Altitude	Duration to maturity (days)	Potential yield (Kg/ha/Yr)	Special attributes
NARITA 4	'Enzirabahima' (AAA) *Musa acuminata* ssp., *burmannica* (Calcutta 4), 'Tjau Lagada' (AA) and 'Pisang Lilin' (AA).	2021	NARO/ IITA	1000 - 1600	149	64.4	Tolerant to weevils and nematodes, resistant to black leaf streak disease, high yielding and big bunch size.
NARITA 17	'Entukura' (AAA), *Musa acuminata* ssp., *burmannica* (Calcutta 4) and *Musa acuminata* ssp., *banksia* (Madang).	2025	NARO/ IITA	1000 - 1600	156	63.0	Resistant to black leaf streak disease, moderate resistance to weevils, tolerant to nematodes, resistant to *Fusarium oxysporum* f.sp., *cubence* (*FOC*-TR4, *FOC*-R1).
NARITA 18	'Kabucuragye' (AAA), *Musa acuminata* ssp., *burmannica* and 'Enzirabahima' (AAA)	2021	NARO/ IITA	1000 - 1600	140	68.2	Resistant to black leaf streak disease, tolerant to weevils and nematodes.
NARITA 22	'Enzirabahima' (AAA) *Musa acuminata* ssp., *burmannica* (Calcutta 4), 'Tjau Lagada' (AA) and 'Pisang Lilin' (AA).	2013-2014	NARO/ IITA	1000 - 1600	151	54.2	High yield of up to 54.2 t/ha/yr., resistant to black leaf streak disease, tolerant to weevils and nematodes.
NARITA 24	Unknown	Unknown	NARO/ IITA	1000 - 1600	149	62.6	Resistant to black leaf streak disease, tolerant to weevils, tolerant to nematodes.
NAROBAN 4 (NARITA 27)	'Nkuuka' (AAA), *Musa acuminata* ssp., *burmannica* (Calcutta 4), 'Sinwobogi' (AA), 'Tjau Lagada' (AA), 'Guyod' (AA), 'Pisang Jari Buaya' (AA) and *Musa acuminata* ssp., *malaccensis*.	2017	NARO/ IITA	1000 - 1600	126	66.9	Resistant to black Sigatoka, tolerant to nematodes and weevils. Exceptionally high-yielding potential (~69 t/ha/year).
NAROBAN 5 (NARITA 30)	Unknown	2019	NARO/ IITA	1000 - 1600	150 - 160	54.5	Big fruit size, resistant to black leaf streak disease, highly resistant to weevils, resistant to nematode, high-yielding (~54.5 t/ha/year); preferred consumer traits/tasty food.

Continued

ENZIRA-BAHIMA	Unknown	Unknown	Landrace	900 - 1800	98	21.0	Susceptible to moisture stress, diseases and pests (black leaf streak disease and weevils), and possesses preferred consumer traits.
MBWA-ZIRUME	Unknown	Unknown	Landrace	1000 - 1600	90 - 120	23.3	Highly preferred for its superior food taste, soft texture, and good flavour when cooked. Intermediate bunch weight (≥18 kg); high market acceptability but susceptible to black leaf streak disease, weevils and nematodes.
FHIA 25	4xSH-3648x2xSH-3142	Unknown	Honduran hybrid	1000 - 1500	120 - 150	50 - 120	Resistant to Fusarium wilt race 1, highly resistant to black leaf streak, high very high yielding.

Sources: Tushemereirwe *et al.*, 2015 [40]; https://www.promusa.org/NARITA+hybrids [41]. Karamura *et al.*, 2012 [20]; Ilukor *et al.*, 2025 [42].

Table 2. Phenotypic characteristics of the East African highland Banana cooking hybrid, dessert and the local cultivars grown for palatability evaluation in the South-Western Agro-Ecological Zone, 2022-2024.

Hybrid variety	Banana fruit bunch	Split mature banana Fruit pulp colour	Hybrid variety	Banana fruit bunch	Split mature banana fruit pulp colour
NARITA 4			NARITA 24		
NARITA 17			NAROBAN 4		
NARITA 18			NAROBAN 5		

Continued

NARITA 22			*ENZIRABAHIMA*		
MBWA-ZIRUME			APPLE BANANA (*KABARAGARA*)		

second cluster from the bunch-top were prepared for sensory testing as unpeeled steamed fingers, peeled steamed-mashed pulps and fresh juices.

Cooked banana food was prepared using 10 fingers that were uniformly picked from the middle of every second hand of a fully mature bunch of the above nine cooking test cultivars. Fresh unpeeled and peeled banana fingers were washed and steamed in banana leaves until they were well-cooked and ready to eat. The well-cooked steamed peeled banana pulp of each variety was gently mashed until it became uniform and smooth for the further steaming on low heat to get it softer and flavoured. The unpeeled cooked fingers were maintained on lower to keep them hot and soft.

For juice preparation, well matured bunches of the 11 cultivars that were ripened to stage five (peel colour is bright yellow, with minor green typically found only at the very tips of fruit, fruit is still relatively firm with pleasant sweetness and a good texture, a perfect ripeness for eating with a sweet flavour) [25], under natural conditions were separately peeled. The pulp of each cultivar was added to corresponding containers of hot water at the temperature of 100˚C in a ratio of one kilogram (Kg) of banana pulp to two litres of water [26]. After adding the banana to the hot water and mixing, the temperature dropped. The mixtures were reheated to restore and maintain their temperatures at 85˚C for 30 minutes. After 30 minutes, each mixture was strained or filtered into clean containers using a cheesecloth secured with a strong string. The resulting fresh banana juices were further cooled and maintained at room temperature, awaiting evaluation.

The banana food samples of steamed whole fingers and mashed pulps were tested and evaluated by a 16-member panel, while the two-juice cycles were tested by a similar 10-member panel. To be selected as a panellist, individuals that had banana as their major food; liked/enjoyed eating the banana as cooked food, ripe fruits and juices; were adults who were interested in participating and voluntarily consented by registering/signing were allowed to participate. The selected panellists were trained on how to use their four senses to test the colours, flavours, textures and tastes of different banana variety food samples based on the 1 - 5 matrix scales and preference ranking. On day 1, the two hot steamed banana samples were served, and well labelled using codes for the 16 panellists to assess them without bias, and take notes as required in the data collection sheets. Each panellist tested all banana samples as steamed-fingers and steamed-mashed pulps. A glass of clean drinking was provided to each panellist to be used to rinse his/her mouth between the different sample tests. The freshly made juice samples of 11 varieties were evaluated by 10 panellists in two cycles. Because different banana varieties tend to have varying maturity periods especially when the plantation is still young and the mother plants have not produced many suckers, we failed to harvest mature banana fruits from all the varieties for the first cycle, so, every set of banana varieties that would have mature fruits would be tested. Therefore, first cycle combined results from the 11 varieties separately tested. In the second cycle, all 11 varieties had mature fruits for us to uniformly extract fresh juices as described in the first cycle. Each well-labelled set of 11 samples of juice was randomly served, and analysed by the different individuals in the panel at once.

Brix or total soluble solids (TSS), which is primarily sugar content a direct indicator of the sweetness and flavour of banana juice was measured using A Contrast 0% - 32% Brix ATC Refractometer or ERMA Hand Refractometer (ERMA INC. Tokyo Japan), which is calibrated to measure 0 - 32 g per 100 g of the sample (2 - 3 drops). This was done to find out the cultivar that produced juices that meet the consumer's preferred taste, since high Brix level typically correlates to a richer and sweeter flavour. A few drops of each extracted, filtered, non-diluted and diluted juice were placed on the prism of a hand-held refractometer that had been calibrated with distilled water [27]. The refractive index of each sample juice was converted by by the refractometer to a percentage Brix value and recorded.

Palatability data of unpeeled steamed fingers, peeled steamed-mashed pulps and fresh juices, were collected based on sensory parameters that included: colour, flavour, texture and taste using the matrix scale of 1 - 5 (1 = very bad, 2 = bad, 3 = fair, 4 = good, 5 = very good). The 1 - 5 scale was used in the sensory evaluation because it correctly modelled human sensory qualitative ratings, which were categorical and ordered as quantitative variables (1 = very bad to 5 = very good) in analysis; it was suitable for scoring the uniformly prepared banana variety samples across the four test parameters; it gave specific numeric figures for every response; its narrow range minimised the range of variation or error within the data sets, and it was easy to apply by the selected individuals. The varying data generated by the different members of the panels, to determine whether the recorded sensory data were actual, and not merely results of uncontrolled variation in responses, the One-Way ANOVA was carried out to assess the statistical significance of variations within each set of data per attribute/parameter. The analysis based on one-way ANOVA (analysis of variance) was conducted to compare the effect of the banana variety [independent variable] on sensory attributes [dependent variable] using the single categorical factor, while effectively preventing errors. The matrix scores (1 - 5) and preference ranking data sets were entered in MS-Excel and analysed using the Statistix analytical software version 10. The means that revealed statistically significant differences among the varieties were separated using the least significant difference (LSD) at the probability level of 5% with the following formula: $LSD_{A,B} = t_{0.05/DFW}\sqrt{MSW\left(1/n_A + 1/n_B\right)}$. Where: t = critical value from the t-distribution table, MSW = mean square within, obtained from the results of the ANOVA test, n = number of scores used to calculate the means.

Preference ranking was based on the panel's choice reasons using sensory parameters (colour, flavour, texture and taste). The most preferred varietal samples of steamed food or juice, were separately ranked number 1, while the least preferred variety was rank last under each attribute assessed by each panellist. Microsoft Excel 7 based logistic preference ranking analysis [24], was used to translate subjective sensory attributes of colour, texture, flavour, and taste into statistically robust probabilities of acceptance based on the number of times a particular variety was ranked in a specific position by the panellists. Ranking tests were used to measure relative preferences, by isolating how the specific attributes (colour, texture, flavour and taste) independently influence the overall acceptance or rejection of a banana variety, which verified and supported the matrix scores results, thus predicting the probability of the consumers' acceptance of a specific banana variety. The level of significance for the logistic regression at 15% ($p < 0.15$) was used to retain all potentially important predictors, accounting for the wide variability in the panellists' qualitative responses.

3. Results

3.1. Sensory Evaluation of Hybrid versus Local Banana Cultivars

The palatability study was carried out to determine the level of acceptability of new cooking hybrid banana varieties by consumers in the South Western Agro-Ecological Zone, bearing in mind that consumer-preference is a key driving force that determines the level of market-demand, directly influencing adoption, and indirectly affecting production and supply. Hybrid banana varieties were evaluated using three common consumption methods (unpeeled steamed fingers, peeled steamed-mashed pulps and fresh juices) based on qualitative attributes (colour, flavour, taste and texture) and preference ranking as described in the materials and methods. The one-way ANOVA, which was conducted to compare the palatability of the different banana cultivars showed that there were significant differences with least significant differences ranging from 0.5 to 1.1 at $P \leq 0.05$ in the colours, flavours, tastes and textures of the unpeeled steamed fingers, peeled steamed-mashed pulps and fresh juices.

Unpeeled steamed fingers: There was a significant difference within each of the parameters used to evaluate the steamed banana finger pulps for colour, flavour, taste and texture, with $F(7, 105)$ = 24.7, 6.4, 8.2 and 4.5, respectively, at $P \leq 0.05$, and the coefficient of variation (CV) range was 25.1 - 30.9. The local cultivar, *Mbwazirume*, had the highest average scores of very good pulp-colour, flavour/aroma, texture and taste (**Table 3**), of steamed banana finger pulps. Although NAROBAN 5/NARITA 30 had good scores in terms of colour, flavour and texture, its taste (3.8) was slightly lower than that of NARITA 22 (3.9). Apart from NARITA 24, which had below average scores for colour, flavour and taste, the rest of the hybrids had fair to good scores for the same sensory characteristics. Based on the taste parameter, *Mbwazirume*, NARITA 22 and NAROBAN 5 had good scores while NARITA 17 and NARITA 24 tasted bad; NARITA 4, NARITA 18 and the local *Enzirabahima* tasted fairly good. Apart from *Mbwazirume*, which had a good flavour, NARITA 4, NARITA 17, NARITA 18, NARITA 22 and NAROBAN 5 had fair to good flavours, while NARITA 24 had a bad flavour. The best attribute displayed by NARITA 17 was colour (3.7), but *Mbwazirume* followed by NAROBAN 5 had the best scores for finger pulp colour.

Peeled steamed-mashed pulps: There were significant differences within each of the parameters used to evaluate the steamed-mashed pulps for colour, flavour, taste and texture with $F(7, 98) = 27.2$, 7.8, 13.2 and 5.7, respectively, at $P \leq 0.05$, and the CV range was 23.6 - 28.1. The mashed banana pulps of the local variety (*Mbwazirume*) had the good to very good scores in all the four test parameters. *Enzirabahima*, had better scores than the hybrids in terms of colour and flavour, but its taste was not as good as that of NARITA 4, NARITA 18 and NARITA 22, while NARITA 18 had a better texture than *Enzirabahima* (Table 3). Although the nine banana food textures could be modified through cooking to suit the consumers' preferences, the natural food colour, taste and flavour of banana varieties cannot be adjusted through cooking to suit consumer preference. Therefore, *Mbwazirume* and *Enzirabahima* had the best scores for steamed-mashed pulps, followed by NARITA 18, which had good texture and taste but its colour and flavour

Table 3. Sensory evaluation of steamed fingers and steamed-mashed pulps of East African highland banana cooking hybrids versus local cultivars based on matrix scores, in the South Western Agro-Ecological Zone of Uganda.

STEAMED FINGERS					STEAMED-MASHED				
Variety/Cultivar	Colour	Flavour	Texture	Taste	Variety/Cultivar	Colour	Flavour	Texture	Taste
NARITA 4	2.8	2.7	2.5	3.3	NARITA 4	2.9	3.1	3.0	3.6
NARITA 17	3.7	2.9	3.5	2.4	NARITA 17	3.7	3.0	3.7	3.0
NARITA 18	3.1	3.4	3.3	2.9	NARITA 18	3.4	3.4	4.1	3.8
NARITA 22	2.3	3.4	3.5	3.9	NARITA 22	2.7	3.4	3.0	3.8
NARITA 24	2.0	2.4	2.8	2.4	NARITA 24	1.6	2.3	2.6	2.2
NAROBAN 4	2.0	2.8	3.1	2.8	NAROBAN 4	2.7	3.5	3.1	3.3
NAROBAN 5	3.8	3.6	3.9	3.8	NAROBAN 5	2.7	2.9	3.0	2.3
ENZIRABAHIMA	2.8	3.3	3.3	2.9	*ENZIRABAHIMA*	3.8	3.8	3.8	3.4
MBWAZIRUME	5.0	4.1	4.1	4.1	*MBWAZIRUME*	4.9	4.3	4.3	4.4
LSD ($P \leq 0.05$)	1.1	1.1	0.8	0.5	LSD ($P \leq 0.05$)	1.1	1.1	1.5	0.8
CV %	25.1	28.0	30.9	29.5	CV %	23.6	26.5	25.6	28.1

were fair/moderate. Apart from NARITA 24, which consistently had bad to fair characteristics, hybrids NAROBAN 4 and NAROBAN 5, had non-significantly different ($p \leq 0.05$) scores ranging from 2.7 (fair) to 3.5 (good) for most of the parameters (colour, flavour and texture).

Fresh juices: The juices extracted from nine cooking banana varieties that included seven hybrids and two local varieties plus two dessert types, were evaluated based on the four sensory parameters (colour, flavour, texture and taste) in two cycles. There was a significant difference at $P \leq 0.05$, within each of the parameters used to evaluate fresh banana juices. On average, juices from FHIA 25, NARITA 4 and NARITA 17 had good to very good scores of colour, flavour, texture and taste in the first cycle (Table 4). The pure dessert types (FHIA 25 and apple banana) had higher average scores (good to very good) than the cooking varieties, of which juices from NARITA 4 and NARITA 17 were good based on the panel's assessments. NAROBAN 4 and NAROBAN 5 had fair (colour and flavour) to fairly good scores of textures and tastes, which categorized them as the third highly scored varieties. The colours and textures of NARITA 22, NARITA 24, *Enzirabahima* and *Mbwazirume* juices were scored as fair or intermediate, while their taste scores ranged between bad and fair (1.7 - 3.0). In the second cycle, the most highly scored juice parameter was taste followed by texture, whereas colour and flavour were considered secondly. Based on taste, FHIA 25 and Apple banana had very good juices, while *Enzirabahima*, NAROBAN 4, NARITA 24, NARITA 18 and NARITA 4 had good juices. Juices from NARITA 17,

Table 4. Sensory evaluation of fresh juices of East African highland cooking banana hybrids versus local cultivars based on matrix scores in the South Western Agro-Ecological Zone of Uganda.

FRESH JUICES I					FRESH JUICES II				
Variety/Cultivar	Colour	Flavour	Texture	Taste	Variety/Cultivar	Colour	Flavour	Texture	Taste
NARITA 4	4.1	3.4	4.2	4.4	NARITA 4	3.5	3.8	3.7	3.5
NARITA 17	3.6	3.4	3.8	3.6	NARITA 17	3.2	3.2	3.5	3.0
NARITA 18	2.1	2.9	2.7	3.0	NARITA 18	3.5	3.5	3.8	3.5
NARITA 22	3.1	2.9	3.0	3.0	NARITA 22	3.3	3.3	3.8	3.3
NARITA 24	3.0	2.7	3.4	2.1	NARITA 24	3.4	3.2	3.8	4.2
NAROBAN 4	3.1	3.1	3.5	3.0	NAROBAN 4	3.3	3.5	4.2	4.1
NAROBAN 5	3.4	2.9	3.5	3.7	NAROBAN 5	2.8	2.5	3.3	3.0
ENZIRABAHIMA	3.2	2.1	2.9	1.7	*ENZIRABAHIMA*	3.0	3.7	4.1	4.2
MBWAZIRUME	3.1	2.8	3.1	2.9	*MBWAZIRUME*	3.2	3.2	3.3	3.4
FHIA 25	4.3	4.5	4.3	4.7	FHIA 25	4.0	3.0	2.0	5.0
APPLE BANANA	2.0	3.5	4.0	4.0	APPLE BANANA	2.8	3.5	4.5	4.5
LSD ($P \leq 0.05$)	1.2	0.7	0.8	0.9	LSD ($P \leq 0.05$)	0.3	0.5	0.9	1.1
CV %	23.3	27.5	25.1	22.2	CV %	20.3	24.5	22.1	23.2

NARITA 22 and *Mbwazirume* had fair tastes. Based on texture, *Enzirabahima* and Apple banana had good to very good juices; FHIA 25, NAROBAN 5 and *Mbwazirume* had bad to fair juices, while the juices from the remaining varieties had good textures. Based on juice colour and flavour, the varieties scored fair/intermediate to good, but the best variety was FHIA 25 for colour, whereas NARITA 4 and *Enzirabahima* were the best for flavour.

Overall, based on the significantly different means at $p \leq 0.05$ derived through the matrix scale of 1 - 5 (1 = very bad; 5 = very good), the local cooking banana cultivar, *Mbwazirume*, had higher scores (4.1 - 5.0) as unpeeled steamed fingers and peeled steamed-mashed pulp (4.3 - 4.9) based on colour, flavour, texture and taste, which are the key characteristics considered for banana variety acceptability by the market and consumers. NAROBAN 5 (NARITA 30), had higher scores as unpeeled steamed fingers based on the four parameters, but when peeled, steamed and mashed, its scores ranged from bad (2.3) to fair (3.0), implying that it is better consumed as unpeeled hot steamed fingers and not mashed. NARITA 22 had good scores as unpeeled hot steamed fingers based on texture and taste, but the peeled mashed pulp had a good score for the taste parameter only. NARITA 17 had good pulp colour and texture as both fingers and mashed pulps, but the flavour and taste of its fingers and mashed pulps were fair/intermediate. NARITA 18 had good scores for texture and taste as mashed pulp, but the colour and flavour of fingers were fairly good. NARITA 4 had one good attribute (taste) as mashed, whereas the rest of the attributes as fingers and mashed pulps were fair.

As fresh juice, FHIA 25, a pure dessert banana variety had the best scores for colour, flavour, texture and taste, while NARITA 4, which initially had fair to good scores for steamed fingers and mashed pulps for most attributes, had good scores for juice based on all four attributes. NAROBAN 4 and NARITA 17 had fair to good juice scores for texture and taste in the two cycles while the apple banana, which is a pure dessert type, scored good to very good in terms of flavour, texture and taste across the two cycles. Out of the seven hybrids, NAROBAN 5 had the highest average score as steamed fingers, while NARITA 17 and NARITA 22, which scored good for only two of the standard parameters, were most likely not to be accepted by the consumers as steamed fingers. As steamed-mashed pulps, NARITA 4, NARITA 18, NARITA 22 had good taste scores, because in order to be accepted, a banana variety must have constantly good to very good scores for all the four parameters, therefore, these varieties had high probability of being rejected by consumers. NARITA 4 and NARITA 18 had better juices than the rest of the hybrids, while NAROBAN 4, NARITA 17, NARITA 24, NAROBAN 5 and *Enzirabahima* had the second ranking juices. Nevertheless, FHIA 25 and Apple banana produced the best fresh juices, while *Mbwazirume*, NAROBAN 5 and *Enzirabahima* had the best steamed fingers and mashed banana pulps.

In summary, based on the average matrix scores, the promising first five highly scored varieties arranged in order of best to least were: *Mbwazirume*, NAROBAN 5, NARITA 22, NARITA 18 and NARITA 17 for steamed fingers, while for steamed mashed pulps the first 5 were *Mbwazirume*, *Enzirabahima*, NARITA 18, NARITA 17 and NARITA 22. There was no significant difference between *Mbwazirume* and NAROBAN 5 for the average sensory test of steamed fingers, while there were no significant differences among *Mbwazirume, Enzirabahima* and NARITA 18 for the average sensory tests of steamed-mashed pulps. The least scored varieties as fingers were *Enzirabahima*, NARITA 4, NAROBAN 4 and NARITA 24, while the least scored varieties as mashed pulps were NAROBAN 4, NARITA 4, NAROBAN 5 and NARITA 24.

3.2. Total Soluble Solids (TSS)/Brix of Banana Juices Extracted from Different Varieties

The total soluble solids (TSS) in the banana juices extracted at ripening stage five were quantified based on the "A Contrast 0 - 32% Brix" (Table 5). All the varieties tested in the current study had higher Brix with Apple banana, NARITA 4, NAROBAN 4, NARITA 22 and NARITA 24 having the highest sugar contents. The concentrated juices' Brix before dilution ranged from 16.0% in *Mbwazirume* to 28.0% in Apple banana (locally known as *Kabaragara*), whereas the diluted juice Brix ranged from 8.6% in NARITA 18 to 16.1% in *Enzirabahima*. Because Apple banana, NARITA 4, NAROBAN 4, NARITA 22 and NARITA 24 had higher Brix or sugar contents, they were sweeter and had good flavours than the rest of the varieties, implying that they are suitable for making sweet juice-based products. Interestingly, FHIA 25, which is popularly known for juice making, had a lower Brix content than the dessert and cooking banana varieties. The apple banana cultivar that had the highest Brix range (25.2% - 28.0% Brix), is naturally a sweet dessert type that is consumed when ripe at stages 5 - 7. The high sugar content in the cooking banana varieties, indicates that, when a banana is allowed to ripen, it accumulates soluble sugars, which can be extracted by either the hot-water

Table 5. Total Soluble Solids (TSS) or Brix of fresh banana juices of the East African highland banana cooking hybrids and local cultivars in the South Western Agro-Ecological Zone of Uganda.

Variety/Cultivars	Concentrated Juice Brix before dilution %	Juice Brix after dilution % (1:1)
NARITA 4	22.3 - 24.1	9.0 - 11.2
NARITA 17	18.1 - 19.3	10.0 - 11.2
NARITA 18	17.3 - 18.3	8.6 - 10.0
NARITA 22	20.5 - 21.3	13.3 - 13.8
NARITA 24	21.0 - 21.4	11.0 - 11.0
NAROBAN 4 (NARITA 27)	22.1 - 23.2	11.1 - 11.3
ENZIRABAHIMA	17.0 - 21.0	12.1 - 16.1
MBWAZIRUME	16.0 - 19.3	12.1 - 15.4
APPLE BANANA (*KABARAGARA*)	25.2 - 28.0	10.2 - 13.0
FHIA 25	16.8 - 17.0	13.0 - 13.4

or enzyme methods. Cooking hybrid varieties had higher Brix or sugar contents than the local varieties (Table 5), which indicated that probably some of their parents were sweet types. Therefore, both the local and hybrid banana varieties can serve as food (fresh and processed), and when properly ripened, they can be used in sweet banana-based product development.

3.3. Banana Probability of Acceptance Based on Preference Ranking with Logistic Regression Analysis

Unpeeled steamed fingers: The probability of acceptance results based on banana variety preference ranking of steamed fingers showed that *Mbwazirume* (local) had the highest probability of acceptance (75.0%) in the first position (Figure 1), and was ranked as the most preferred variety. At preference ranking position two, *Mbwazirume* maintained the highest probability of acceptance with 87.5%, and 100% probability of acceptance at position three (Figure 1). At the first preference ranking position, NAROBAN 5 (NARITA 30) was ranked as second with the intermediate probability of acceptance (37.5%), and gained the high rank in position two (87.5%). At rank positions three and four, *Mbwazirume* and NAROBAN 5 maintained the highest (87.5% - 100%) probabilities of acceptance, while NARITA 17 and NARITA 22 also ranked high with 75.0%. Based on this steamed finger analysis, NAROBAN 5 (NARITA 30) and *Mbwazirume* had relatively high slopes with positive b-intercepts that were statistically different at the 15% level of significance, which indicated high levels of acceptance in the first place of ranking (Table 6). The rest of the hybrids and local varieties had high slopes with negative b-intercepts, which indicated high probabilities of rejection as regards the first positions of the ranking.

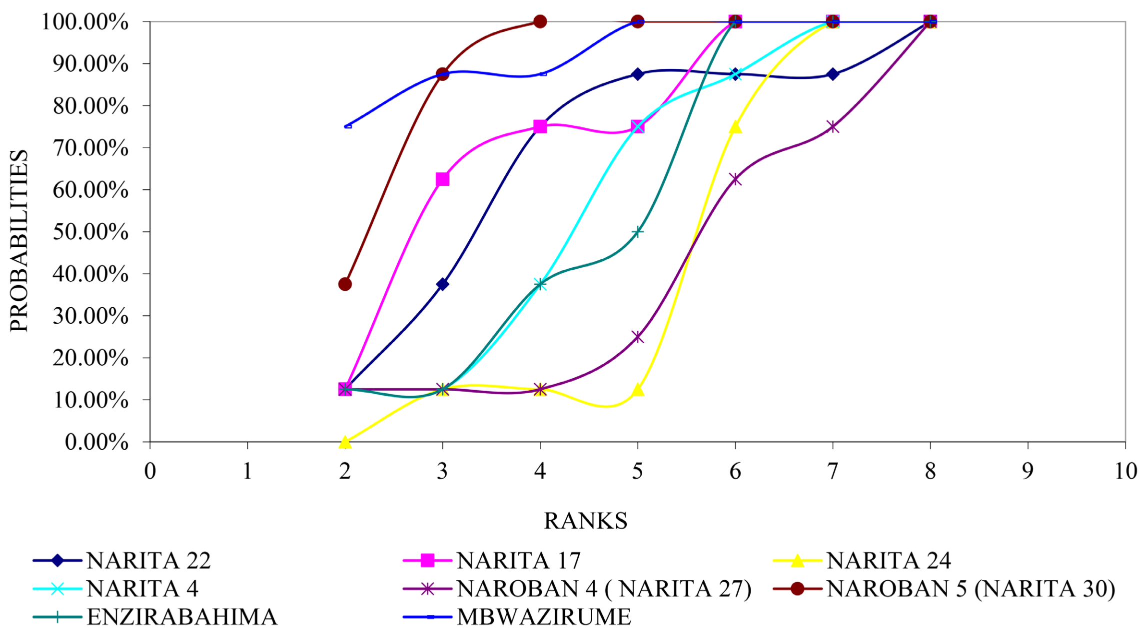

Figure 1. Probability of acceptance of unpeeled steamed banana fingers of hybrid and local cultivars based on their sensory preference rankings in the South Western Agro-Ecological Zone of Uganda.

Peeled steamed-mashed pulps: This is the most common and preferred method of preparing a good banana meal in the SWAEZ of Uganda. Ranking of the steamed-mashed banana pulps showed that *Mbwazirume* was the most preferred variety, being ranked as the best in the first, second and third ranks attaining the moderate to highest probability of acceptance in the first three positions (Figure 2). *Enzirabahima* (local) and NARITA 4 had the second-choice probabilities of acceptance with intermediate ranking in position two while the rest of the hybrids had low probabilities of acceptance in ranks two and three. Based on the steamed-mashed pulp analysis, *Mbwazirume* and *Enzirabahima* had relatively high slopes with positive b-intercepts that were statistically different and not

Table 6. Statistical analysis of preference ranks of steamed fingers of the East African highland banana cooking hybrids and local cultivars using the logistic regressions

Variety/Cultivars	Estimated parameter b (intercept)	Estimated parameters m (slope)	Standard error (SE) for b	Chi square	b intercept	The significance of the statistical differences based on a level of 15%
NARITA 22	−0.053571429	0.147321429	0.116171546	0.497091345	Negative intercept	No significant difference
NARITA 17	−0.013392857	0.148809524	0.125592064	0.74400495	Negative intercept	No significant difference
NARITA 24	−0.352678571	0.165178571	0.156727586	0.13359154	Negative intercept	Statistically different
NARITA 4	−0.21875	0.166666667	0.087418471	0.113677889	Negative intercept	Statistically different
NAROBAN 4 (NARITA 27)	−0.254464286	0.139880952	0.108202023	0.125142321	Negative intercept	Statistically different
NAROBAN 5 (NARITA 30)	0.34375	0.104166667	0.153143727	0.134079544	Positive intercept	Statistically different
ENZIRABAHIMA	−0.178571429	0.157738095	0.116737254	0.216159467	Negative intercept	No significant difference
MBWAZIRUME	0.59375	0.0625	0.074389879	0.004725525	Positive intercept	Statistically different

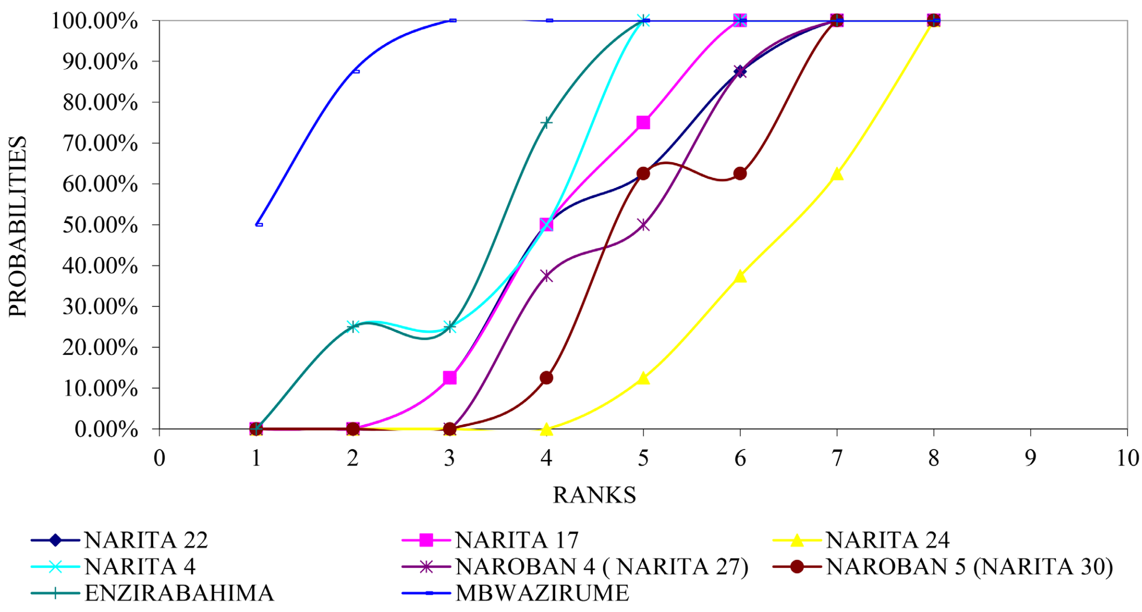

Figure 2. Probability of acceptance of steamed-mashed banana pulps of hybrid and local cultivars based on their sensory preference rankings in the South Western Agro-Ecological Zone of Uganda.

different, respectively, at the 15% level of significance, which indicated high levels of acceptance in the first place of ranking (Table 7). Similarly, NARITA 17 and NARITA 22 had positive-b intercepts, high slopes and non-significantly different low (10%) to intermediate (50%) probabilities of acceptance in the third and four positions. The rest of the hybrids had high slopes with negative b-intercepts, which indicated high probabilities of rejection as regards the first places of the ranking.

Fresh juice: Preference ranking of fresh juices extracted from banana hybrids and local cultivars showed that the probability of acceptance of the most preferred NARITA 4 was the intermediate (40%) in the first rank (Figure 3). In rank two, NARITA 4 maintained the intermediate probability of acceptance (50%), NAROBAN 5 had a similar position, while NARITA 17 and rest of the varieties had low probabilities of acceptance (≤20%). In rank three, NARITA 4 had the highest probability of acceptance (80%), followed by NAROBAN 5 and NARITA 17, which had intermediate probabilities of acceptance (60%). Overall, NARITA 4, NARITA 17 and NAROBAN 5 had the highest probabilities of acceptance as fresh juices, and had high slopes with positive b-intercepts (Table 7), indicating high degrees of acceptance. The fresh juices from the most preferred steamed *Mbwazirume* and *Enzirabahima* had the lowest probabilities of acceptance across the first three ranks. Similarly, juices from NARITA 22, NARITA 24 and NAROBAN 4 had low probabilities of acceptance (Figure 3). Based on the statistical analysis of juices, NARITA 4, NARITA 17 and NAROBAN 5 (NARITA 30), had high slopes with positive b-intercepts that were statistically different at the 15% level of significance, which indicated high levels of acceptance in the first positions of ranking (Table 8). The rest of the hybrids and local cultivars had high slopes with negative b-intercepts, which indicated rejection as regards the first positions of the ranking.

Table 7. Statistical analysis of preference ranks of steamed-mashed pulps of the East African highland banana cooking hybrids and local cultivars using the logistic regressions.

Technology	Estimated parameter b (intercept)	Estimated parameters m (slope)	Standard error (SE) for b	Chi square	b intercept	The significance of the statistical differences based on a level of 15%
NARITA 22	0.017857143	0.138392857	0.134213487	0.715290127	Positive intercept	No significant difference
NARITA 17	0.084821429	0.133928571	0.1365079	0.43053996	Positive intercept	No significant difference
NARITA 24	−0.075892857	0.117559524	0.086444117	0.348766172	Negative intercept	No significant difference
NARITA 4	−0.200892857	0.169642857	0.102484288	0.161488638	Negative intercept	No significant difference
NAROBAN 4 (NARITA 27)	−0.040178571	0.154761905	0.120075547	0.56295663	Negative intercept	No significant difference
NAROBAN 5 (NARITA 30)	−0.196428571	0.154761905	0.050595238	0.048796126	Negative intercept	Statistically different
ENZIRABAHIMA	0.080357143	0.138392857	0.128187982	0.428505914	Positive intercept	No significant difference
MBWAZIRUME	0.433035714	0.087797619	0.120310452	0.05780324	Positive intercept	Statistically different

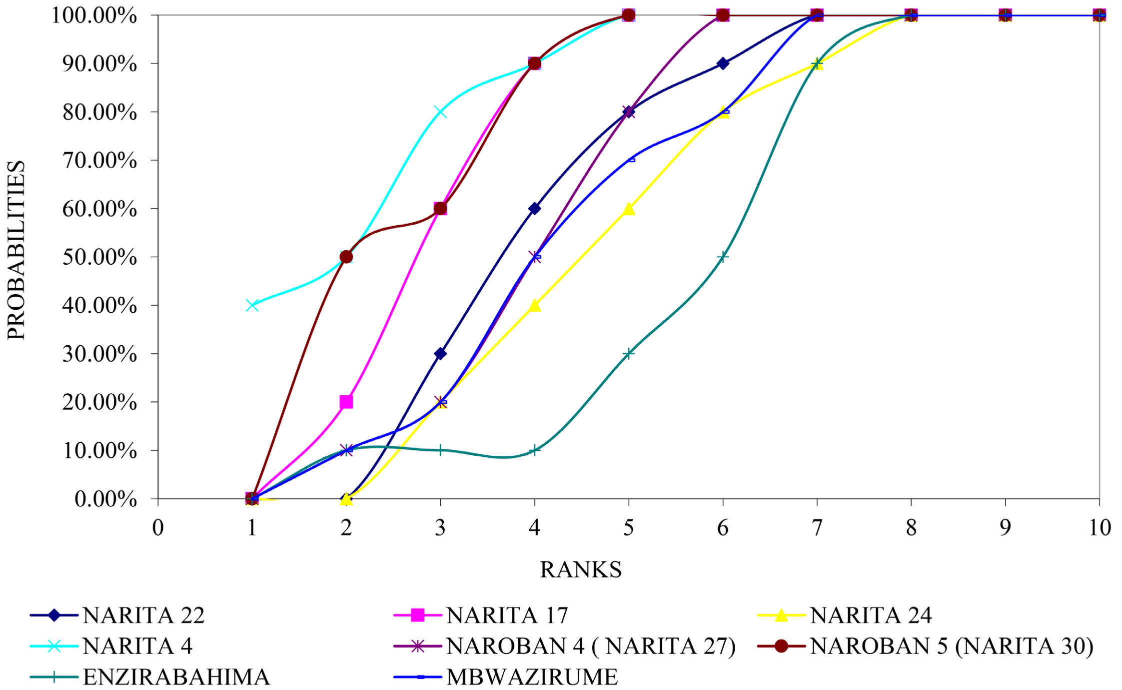

Figure 3. Probability of acceptance of fresh banana juices extracted from hybrid and local banana cultivars based on consumers' sensory preference rankings in the South Western Agro-Ecological Zone of Uganda.

Table 8. Statistical analysis of preference ranks of fresh juices of the East African highland banana cooking hybrids and local cultivars using the logistic regressions.

Technology	Estimated parameter b (intercept)	Estimated parameters m (slope)	Standard error (SE) for b	Chi square	b intercept	The significance of the statistical differences based on a level of 15%
NARITA 22	−0.033333333	0.126060606	0.116575722	0.592835922	Negative Intercept	No significant difference
NARITA 17	0.206666667	0.102424242	0.155686813	0.249259136	Positive Intercept	No significant difference
NARITA 24	−0.133333333	0.131515152	0.077159156	0.188662685	Negative intercept	No significant difference
NARITA 4	0.52	0.061818182	0.093143747	0.018138025	Positive intercept	Statistically different
NAROBAN 4 (NARITA 27)	−0.04	0.127272727	0.120189245	0.564010014	Negative intercept	No significant difference
NAROBAN 5 (NARITA 30)	0.306666667	0.08969697	0.1441555	0.144692374	Positive intercept	Statistically different
ENZIRABAHIMA	−0.246666667	0.135757576	0.09646269	0.109798446	Negative intercept	Statistically different
MBWAZIRUME	−0.066666667	0.126666667	0.089504811	0.388115194	Negative intercept	No significant difference

4. Discussion

The East African Highland Banana (EAHB) hybrids were developed through collaborative research between the National Agricultural Research Organisation (NARO) Uganda and International Institute of Tropical Agriculture (IITA) to improve banana productivity for food security [28], and income generation especially for communities that are highly dependent on banana, and the contribution to the gross domestic product (GDP). In this study, seven hybrid varieties were selected based on their high level of pest and disease resistant, and stable high yielding potential across environment and season. Although, previous research studies elsewhere, showed that the sensory characteristics of the banana hybrids were closest to those of most popular local consumer-preferred cooking banana cultivars such as *Mbwazirume* in terms of pulp-food colour, flavour/aroma, taste and texture; hybrids have not been well adopted in Uganda [22] [29], especially in the South Western Agro-Ecological Zone, where banana ranks first as the major staple food security and income generation crop among the majority farmers [16].

In the South Western Agro-Ecological Zone (SWAEZ), farmers adopt banana varieties based on a number of attributes, of which the key ones are: productivity, marketability and culinary associated attributes, implying that an adoptable variety must be high yielding, highly marketable and with very good palatability traits [30]. A study by Nasirumbi *et al.*, 2023 [31], found out that hybrid banana varieties had very good productivity characteristics of high yields, big bunch sizes, big fruit fingers and many hands, while the local cultivars were rated superior based on the consumer-associated qualities. Local cultivars also referred to as traditional landraces, have been observed to be more preferred than the improved varieties because of their superior consumption attributes [32]. In the current study, the local *Mbwazirume* was consistently ranked the best as unpeeled steamed fingers and peeled steamed-mashed pulps by consumers based on the four culinary or sensory evaluation parameters (colour, flavour, taste and texture). In preference ranking, *Mbwazirume* was given the first ranks with the highest probabilities of acceptance by consumers. Previous studies have shown that consumer preference traits of any banana variety significantly affect its adoption, marketability and profitability [13] [16] [33].

Commercially, farmers prefer to grow banana varieties with good agronomic attributes, such as the hybrids, but they often face significant trade-offs, such as low consumer preference for their food's taste, texture, flavour and colour, which makes them rejected and not adopted [29]. Because of the very short shelf-life of the cooking banana types after maturity [34], due to their high-water content, susceptibility to pests and diseases, and quick ripening rate [35], risks of significant post-harvest losses are high. The inferior attributes of the improved banana varieties, and in this case the hybrids, caused them to have high probabilities of rejection by farmers and consumers. Apart from the local cultivar (*Mbwazirume*) that had good average scores as unpeeled steamed finger pulps and peeled steamed-mashed pulps, the average scores of NAROBAN 5 were not significantly different from *Mbwazirume,* while the scores of NARITA 22, NARITA 18 and NARITA 17 followed closely to NAROBAN 5 (NARITA 30). A similar set of varieties had moderate to very good scores as peeled steamed-mashed pulps, but *Mbwazirume* and *Enzirabahima* were very good and good, respectively, while the sensory scores of NARITA 18, NARITA 17 and NARITA 22 were not significantly different from *Enzirabahima.* Interestingly, the current study results emphasise that the local *Mbwazirume* was the most highly scored cooking banana cultivar compared to the NARITA hybrids, which deviates from previous findings, where for example

NARITA 4 and *Mbwazirume*, had high and moderate scores in preference as food in Mbarara, respectively [13]. This observation suggests probable genotype by environment interactive and/or physiochemical composition effects [29] [36]. NARITA hybrids have been found to be superior in agronomic traits, while the local varieties such as *Mbwazirume* remain superior in culinary qualities (sensory traits) [37], although based on the current study, the food sensory attributes of some hybrids (NAROBAN 5/NARITA 30, NARITA 22, NARITA 17 and NARITA 18) were not significantly different from the good local cultivars.

In agreement with the matrix scores, preference ranking revealed that *Mbwazirume* maintained the first position as the most consumer preferred banana variety as steamed fingers and mashed pulps with the moderate to high probabilities of acceptance in the first ranking position, followed by NAROBAN 5 (NARITA 30) with a moderate probability of acceptance in the same position. In second ranking position, the two banana varieties maintained high probabilities of acceptance as steamed fingers, while as steamed-mashed, *Mbwazirume*, NAROBAN 5 and *Enzirabahima* attained the high, moderate and moderate PoA, respectively. In position two, NARITA 17 and NARITA 22 had moderate probabilities of acceptance as steamed fingers, while NARITA 4 and *Enzirabahima* had low PoA. In the third position *Mbwazirume*, NAROBAN 5, NARITA 17 and NARITA 22 attained high PoA, NARITA 4 and *Enzirabahima* had moderate PoA, while the rest of the cultivars had low probabilities of acceptance as steamed fingers. As a steamed-mashed pulp, *Mbwazirume* maintained the moderate to high PoA, followed by *Enzirabahima* and NARITA 4, which had moderate PoA in positions two and three.

Apart from FHIA 25 and Apple banana (*Kabaragara*), which are well known to be juice and dessert cultivars, respectively, the cooking hybrids NARITA 4, NARITA 17 and NAROBAN 4/NARITA 27, had good average scores for juice sensory attributes (sweet taste and flavour) that were not significantly different from FHIA 25 and *Kabaragara*, implying that some of the test cooking hybrids may possess traits that make them suitable in juice, dessert and sweet product making. Based on the taste attribute, the best performing varieties were FHIA 25, *Kabaragara*, NARITA 4, NARITA 24 and NAROBAN 4 (NARITA 27). While the local cooking banana cultivars (*Mbwazirume* and *Enzirabahima*) were most preferred as steamed fingers and mashed pulps, the hybrids (NARITA 4, NAROBAN 5 and NARITA 17) had moderate PoA in ranking positions one, two and three as fresh juices, but in position three, NARITA 22, NAROBAN 4, *Mbwazirume* and NARITA 24 had moderate PoA.

Considering the previous results that showed taste as the most highly scored attribute, the moderate ranking of hybrids (NARITA 4, NARITA 17 and NAROBAN 4) as the most preferred varieties for juices revealed that the hybrids contained higher sugar contents than the local cooking cultivars. These results align with the fundings of Nowakunda *et al.*, in 2024, where NARITA 4 and NARITA 17, whose scores were close to the most preferred genotypes, suggesting that they have a high potential for adoption [29]. Additionally, because of their moderate, very good attributes as either food and/or juices and desserts, the hybrids have a potential of being adopted because of their multi-trait or multi-purpose characteristics, good agronomic performance (early maturity, high yield, big bunch size), high multi-stress (abiotic and biotic stress) tolerances, which characteristics might the most preferred local banana cultivars and landraces not possess. Considering the fact that consumer preference is the key determinant of what banana variety the market should supply and the farmer should produce [38], which also indirectly affects the profitability and sustainability of the banana trade, there is a need for breeders to first prioritize consumer preferred attributes when developing varietal and non-varietal technologies and banana-based products [35] that are expected to be accepted and adopted by farmers and consumers. The unique attributes possessed by most local banana cultivars keep farmers committed to growing them, even when some of them may be: inferior in the key agronomic traits, susceptible to pests and diseases and non-drought tolerant, are very important and should no longer be ignored in technology development [16] [39].

5. Conclusion

The local or traditional East African Highland cooking banana cultivars were the most preferred based on matrix scores, preference ranking and probability of acceptance (PoA) based on colour, texture, taste and flavour of steamed finger pulps and steamed-mashed pulps, whereas the hybrids were most preferred as fresh juices, which were extracted through the hot water method. The second ranking varieties with moderate PoA in positions two and three as fingers after *Mbwazirume* were NAROBAN 5 (NARITA 30), NARITA 22 and NARITA 17, whereas as steamed-mashed pulps were *Enzirabahima* and NARITA 4 in ranking positions two and three with moderate PoA. NARITA 17 and NARITA 22 had low PoA, non-significant positive intercept. As juices, the local apple banana had the highest scores as juice, but the juices of the cooking hybrids (NARITA 4, NAROBAN 5 and NARITA 17) had moderate PoA, high slopes and positive intercepts, implying that they had high probabilities of being accepted by the consumers. Apple banana, NARITA 4, NARITA 22, NARITA 24 and NAROBAN 4 (NARITA 27) had higher sugar contents (Brix) than the rest of the varieties. Overall, the hybrid varieties (NAROBAN 5, NARITA 22, NARITA 17 and NARITA 4) had high probabilities of acceptance as food and juices like the *Mbwazirume* and FHIA 25 and/or *Kabaragara*, respectively.

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Conflicts of Interest

The authors declare no conflicts of interest.

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