Study Report

Banana Market Segmentation & Value chain Analysis for Rwanda

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Banana Market Segmentation & Value chain Analysis for Rwanda

International Institute of Tropical Agriculture (IITA)

Rwanda Agriculture and Animal Resources Development Board (RAB)

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Executive summary

A study was conducted in Rwanda to identify and characterize different banana market segments, with a focus on cooking and dessert bananas. The goal was to generate production and market-related information to inform the development of banana target product profiles (TPPs) for Rwanda, which can support crop development programs and other actors in meeting the needs of different end-users such as farmers, processors, and consumers. The study employed a mixed-methods approach consisting of qualitative and quantitative data collection methods, including a stakeholders' workshop, an experts' workshop, and semi-structured interviews with various actors along the banana value chains.

The findings indicate that Banana's importance as a food and cash crop continues to grow with time in Rwanda. With a fast-growing population, urbanization, and the influx of people from high banana eating countries in the recent past, consumption of cooking banana has widened both in quantity and variety of cooking ways (dishes). This presents both challenges and opportunities for value chain actors to meet the changing demands for new products e.g., varieties or traits. The production of cooking banana has been steadily increasing at the expense of beer banana, with both now occupying almost equal shares of planted areas. Meanwhile, the proportion of dessert banana has also seen growth over time. Nevertheless, the importance of beer banana remains strong due to better adaptability of beer cultivars in some locations, easy marketing in poorly connected regions, and its importance to the beer and wine industry in the country.

Male and female farmers in Rwanda have similar preferences for cooking and dessert banana traits. However, brewing banana seems to be a male's crop, most likely because it is mainly grown for cash rather than food for home consumption. Banana farmers tend to sell their surplus produce to multiple market options, preferring nearer markets to reduce transportation costs, which is one of the key challenges to marketing. Urban consumers' preferences for cooking and dessert banana are narrow in range and common across different groups. However, their choice of variety in the market is highly associated with prices, resulting in affluent and less affluent consumers eventually eating different varieties for both cooking and dessert banana. This leads to market segments being strongly determined by purchasing power and geographical differences.

The study revealed that crop improvement has great potential to improve farmers' livelihoods by addressing production constraints and responding to changing consumer preferences. Diseases such as Banana Xanthomonas Wilt (BXW), Fusarium Wilt, and Banana Bunchy Top Virus remain significant challenges to production. Many landrace cultivars with preferred traits are low yielding and susceptible to these diseases. Moreover, there are insufficient crop development capacities at RAB, which has resulted in no release of improved varieties for cooking banana for a long time. With little effort, Rwanda can benefit from breeding achievements that have been made in the region recently. However, this requires better regional collaboration, as well as financial and technical support for crop development work in Rwanda. This includes development of a strategy (including methodological framework) on how to prioritize, design, and involve different value chain actors in the introduction, testing, and evaluation of new germplasms.

Summary of study findings

The Improvement of Banana for Smallholder Farmers in the Great Lakes Region of Africa[1] Project conducted a study to identify and characterize banana market segments in Rwanda, with a focus on cooking and dessert banana. The objective was to generate production and market related information to inform development of banana target product profiles (TPP) for Rwanda. This information can help crop development programs in Rwanda (e.g., RAB banana program) and in the region (e.g., Accelerated Breeding of Better Bananas (ABBB)[2]) and other actors to respond to changing needs of different end-users i.e., farmers, processors, and consumers. The study employed a mixed-methods approach consisting of qualitative and quantitative data collection methods, including a stakeholders' workshop, an experts' workshop, and a survey of different actors along the banana value chains through semi-structured interviews. The findings were utilized to identify key banana market segments and product traits valued by different end-users, which formed the basis for developing basic product profiles for different target product environments (TPE) in Rwanda. The study took place between November 2022 and March 2023.

The findings indicate that Banana's importance as a food and cash crop continues to grow with time in Rwanda. With a fast-growing population, urbanization, and the influx of people from high banana eating countries in the recent past, consumption of cooking banana has widened both in quantity and variety of cooking ways (dishes). This presents both challenges and opportunities for value chain actors to meet the changing demands for new products e.g., varieties or traits.

Majority of interviewed farmers grow a mixture of cooking, dessert, and brewing bananas (types) in their fields. Cooking banana represents 47% of their banana planted areas while the other two types occupy 30% and 23%, respectively. More farmer respondents were from the Eastern region though where cooking banana predominates, unlike the Western and Southern regions dominated by brewing banana. From stakeholders' views, the shares countrywide would be 40-45% for cooking, 40-45% for beer, and 10-15% for dessert. This presents a significant shift for cooking banana, which is slowly replacing the beer banana from the historical first position. Although, despite this reduction in share, the importance of brewing banana as raw material for beer and wine industries remains strong. With increasing urbanization and incomes, consumption of dessert banana has also been on rise.

Three cooking cultivars dominate farmers' fields namely *Injagi*, *Nkazikamwa*, and *Ibinyarwanda*. For the dessert banana, the variety of cultivars is narrow, with only four cultivars widely found in farmers' fields. Those are *Kamaramasenge* (AAB), *Gros Michel* (AAA), FHIA-17, and *Poyo*. Popular brewing varieties are also few and common across all districts. *Indaya* and FHIA-25 are significantly more popular than others. In terms of marketing, farmers sell surplus to more than one market option. The Majority of farmers sells surplus to open markets in their villages (60%), open district markets (45%), and aggregators (34%). The first two options represent more than 55% of quantities sold. Cooperatives are also an important option for farmers in the Eastern province. Transport costs is the main reason farmers prefer selling in their own villages (open markets, aggregators, cooperatives). Poor farmers value yield more, while those who are better-off consider other traits such as taste & flavor, shape & (big) size of finger, shape and (big) size of bunch, and marketability also important. Male and female farmers seem to have the same

[1] https://breedingbetterbananas.org/improvement-of-banana-for-smallholder-farmers-in-the-great-lakes-region-of-africa/

[2] https://breedingbetterbananas.org/#1561381429663-2-9

preference for cooking and dessert banana traits. However, brewing banana seems to be a male's crop, because it is mainly grown for cash (for the male-dominated beer and wine industries) rather than home consumption.

Urban consumers' preferences and traits for cooking banana are narrow in range and common to all. They highly value taste and flavor, shape and (big/thick) size of finger, (soft) texture after cooking, and shape and (big) size of bunch in that order. However, their variety choice in the market is highly associated with prices. Affluent consumers buy *Injagi* and *Nkazikamwa* while poor consumers buy a variety of local cultivars including *Intokatoke*, *Ingenge*, and *Inkonkobora* (*Ibinyarwanda*). Similarly, for dessert banana, affluent consumers buy almost exclusively *Kamaramasenge* and *Gros Michel,* while poor consumers buy FHIA-17 and *Poyo*. Female consumers value more cooking related traits (e.g., texture after cooking and peeling qualities) than male counterparts. In general, Rwandan banana consumers particularly love *Injagi variety*, owing this not only to its taste and roasting qualities but also to the cultural value attached to it.

Five market segments were identified for cooking banana, three for dessert, and two for brewing namely:

(1) Cooking banana - consumers in rural areas - farming households,
(2) Cooking banana - affluent urban consumers - home and restaurants & hotels,
(3) Cooking banana - poor urban consumers - home and restaurants & hotels,
(4) Cooking banana - banana for roasting (rural and urban) - Bar, Restaurant, Hotel,
(5) Cooking banana - plantain - urban consumers - Restaurants, Hotel, and homes,
(6) Dessert – consumers in rural areas - farming households,
(7) Dessert - affluent urban consumers - home and restaurants & hotels,
(8) Dessert - poor urban consumers - home and restaurants
(9) Brewing – rural areas - traditional processors, and
(10) Brewing – urban areas – industrialized/modern processors.

From the identified market segments and major TPEs in Rwanda, recommendations were made for crop improvement for developing the identified TPP as summarized in the table below.

Banana type	**TPE**	**Key feature**	**Key traits to tackle**
Cooking	East (TPE 2 & 4)	Long finger, big shallow bunch (good looking), easy to roast	Resistance to wind (strength of stem), easy of harvesting (shorter stem), tolerance to diseases, bigger finger, yellowish pulp, easy roasting
	East (TPE 2 & 4)	Medium finger, big and compact bunch, yellow pulp	Big bunch weight, resistance to stress and pests
	West (TPE 3 & 5)	Long finger, big bunch, less compact bunch (good looking)	Resistance to wind (strength of stem), easy of harvesting (shorter stem), tolerance to disease, bigger finger, yellowish pulp, easy roasting, adaptation to West conditions
	West (TPE 3 & 5)	Medium finger, big bunch, yellow pulp	Big bunch, resistance to stress and pests, adaptation to West conditions, yield
	South (TPE 1)	Long finger, big bunch, less compact bunch (good looking)	Resistance to wind (strength of stem), easy of harvesting (shorter stem), tolerance to disease, bigger finger, yellowish pulp, easy roasting, adaptation to South conditions
	South (TPE 1)	Medium finger, big bunch, yellow pulp	Big bunch, resistance to stress and pests, adaptation to South conditions, yield

Dessert	All TPE	Long finger, good taste, big bunch	Size of finger, size of bunch, resistance to fusarium and other diseases
	All TPE	Medium finger, good taste, big bunch	Size of bunch, resistance to fusarium and other diseases
Brewing	East (TPE 2 & 4)	Medium finger	Yield, bunch size, juice qualities (quantity & quality), resistance to diseases, adaptation to East conditions
	West (TPE 3 & 5)	Medium finger	Yield, bunch size, juice qualities (quantity & quality), resistance to diseases, adaptation to West conditions
	South (TPE 1)	Medium finger	Yield, bunch size, juice qualities (quantity & quality), resistance to diseases, adaptation to South conditions

The study reaffirmed that crop improvement has potential to improve farmers' livelihoods by responding to production constraints and consumer preferences. Diseases such as BXW Fusarium Wilt, and Banana Bunchy Top Virus remain big challenges for banana production, despite ongoing efforts to manage them. Landraces that have preferred traits by consumers are the most vulnerable. For instance, despite high demand for dessert cultivars of *Kamaramasenge* and *Gros Michel*, they are highly susceptible to Fusarium Wilt and other diseases. Disease resistance for these varieties could make a big difference. Other key challenges and potential areas for interventions in the banana value chain include:

- Traders and other downstream actors can detect the mismatch between supply and demand. In this study, they noted that *Injagi* and *Nkazikamwa* are highly demanded, and supply is unable to meet the demand for these varieties. There is opportunity for producers in favorable environments to focus on these varieties. Continuous collection of feedback is needed, but there is also need for a strategy to take feedback back to producers.
- Transport costs and damage on the way continue to challenge banana business. This is an opportunity to improve the supply chain and logistics through locally adapted mechanisms and technologies.
- There is need for better understanding of the value chain functioning such as volumes and proportions that different value chain segments and actors handle e.g., how much banana goes to Kigali and other towns, how much is consumed locally, etc. This goes with prices and transaction costs. It would be useful to understand the transaction costs along the value chain and where the biggest share could be occurring and why. This can guide investment planning and resource allocation.
- Diversity and geographical distribution of banana germplasm in the country need to be studied and understood in order to make good use of it during crop development and conservation efforts both locally and regionally.
- This study focused on cooking and dessert bananas, but only covered the production part of beer banana. Given the importance of the latter in the banana sub-sector in Rwanda, there is a need to conduct a more comprehensive study of its value chain.
- There are insufficient crop development capacities at RAB, which has resulted in no release of improved varieties for cooking banana for a long time. Moreover, good progress has been made in the region in this aspect. With little efforts, Rwanda can benefit from these achievements. For this to happen, there is a need for better regional collaboration, as well as financial and technical support. This includes the development of a strategy (including a methodological framework) on how to prioritize, design, and involve different value chain actors in the introduction, testing, and evaluation of new germplasms.

1. Introduction

Banana is an important crop in Rwanda due to its diversified and wide uses in the society, from food, beer, to farming and socio-cultural values. It is ranked first in terms of production quantities among all food crops. It occupies nearly 20% of the total cultivated lands annually, second only to beans. Smallholder farmers highly rely on banana production for their incomes, own consumption, and its beneficial agronomic characteristics. In 2022, the total banana cultivation area reached 236,413 hectares (ha), with a production of 2.2 million metric tons (MT), according to the National Institute of Statistics of Rwanda (NISR, 2022). Banana production plays a significant role in the national economy by contributing to food security, incomes, and employment for many people.

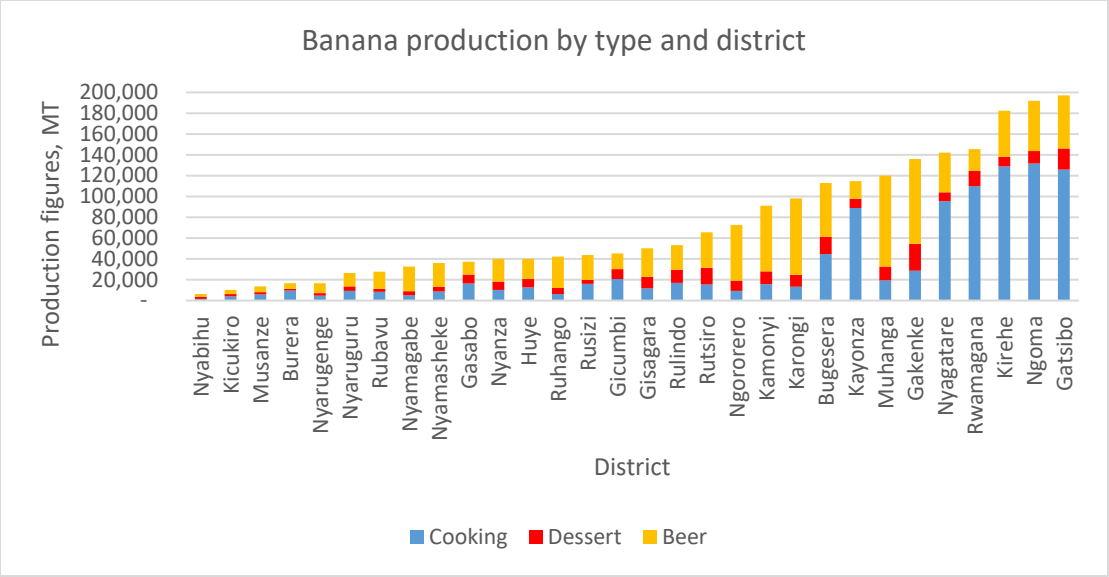
Banana is primarily consumed as cooked food, fruit, or dessert and processed into beer and wine. These are almost equally important in society. The consumption of the cooking banana has been growing steadily for the past 25 years or so, especially since the return of Rwandans from countries with high banana consumption habits like Uganda. This has been compounded by growing urbanization. Similarly, dessert banana has gained popularity as a fruit and dessert option, and its production has increased to approximately 15% of total banana production (NISR, 2022).

Beer banana is a traditional beverage with cultural significance and is used as a means of social cohesion in Rwanda. It is offered as a drink as well as gift in cultural functions (e.g., weddings, etc) and is considered more than just a drink in some of those circumstances. Despite the importance, its production proportions have reduced in the recent past partly due to bigger demand for food from urban areas. The beer and wine industry is reported to be fast-growing again though, attracting above Rwf 500million in private investment and growing by more than 23% in turnover annually (NIRDA, 2017).

Banana is also important in the Rwandan farming systems where majority of lands are prone to water erosion and agriculture is primarily rain-fed. Smallholder farmers grow it to protect their lands against erosion or at least to minimize the impact and to retain water in soil (by limiting soil exposure to sunshine) thanks to its vegetative stature covering most of the land where it is grown. This is important because while the eastern region is known for insufficient rains and frequent droughts, the western region is also known for high rains and severe erosion.

Beer and cooking bananas dominate production in terms of both cultivated areas and quantities. The National Institute of Statistics of Rwanda reports that in 2022, 45.1% of total produced banana quantities was cooking, 42.5% beer and 12.3% dessert. However, beer banana came first in terms of cultivated areas with 48.3%, followed by cooking with 35.8%, and dessert with 15.8%. The bigger cultivated areas with lower produced quantities for beer and dessert compared to cooking banana is explained by lower productivity levels of the two types. The national yield averages for the three types in season A of 2022 were 13,7MT/ha, 9,8MT/ha, and 7,9MT/ha for cooking, beer, and dessert banana respectively (NISR, 2022).

The Eastern Province remains the biggest producer and supplier of banana in the country with 7 out 10 biggest banana producing districts and with 61% of the total national production quantities (Fig. 1). The ten biggest producing districts are Gatsibo, Ngoma, Kirehe, Rwamagana, Nyagatare, Gakenke (North), Muhanga (South), Kayonza, Bugesera, and Karongi (West).



Source: Raw data from Excel dataset of NISR, 2022; graph by authors

Figure 1: Production quantities of banana types by district in 2022 (MT)

The Government of Rwanda (GoR) recognizes the importance of banana to food and nutrition security and the national economy in general. Banana is among the eight priority crops selected by the government for strategic investment (MINAGRI, 2011). It has since reportedly received some attention and investments over the years including support for replacement of fusarium wilt susceptible varieties, access to clean seeds, control of banana wilt and Banana Xanthomonas Wilt (BXW), as well as introduction of improved FHIA varieties. It is also reported that the government has promoted increasing production of cooking banana at the expense of beer banana for food security reasons (Gaidashova *et al*., 2005).

However, the crop also faces several challenges from production to consumption. Production challenges include land fragmentation and availability (pressure), poor soils, weak seed systems, diseases, and weather-related challenges among others, all resulting in low productivity at farm level. In the recent past, diseases such as Banana Xanthomonas Wilt (BXW) and banana Fusarium Wilt have been the biggest constraints to production resulting in complete loss of thousands of hectares of banana plantations. At other value chain segments, challenges include poor road networks and conditions resulting in high transportation costs or complete lack of market for farmers, short shelf-life of fresh banana aggravated by limited processing and value addition capacities, and weak value chain coordination.

There is also limited support for research for development for the banana sub-sector. As a result, there is little to no significant research happening at crop development level and lack of up-to-date information on the performance of the sub-sector in general, which is necessary to guide investment and interventions. A nationwide banana market survey was last conducted in Rwanda more than 20 years ago in 2002 (Ferris et al., 2002). Given how the market usually evolves following changing consumer preferences, demand and supply dynamics, and market infrastructure, there is need to constantly hear from the market. Moreover, understanding traits for banana product development would help to orient banana breeding work at RAB and CGIAR programs, especially for highland cooking banana, for which no improved varieties were adopted

in Rwanda despite some important breeding achievements within the East African region. This study aims to narrow these information gaps.

2. Objective

The main objective of the study was to identify market segments for cooking and dessert bananas and to provide a starting point for preparation of country target product profiles (TPP) for Rwanda. The study also generated information on key banana traits valued by different market segments. Although the study focused on cooking and dessert bananas, basic information collected on production (through the survey) and marketing (through the workshops) of brewing banana allowed to propose the key market segments for brewing banana too. Specific objectives are below.

Specific objectives

- Identify key players in the banana value chains.
- Identify key banana traits and preferences valued by different consumer categories.
- Identify and characterize market segments for cooking and dessert bananas across urban and rural consumers.
- Propose basic target product profiles (TPP) basing on identified target product environments (TPE) for Rwanda

3. Methodology

3.1. Methods and sampling

The study employed a mixed approach methodology consisting of qualitative and quantitative methods. Data collection methods consisted of a stakeholder workshop, expert workshop, and survey. The stakeholder workshop consisted of a one-day meeting whereby various banana value chain stakeholders were invited and facilitated by scientists to provide information on key value chain information such as varieties in production and markets, production areas, movements of banana from farm to end-users, key actors, and partners. Participating stakeholders included farmers, representative of farmer cooperatives, aggregators, rural-urban traders, wholesalers, retailers, transporters, seed producers, restaurants and hotels, and consumers. Policy makers from the ministry of agriculture were also part of the workshop. The expert workshop consisted of a technical meeting between scientists and technicians from the RAB banana program and IITA researchers in which they systematically gathered and recorded information from their knowledge of varieties and their characteristics and information on banana research program priorities, capacities, and plans. Information of interest included the kind of varieties available to researchers, breeding products in the pipeline, how they determine breeding goals, and early generation seed (EGS) production capacities. The survey consisted of interviews through semi-structured questionnaires, which well-trained enumerators administered to various value chain actors including farmers, seed multipliers, traders (aggregators, wholesalers, and retailers), transporters, processors, hotels and restaurants, and individual consumers (urban and rural). Survey data were collected using pre-prepared ODK-based questionnaires, customized for each value chain segment. Enumerators used android tablets to collect data on field. The study took place between November 2022 and March 2023 (with data collection happening from November to January and data analysis and reporting from January to March).

Sampling of respondents and participants involved an integrated strategy which combined purposive sampling, snowballing, and random selection techniques across different value chain segments depending on the relevant data collection method. High banana growing districts (Fig. 1, Table 1) and sectors were purposively selected with the help of RAB Banana program staff, while cells, villages, and farmer and consumer respondents were randomly selected. For cells and villages, the list of all elements was entered into MS excel and the random function was used to randomize and pick the required number of elements. For farmers, once the two enumerators were in the center of the selected village, they picked every 5th household in both opposite directions of the street until the target number was complete. For the rest of value chain segments i.e., hotel and restaurants, traders, transporters, processors, and seed producers, respondents were identified using snowball and purposive selection whereby researchers used their knowledge of actors to determine who can be interviewed as well as asking actors for names and contacts of their counterparts.

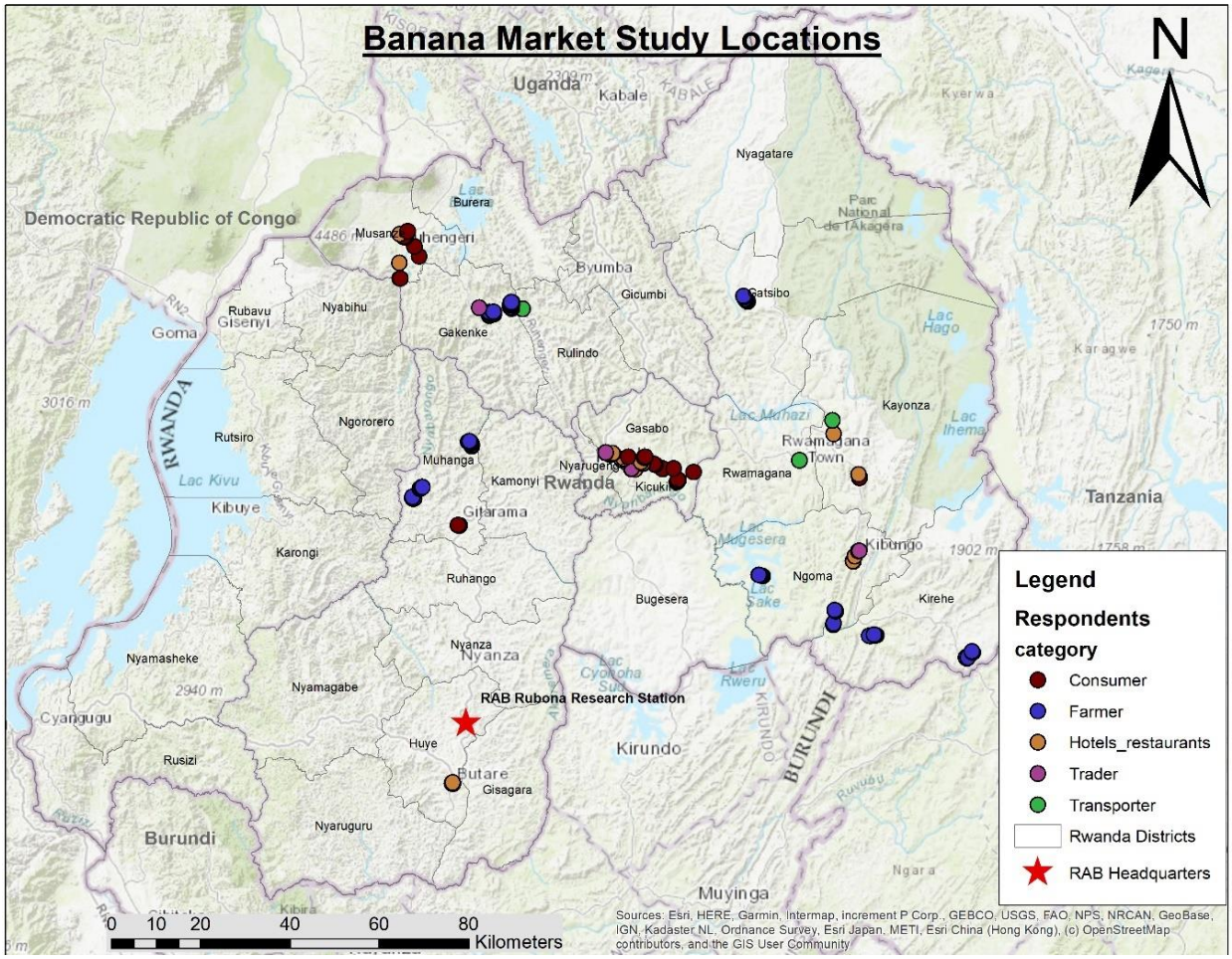
3.2. Sample size and distribution

The sample sizes were determined purposively, not necessarily statistically because the study was more qualitative in nature and limited in capacity to collect more data. The aim was to collect detailed information from a relatively small number of respondents as compared to statistically representative sample sizes. It should be noted that in addition to the survey, there were stakeholder and expert workshops to enrich the interview questions before the survey and complement the data after interviews. In the table below are the targeted numbers and location of respondents for each category.

Table 1: Sample size and location for each respondent category

Value chain segment	**District and respondent number in ()**	**Number of Respondents**
Farmers	Kirehe (21), Ngoma (22), Gatsibo (12), Gakenke (20), Muhanga (20)	95
Consumers	30 in Kigali City, Musanze (10), Kayonza (5), Ngoma (5), Huye (2), Muhanga (3)	55
Hotel & Resto	Kigali (12), Musanze (3), Kayonza (3), Ngoma (3), Huye (2), Muhanga (1)	25
Traders	10 in Kigali, Musanze (3), Kayonza (2), Ngoma (3), Huye (2), Muhanga (3)	23
Transporter	Kirehe 1, Rwamagana 1, Muhanga 1, Kayonza 1, Rulindo 1	5
Processors	Kayonza (1), Musanze (1), Rulindo (1)	3
Seed producers	Muhanga (1)	1
Total		**207**

For farmers, in the 5 identified districts, 2 sectors were selected, in each sector 2 cells, in each cell 2 villages. Consumers were randomly selected by enumerators at banana shopping places (shops and markets) in both urban and rural areas. The survey of farmers focused on the eastern region where banana is among the top two crops to most farmers, and from where majority of banana in the urban markets is sourced. Three districts were selected from the Eastern Province (Kirehe, Ngoma, Gatsibo), one in the northern (Gakenke), and one in the southern (Muhanga). Other respondents were selected from both rural and urban districts, including Kigali.



Source: Map by IITA team

Figure 2: Map of data collection locations for the survey

3.3. Data handling and analysis

Data were analyzed quantitatively and qualitatively using R programming language and MS excel software. Data analysis consisted of two major steps. First, descriptive statistics were computed to characterize banana value chain actors, banana type, and varieties. Qualitative analysis involved performance of descriptive statistics such as frequencies, proportions, and content analysis to understand characteristics and qualities of various value chain actors and certain market features using qualitative variables. Quantitative statistics such as central tendencies (e.g., means), standard deviations, and cross-tabulations were computed to understand the levels, variations, and relations among quantitative variables across value chain actors and banana business related variables (age, location, gender, quantities handled, proportion of different types of bananas, proportions of different varieties, sales, etc). Emphasis was put on qualitative analysis to understand the underlying, driving, and qualifying factors for respondents' behaviors, preferences, and perceptions especially because the sample sizes were not big enough to provide statistically meaningful quantitative results and represent the populations. All data analyses were preceded by data cleaning and organization, which was made easier by the fact that data were collected digitally using ODK-based questionnaires on tablets.

4. Results

In this section we present results from the survey on banana production, marketing, trading, and consumption in studied areas. The results are summarized in three sections namely banana production, trading, and consumption. Results from the stakeholder and expert workshops were used to discuss the survey results in the following section of “Discussion of results”.

4.1. Banana production

1. Characteristics of interviewed farmers

- 95 banana farmers were interviewed, of whom 76% was male, and 86% of respondent households was male headed.
- Majority of interviewed farmers was smallholder farmers. The average banana planted area for banana per household is 0.32 hectare (min. = 0.015, max. = 4, sd = 0.5).
- Average age of respondents was 47 years, whereas the average number of people living in a household was 5.2 (min = 1, max = 11, sd = 1.8).
- In terms of education, 59% completed primary education, 26% never completed primary but can read and write, 19% have no education at all or are illiterate, and 2% completed secondary education.

2. Banana types in farmers’ fields

Farmers were asked which banana types (cooking, dessert, brewing) they grew and the proportion of each type in their own fields.

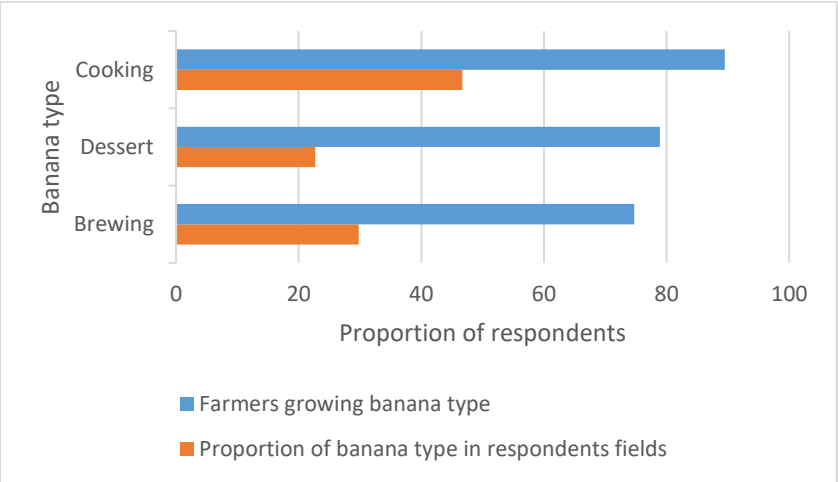


Figure 3: Farmers growing banana type and proportions of each type in fields (N = 95)

- Majority farmers grow a mixture of cooking, dessert, and brewing bananas in the same fields. 90%, 79% and 75% of interviewed farmers have cooking, dessert and brewing bananas in their fields, respectively. Despite majority of farmers having the three types in their fields at the same time, the proportions for each type are much different from one farmer to another. On average, cooking banana occupies 47% of their banana planted areas while the other two types occupy 30% and 23% respectively. However, it is

important to note that our sample had more farmer respondents from the Eastern region, which grows more cooking and dessert banana types than other regions.

- Slightly more farmers grow dessert banana as compared to brewing, but brewing banana takes bigger areas than dessert in farmers' fields.
- In Gatsibo district, farmers focus on cooking banana, and dessert to a lesser extent, while in other districts they tend to grow all three types.

3. Distribution of varieties in different districts

Farmers were asked to name the cultivars they had in their own fields for the 3 banana types. Results are below.

3.1. Cooking varieties

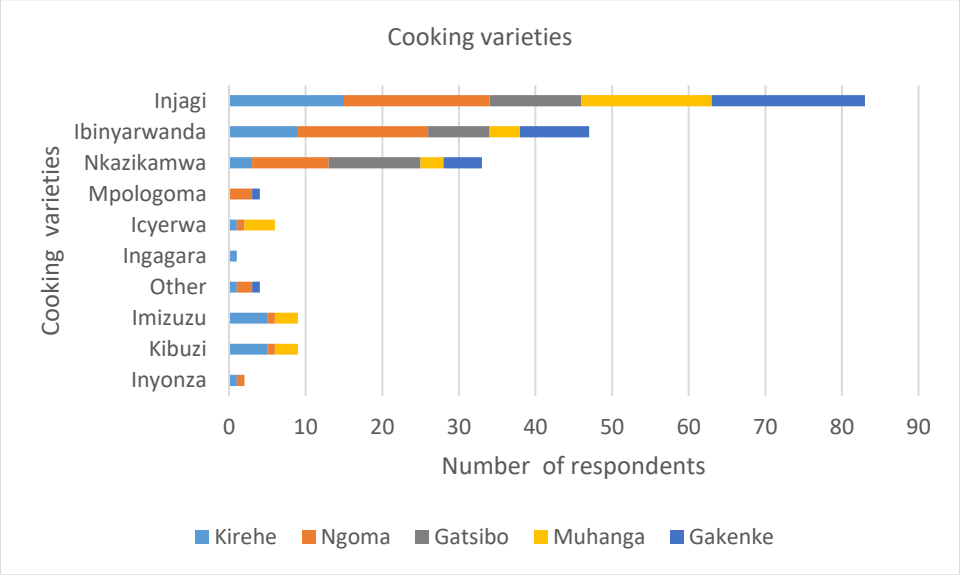


Figure 4: Cooking varieties in farmers' fields during survey (N = 95)

- *Injagi*, *Nkazikamwa*, and *Ibinyarwanda* (*Intokatoke, Ingenge, Inkonkobora*) are common varieties in the surveyed districts. *Injagi* is by far the most common variety.
- There is no apparent difference between varieties found in the respondents' region in general and varieties in their own fields, suggesting that farmers have access to whatever varieties available.

3.2. Dessert varieties

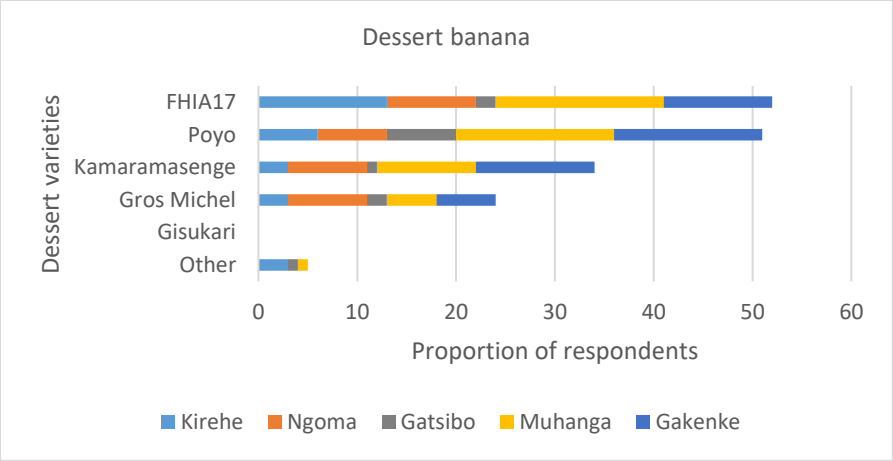


Figure 5: Dessert varieties in farmers' fields during survey (N = 95)

- Dessert varieties are generally few in Rwanda. There are mainly four varieties namely Kamaramasenge, Gros Michel, Poyo, and FHIA17. They are widely distributed in the surveyed districts. FHIA-17 and Poyo rank number one and two in terms of presence in farmers' fields.
- *Gisukari* is an old local cultivar but currently found in few places, probably because of its very late yielding and medium bunch size.

3.3. Brewing varieties

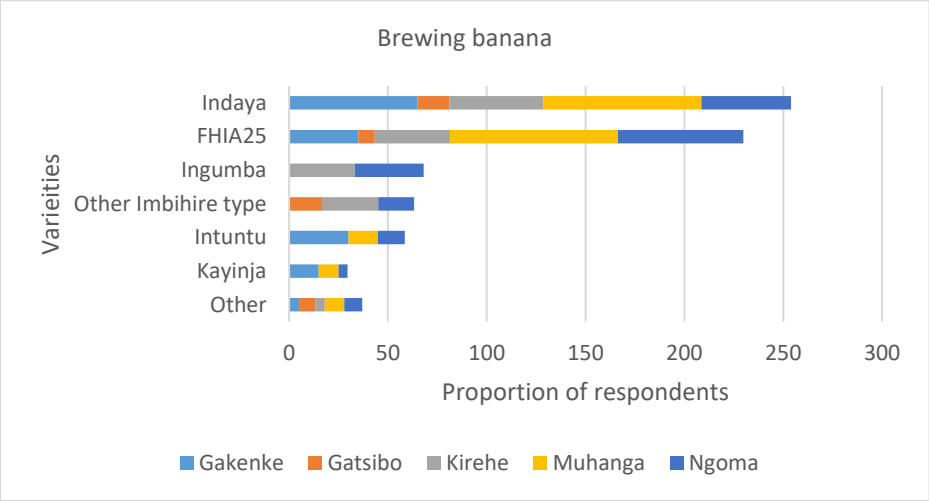


Figure 6: Brewing varieties in farmers' fields during survey (N = 95)

- *Indaya* and FHIA 25 are significantly more popular than other brewing varieties.
- Gatsibo district grows less brewing banana compared to other districts.
- Brewing varieties are common across different districts.

4. Varieties' traits by social class

Farmers were asked to select traits (from a list of traits) they thought were more important to them. The study used the GoR established social classes[3] based on incomes and welfare.

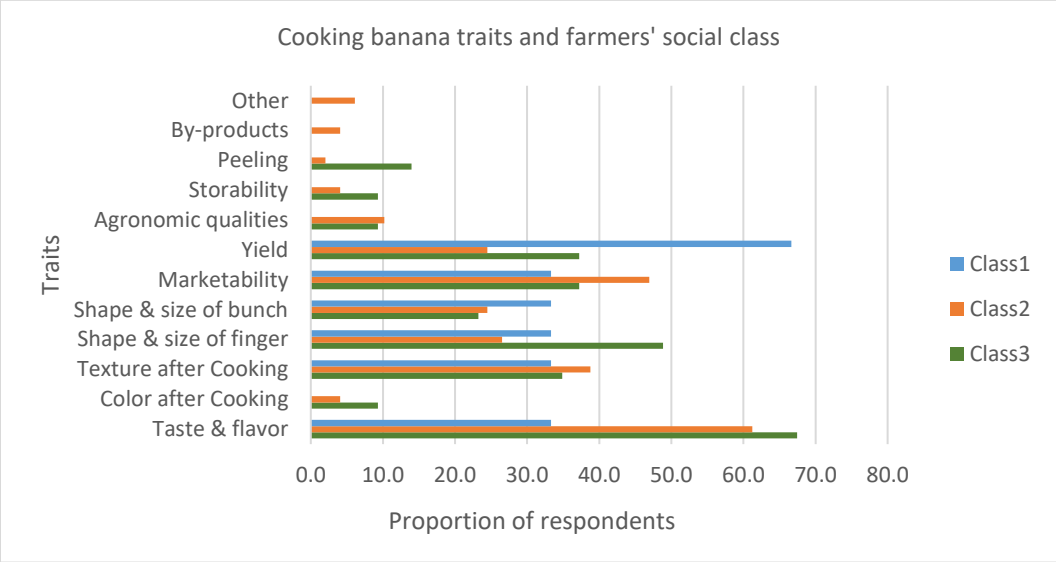


Figure 7: How different farmer social classes value cooking banana traits (N= 95)

- Yield seems to be more important to poorer farmers (class1). Taste & flavor, texture after cooking, shape & size of finger, shape & size of bunch, and marketability are of equal importance to them. For both finger and bunch, they want big size.
- For better-off farmers (class3), more traits are valued compared to poorer counterparts. They value most taste & flavor and shape & size of finger. Texture (soft) after cooking, marketability, and shape & size of bunch are also important, but come in second rank. Other traits such as peeling and storability are also of importance unlike for poor farmers.

5. Varieties' traits by gender

Farmers' valuation of variety traits was also analyzed by gender to identify male and female preferences.

5.1. Cooking banana

[3]For more: https://www.minaloc.gov.rw/index.php?eID=dumpFile&t=f&f=17780&token=b8d980c6343b1bb6d27ab4c3fba3516e4741493d

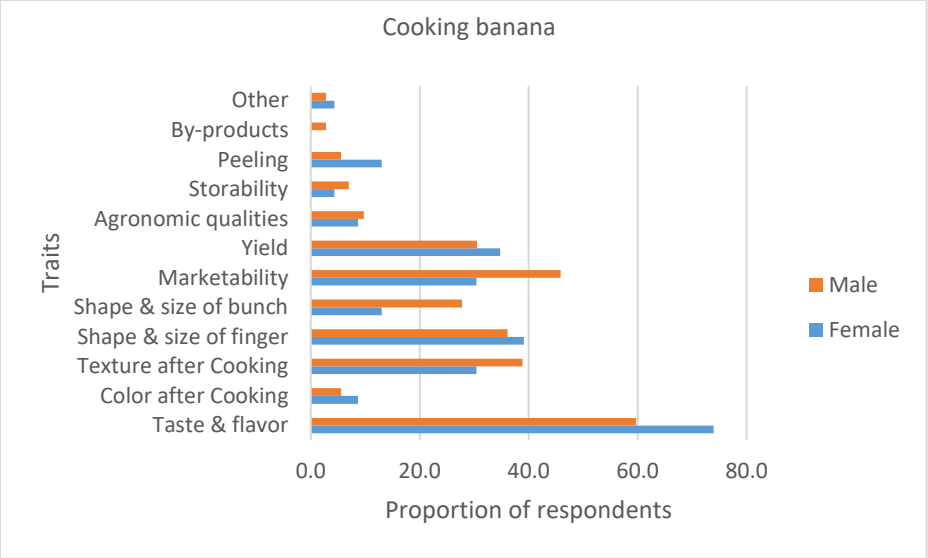


Figure 8: How farmers value cooking banana traits by gender (N= 95)

- There seems to be no significant difference between males and females in terms of how farmers value traits for cooking banana. However, female farmers tend to value cooking and sensory traits more than their male counterparts. These include taste & flavor, peeling, and color (yellow) after cooking.

5.2. Dessert banana

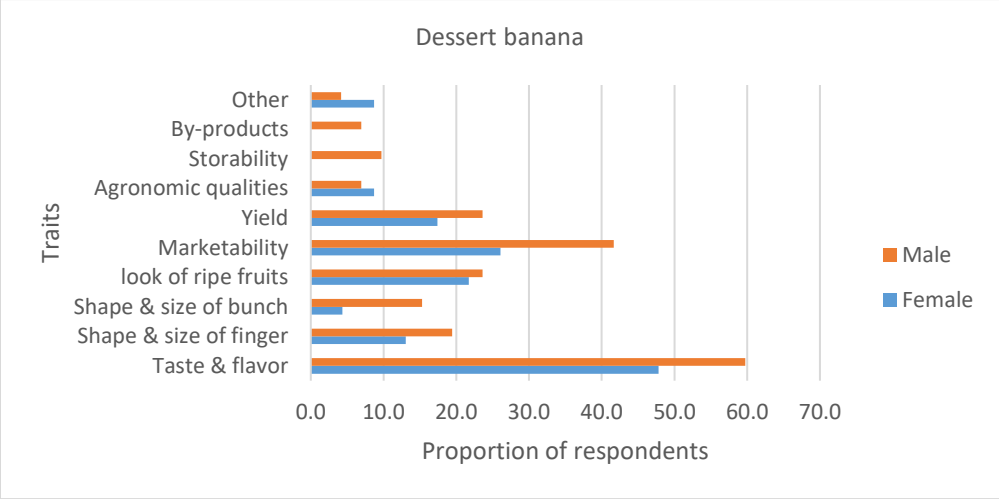


Figure 9: How farmers value dessert banana traits by gender (N= 95)

- Generally, there is no big difference between the two groups. However, male farmers tend to value more traits than female i.e., storability, by-products. They also tend to value more market-related traits such as marketability, shape and size of bunch, and storability than female farmers.

5.3. Brewing banana

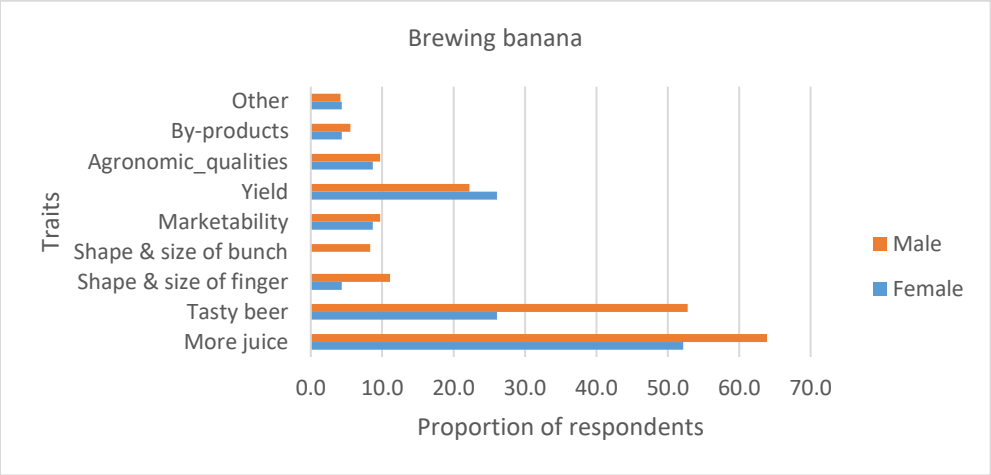


Figure 10: How farmers value brewing banana traits by gender (N= 95)

- Male farmers value more juicing qualities, taste of beer, size & shape of bunch, and size & shape of finger. Men seem more interested in nearly all traits than female for brewing banana. Brewing banana looks more like a male's crop, which is not surprising since it is more of a cash crop than food.

6. Usage of cooking banana by farmers

Farmers were asked how they use their production of cooking banana.

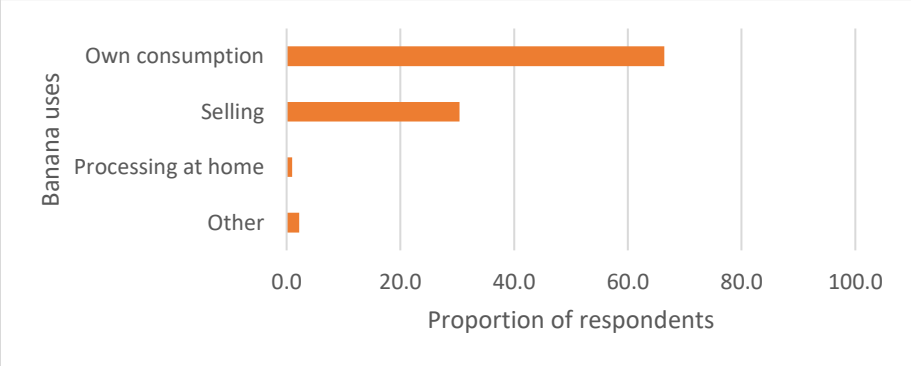


Figure 11: Use of cooking banana by farmers (N = 95)

- Own consumption takes 66% of cooking banana production at farmers' level. Selling takes 33%, while home processing takes less than 1%. This reflects that most interviewed farmers are small-scale, consuming majority of their production for cooking banana.

7. Market options for farmers

Farmers were asked where they sell their banana surplus, which we call market options herein.

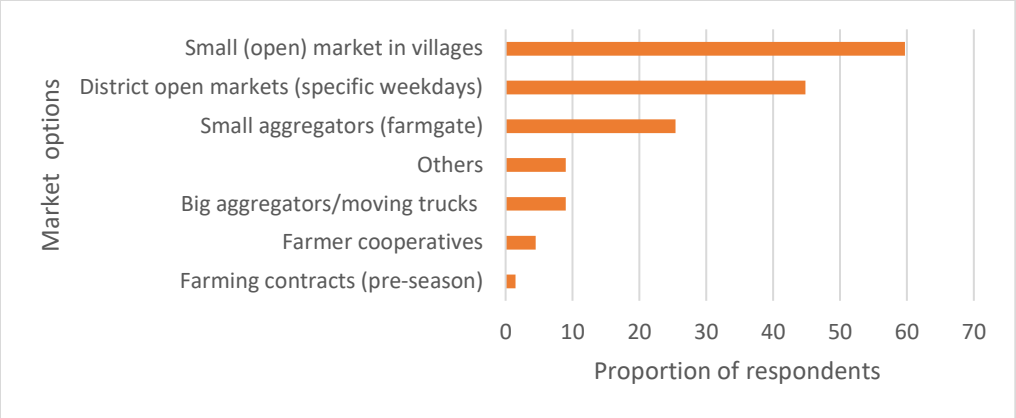


Figure 12: Market options for sold banana by farmers (N = 95)

- Majority of farmers sells in open markets (60% in village markets and 45% in big district markets). Village markets are preferred because they are nearer, thus reduced transport costs. District open markets are preferred because they are attended by buyers from different places, making prices competitive.
- 76% of farmers sell the biggest share of marketable production to open markets; with 40% selling to 'small open markets in village' and 36% to 'big district open markets'. 46-56% of quantities sold are channeled through one of these options.
- Many farmers (34%) also sell to aggregators moving in villages (25% to small aggregators and 9% to big aggregators).
- Many farmers sell to more than one market options. They tend to sell big-quantity-at-once to other options other than open markets. This suggests that aggregators, though not used as often as open markets, they buy big quantities.
- Majority farmers think the price is best around November and December and worst around June-August. They also think *Injagi* always fetches the best price followed by *Nkazikamwa* and *Ibinyarwanda* cultivars gets the worst price.

8. Farmers' views on destinations for their sold production

Farmers were asked to choose the two biggest destinations for their sold banana.

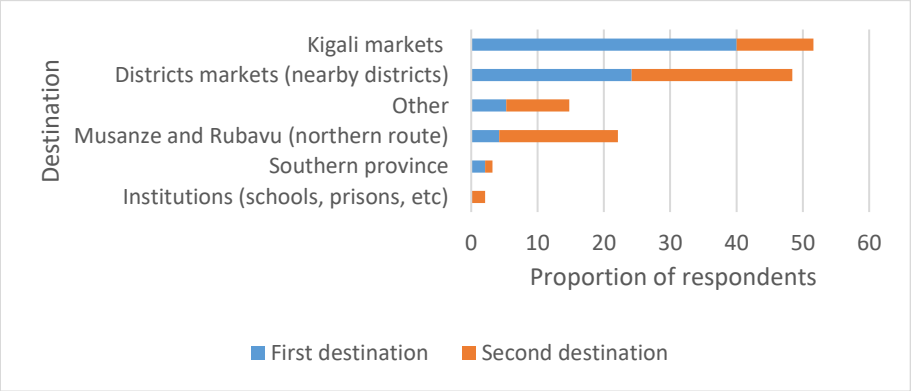


Figure 13: Destinations for sold production according to farmers (n=95)

- 40% of interviewed farmers think that buyers procure mainly for Kigali markets as the first (main) destination followed by consumers in nearby districts (24%).
- Musanze and Rubavu markets are significant markets for farmers including those from the Eastern Province.

9. Challenges to production and marketing for farmers

Farmers identified the following challenges as significant for banana production and marketing:

- Diseases are the biggest constraint to banana production in all districts as expressed by 80% of interviewed farmers. This challenge is followed by lack of production related information mainly in Gakenke and Gatsibo districts, poor soils, weather related challenges, and lack of planting material of improved varieties and preferred local ones.
- Constraints to marketing are mainly related to transport due to poor road conditions and connectivity. This is highly visible in Muhanga and Kirehe. However, farmers in these districts also acknowledge that improvements have been made in recent years.
- Farmers also think that banana price fluctuations across seasons is high.

4.2. Banana trading

1. Characteristics of interviewed traders

- 23 traders were interviewed in total, of whom 65% was female, with a mean age of 41 years (min. = 20, max. = 60, sd = 10).
- They were made up of retailers in Kigali markets (48%), retailers in districts towns (39%), wholesalers in district towns (17%), wholesalers in Kigali (9%), and rural aggregators (13%). Some identified themselves in two categories e.g., wholesaler in district and aggregator in rural area (that's why total proportion is more than 100%).
- They commerce mainly cooking banana, making up 93% of their traded volumes. Stakeholders explained that there are specific traders for dessert banana, which follow the same supply chain as cooking but with separate traders (usually fewer in number).

2. Varieties traded

Traders were asked to name the varieties they traded and the proportional volume for each variety.

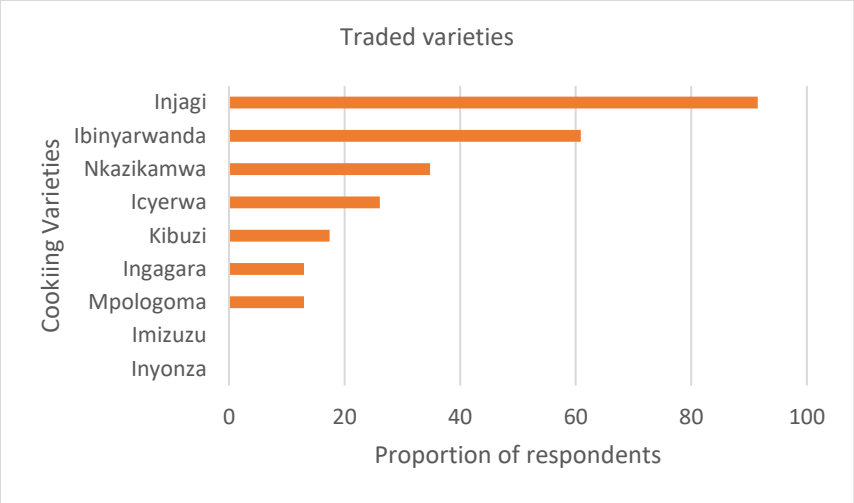


Figure 14: Varieties traded by interviewed traders (N = 23)

- Almost all traders buy and sell *Injagi*. It is followed by *Ibinyarwanda and Nkazikamwa*.
- *Icyerwa*, *Kibuzi*, *Ingagara*, and *Mpologoma* are also traded by many traders. No interviewed trader traded *Imizuzu* type (plantain) mainly because they were not common in the East province in marketable volumes but present rarely as single mats within banana fields.

3. Sources of banana for traders

Traders were asked to choose where they source banana for re-selling. Below are the results:

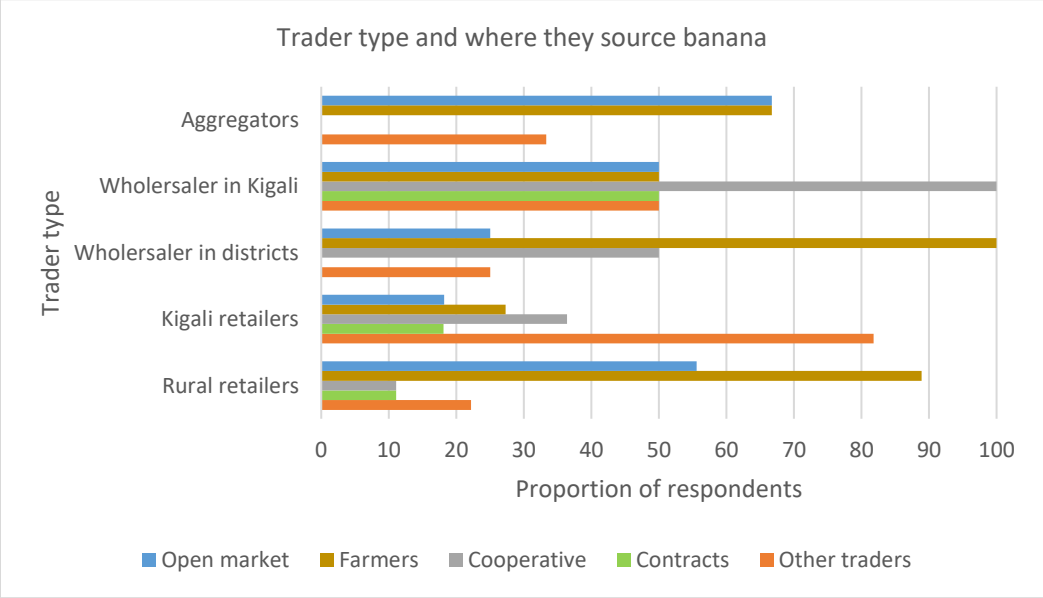


Figure 15: Where traders source banana for re-selling (N = 23)

- All types of traders buy directly from farmers to some extent. Retailers in Kigali who buy directly from farmers operate relatively at scale and have the capacity to source in rural areas.

- Wholesalers in Kigali buy banana from many sources using different approaches, including but not limited to contract farming (often informal and not binding).
- Banana often passes through hands of intermediaries as indicated by how every type of trader sources banana from another trader to some extent. For retailers, it would be expected, but even wholesalers also buy from other traders or aggregators.
- Traders source the biggest quantities directly from farmers and aggregators.

4. Variety preferences by traders

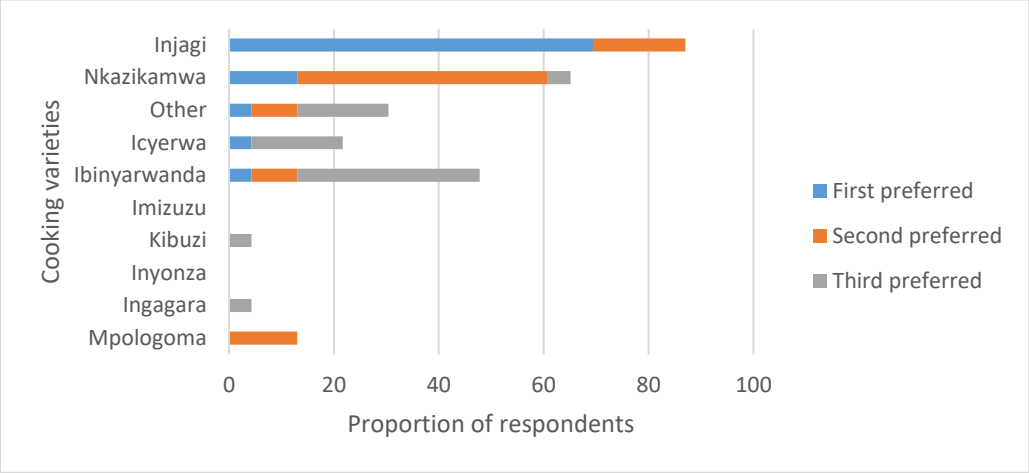


Figure 16: Preferred varieties by traders (N = 23)

- Traders' preferences are not different from consumers. *Injagi* and *Nkazikamwa* always come first. It is not surprising since they respond to consumer demand.

5. Trait preference by traders

Traders were asked to select traits they thought were important to consumers – their customers.

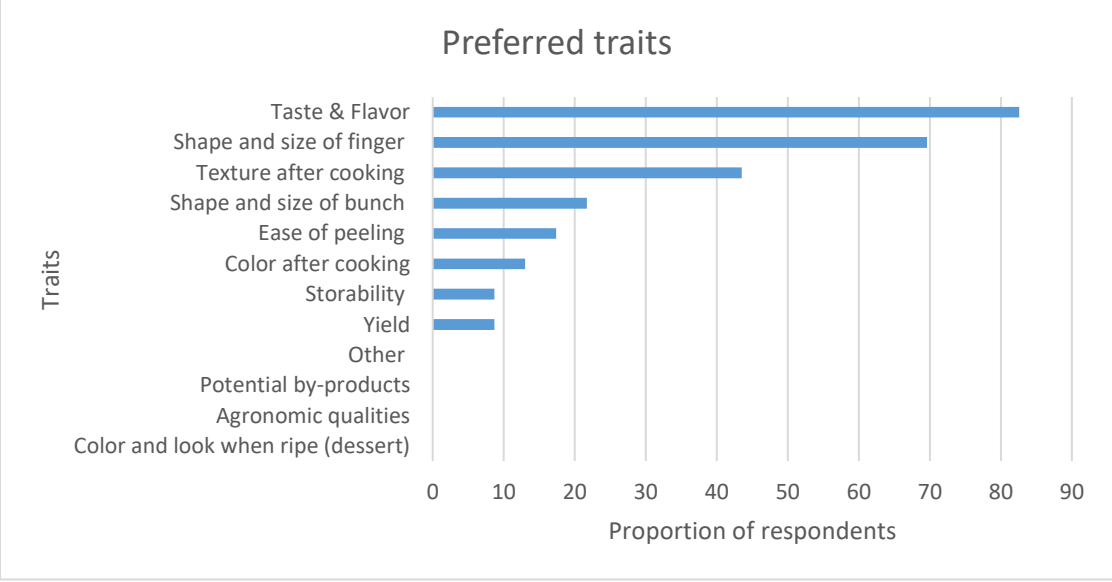


Figure 17: Traits traders think are most preferred by their customers (N = 23)

- In general, the three most wanted traits by customers according to traders are taste and flavor, shape and size of finger, texture after cooking.

6. Storage qualities

- Mean storage time for good-storage varieties is 7 days, while for worst storage varieties is 3.5 days.
- *Injagi* was reported to have the longest shelf life as compared to *Nkazikamwa*
- Traders did not report storage related information for other varieties (*Kibuzi, Inyonza, Ingagara*, etc)

7. Banana customers

- Key customer groups are poor consumers, affluent consumers, restaurants and hotels, and bars.
- Poor consumers buy *Ibinyarwanda.* Affluent consumers buy *Injagi* and *Nkazikamwa.*
- Restaurants and hotels mainly buy *Injagi*, *Nkazikamwa*, and *Mpologoma and Ibinyarwanda* depending on the type of restaurant or bar.

8. Challenges and opportunities for banana trading

- Supply of cooking banana is limited. Traders think that demand for cooking banana has been increasing, but the growth in supply did not follow the same trend. As a result, the market price keeps rising, leading to the reduction to the quantity consumed by some groups.
- High damage during transport. Banana is roughly transported, first, on bicycles from farm to markets, then in trucks from villages to urban areas. During the process banana is often damaged with punctured, broken, and discolored fingers. Fingers and hands are sometimes disjointed from the bunch.
- Transport costs seem to be very high, resulting in higher prices for banana. They also complained about high government taxes (this needs to be properly studied and understood).

4.3. Banana consumption

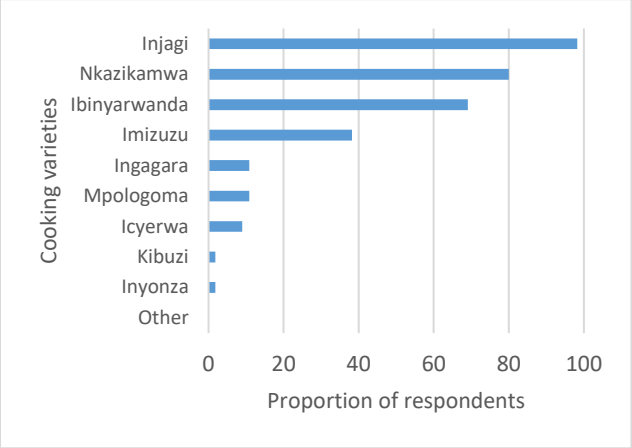
1. Characteristics of interviewed consumers

- 55 individual consumers were interviewed, of whom 69% was female.
- Respondents' main occupations varied from business related work (51%), professional work (24%), agriculture (13%), and other low paying work such as domestic work, manual labor, etc (12%).
- All consumers interviewed ate banana on an individual level, and their homes frequently cooked banana. Average times respondents eat cooking banana in a week is 3.5 (min. = 1, max. = 8, sd. = 1.8). This includes meals outside home (e.g., lunch at workplace). Average days each respondent's home cook banana in a week is 3.3 (min. = 1, max. = 7, sd. = 1.7).
- In terms of where consumers live, 65% were in urban, 22% in semi-urban, and 13% in rural areas.

2. Knowledge of banana varieties among consumers

Consumers were asked to name all the banana varieties they know. Below are the results.

2.1. Cooking



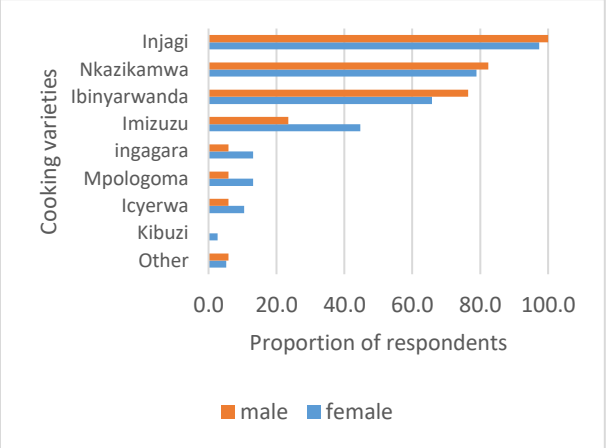


Figure 18: Consumers who know listed cooking varieties (N = 55). Figure 19: Gender comparison of consumers knowledge of varieties (right)

- The knowledge of varieties among consumers is not very wide, just 2-3 varieties are well known by urban consumers, and more by rural consumers.
- *Injagi* and *Nkazikamwa* are popularly known varieties. *Ibinyarwanda* is quite known but many consumers would not differentiate the specific cultivars in the group. Plantain or *Imizuzu* is also well known.
- Some consumers said they do not know names of some varieties, but they know their traits and can identify them visually.
- There is no significant difference between male and female in their knowledge of banana varieties.

2.2. Dessert

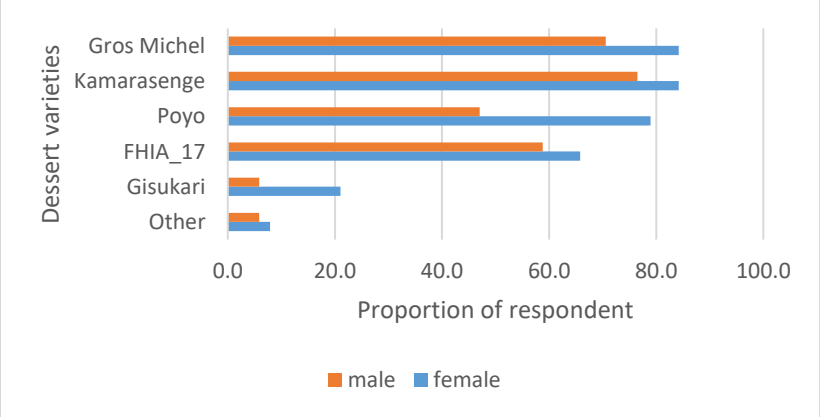


Figure 20: Consumers who know listed dessert varieties (N = 55)

- Dessert varieties on the market are generally few, but well known by consumer, except for *Gisukari*.

- Female consumers seem to know better dessert varieties.

3. Cooking varieties preference by consumers

Consumers were asked which cooking varieties they preferred. Results are below.

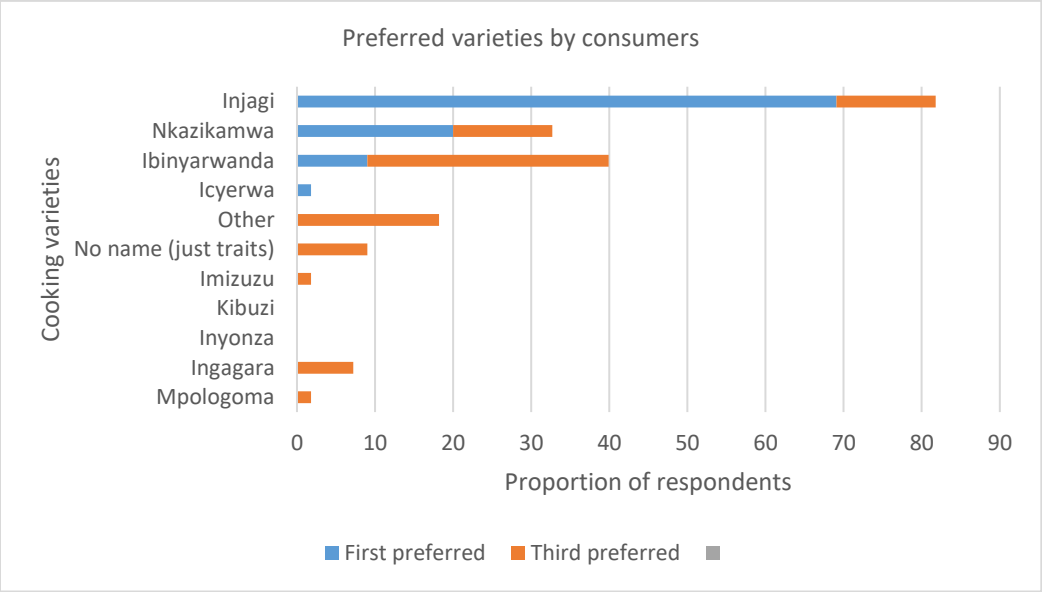


Figure 21: Individual consumers' choice for first, second, and third preferred cooking varieties (N=55)

- *Injagi* and *Nkazikamwa* are the most preferred varieties by consumers. *Ibinyarwanda* group of varieties are also popular.
- 'No name' means that a consumer knows the variety through physical features, but they do not know the name. 'Other' means the variety is unnamed on the list.

4. Comparison between individual consumers and Restaurants (Resto) and Hotels preferences

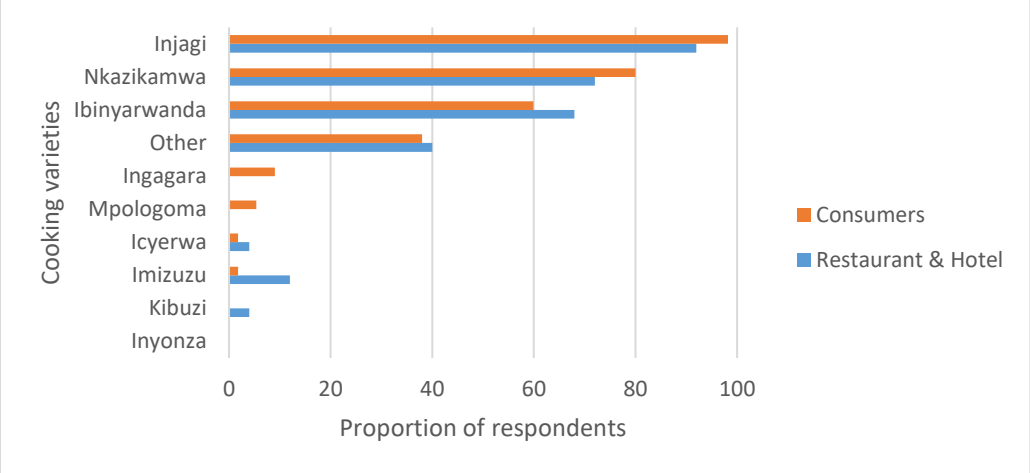


Figure 22: Comparison of preferred varieties between individual consumers and Resto & hotels (N=55)

- *Injagi* and *Nkazikamwa* are the most preferred varieties by both individual and restaurants and hotel consumers.
- There is no significant difference between individual consumers and hotels and resto in terms of preferred varieties. Same for traits.
- 'Other' also means any. When consumers do not buy their preferred varieties, they can buy any, resulting in them picking 'other' on the third choice but not necessarily meaning another specific variety.
- The first preferred variety by resto & hotel takes on average 68% of the shopping volume. The second and third take 23% and 9% respectively. This means that they majorly buy only two varieties.

5. Traits preference by consumers (cooking banana)

Consumers were asked why they liked their preferred varieties. The results are below:

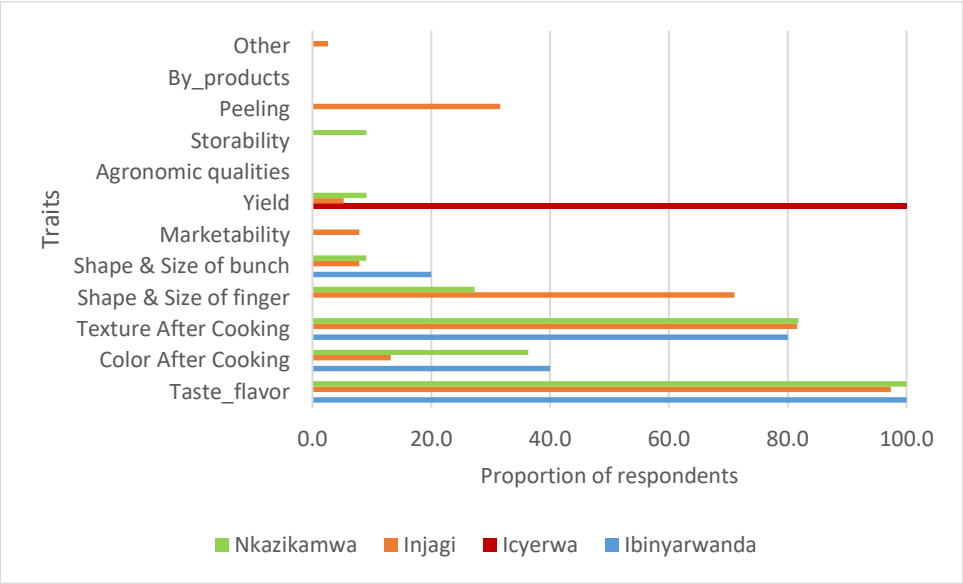


Figure 23: Why consumers prefer their first-choice variety (N = 55)

- *Injagi* is mainly liked for its taste & flavor, (soft) texture after cooking, shape & size of finger (big & long finger).
- *Nkazikamwa* is preferred for its taste & flavor, (soft) texture after cooking, and yellow color after cooking.
- *Ibinyarwanda* is appreciated for its taste & flavor, texture after cooking, and color after cooking. However, in general fewer people like them.

6. Traits by social class (cooking banana)

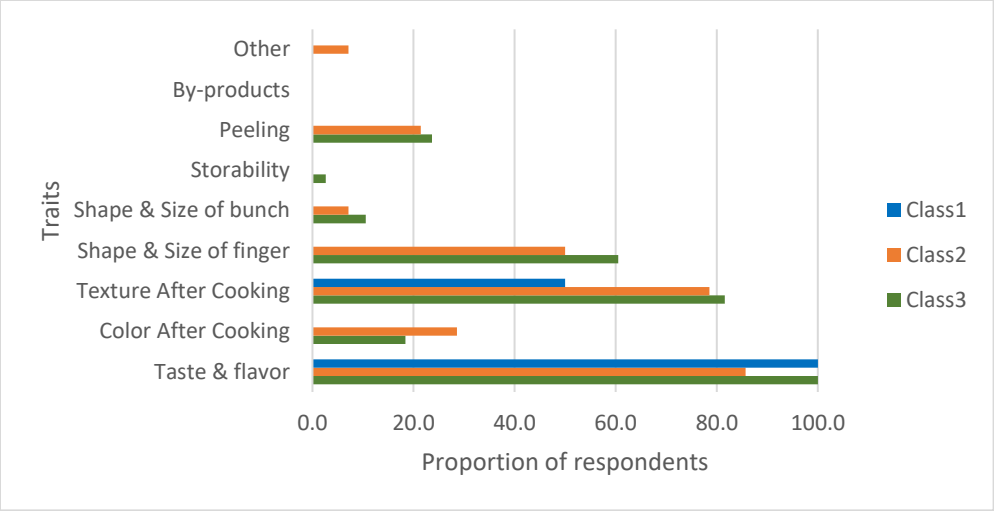


Figure 24: How consumers value traits by social class (N = 55)

- Poor consumers (class1) do not care much about traits as compared to affluent counterparts. While they selected only two traits as to why they like their first-choice variety, affluent consumers (class3), selected up to 5 including peeling qualities i.e., easiness of peeling. Poor consumers only selected taste & flavor and texture after cooking while affluent consumers selected taste & flavor, texture after cooking, shape & size of finger, color after cooking, and easiness of peeling. For consumers, a soft texture is preferred.

7. Preferred traits by gender (cooking banana)

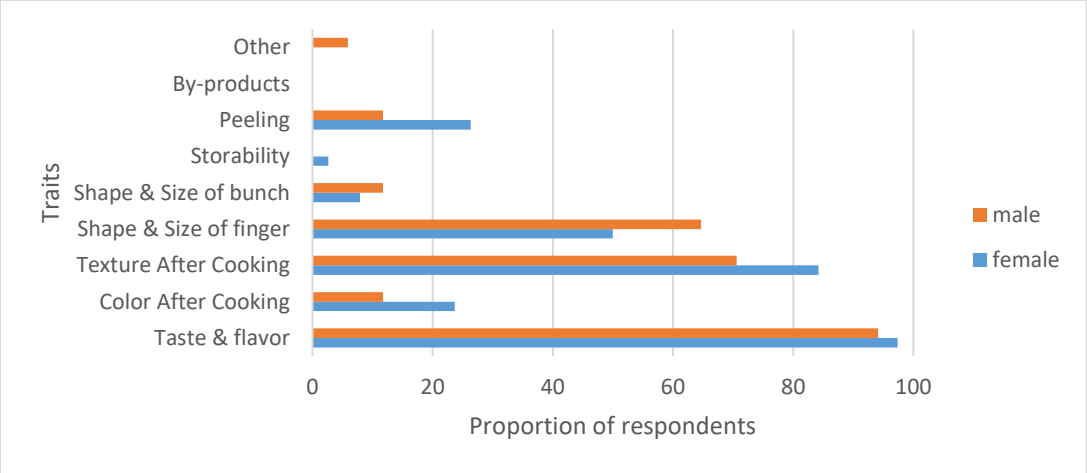


Figure 25: How consumers value traits by gender (N = 55)

- Although, there is no big difference between male and female in traits preference, women value more texture (soft) and color after cooking (yellow) and peeling qualities (easy).

8. Preference for dessert varieties by consumers

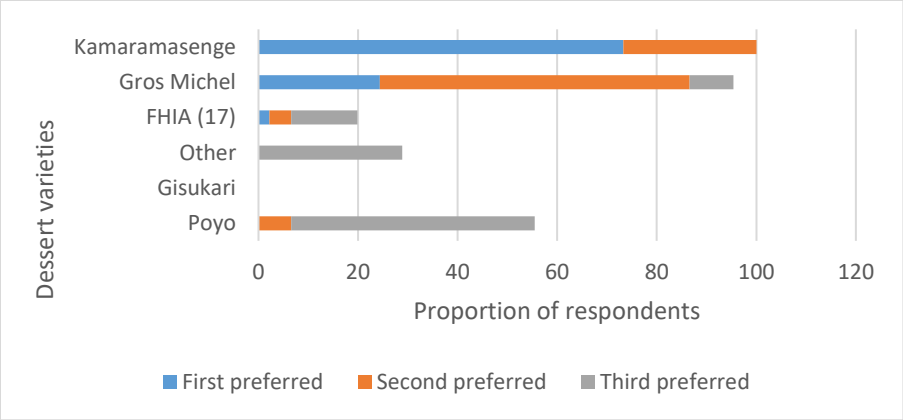


Figure 26: Consumers' choice for first, second, and third preferred dessert varieties (N=55)

- Consumers highly prefer two dessert varieties: *Kamaramasenge* and *Gros Michel*. However, for price and availability reasons, they also take *Poyo* and FHIA-17.
- 'Other' means more of 'no other choice after choice 1 and 2' than other unlisted varieties.
- Restaurants and hotels preferred strictly *Kamaramasenge* and *Gros Michel*. However, respondents in this group were more of urban (and high-end) entities, which could make a difference with those that target poorer consumers.

9. Market and shopping options

Consumers were asked to select options for where they shop cooking and dessert banana. Below are the results.

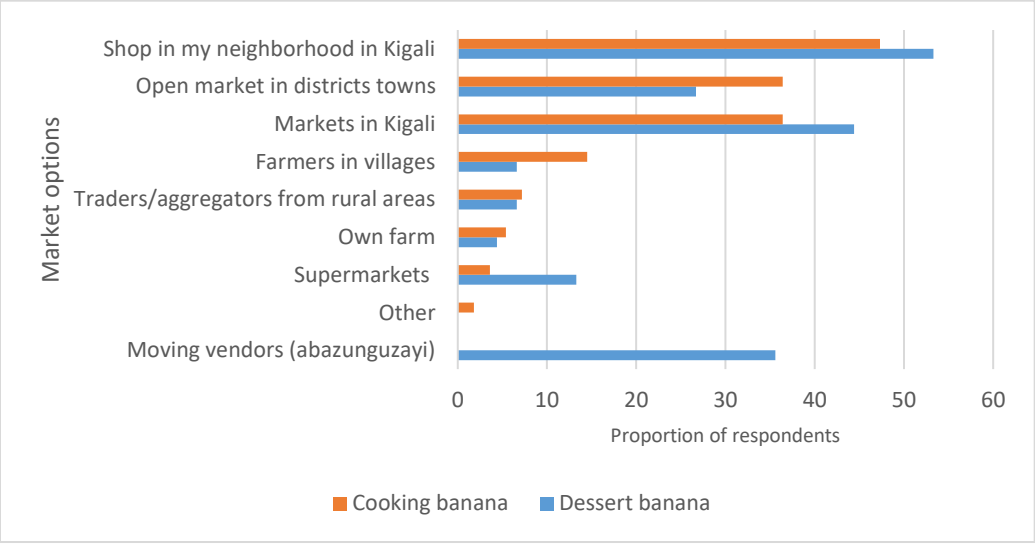


Figure 27: Where consumers shop banana (N = 55)

- Consumers in Kigali mainly buy cooking banana from shops in neighborhoods and (Kigali) markets while consumers in district towns mainly shop cooking banana from open markets and banana outlets.

- Consumers in Kigali mainly shop dessert banana from shops in neighborhoods, Kigali markets, and moving vendors, while consumers in district towns shop for dessert from open markets in rural areas and shops.
- The most common shopping frequency is 'when they want to cook it' (33% of respondents), two times in a week (29%), and 1 time per week (27%). This shows that the 3 choices are all important for banana consumers.
- The biggest difference in shopping cooking and dessert banana is that first one is procured mainly in markets and shops whereas dessert is more sourced from shops, markets and moving vendors.

10. Cooking ways or dishes for cooking banana

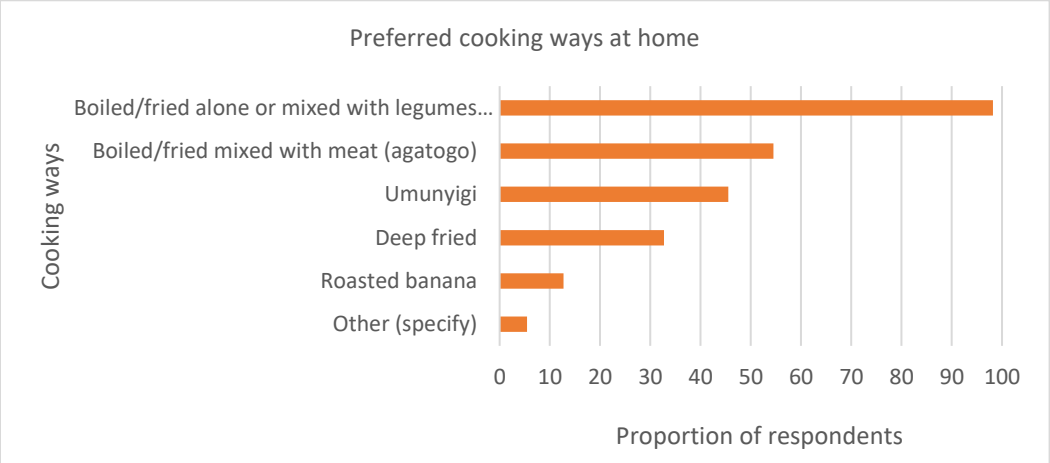


Figure 28: Common cooking ways (dishes) at home (N = 55)

- Majority of respondents' homes cook banana as 'Boiled/ fried alone or mixed with legumes (beans, peas, G-nuts)', followed by 'banana mixed with meat' and '*Umunyigi'* (a banana-made paste-like food originated from Uganda).
- Roasted banana (with peels on) is very common in Rwanda but mainly in bars and hotels. *Injagi* is the most preferred variety for roasting because of the shape of its finger.
- Another dish identified is the boiled banana with peels on, a very traditional dish.
- *Nkazikamwa* and *Injagi* are said to make the best *Umunyigi*, with the latter more preferred because of the yellow pulp.

11. Challenges for banana consumers

- Generally, limited supply and high price are the most common challenges mentioned by consumers. 50% of interviewed respondents think that the supply of banana at the nearest market should be improved, especially the supply of sufficient quantity of *Injagi* and *Nkazikamwa* varieties. Another challenge is the price, which keeps increasing.
- Banana is physically damaged the time urban consumers buy it in markets and shops. Handling and transportation need to be improved.

12. Desired traits by banana consumers

- Consumers expressed their wish to have varieties with bigger and long fingers e.g., as long as or longer fingers than *Injagi*, and/or but bigger in size (bigger diameter).

5. Discussion of results

Production

Majority of banana farmers in Rwanda is smallholders. They grow a mixture of cooking, dessert, and brewing bananas in the same fields. They do not separate the types even when they have more than one field. The results of the survey indicated that majority farmers grow all the three types (90%, 75% and 79% of farmers, respectively). In surveyed districts, 47% of banana planted areas is cooking banana while 30% and 23% are for beer and dessert banana respectively. According to stakeholders though, currently cooking and beer banana have the same weight at the national level with 40 – 45% of land planted with banana. This is a significant shift in history of banana production in Rwanda as brewing banana used to occupy more than 60% (Ferris *et al*., 2002, Nsabimana *et al*., 2008). Stakeholders think that dessert banana takes around 10-15% of total banana planted area.

The proportions between the three banana types are different from farmer to farmer depending on the farmer's socio-economic realities and farming objectives. They are also different from region to region, with the eastern and central regions growing more cooking and dessert banana compared to western and southern regions (Gaidashova *et al*., 2005, Nsabimana *et al*., 2008), which is the reason for higher proportions for cooking and dessert banana and lower for beer in this survey as more respondents were from the Eastern districts. The share of the three types of banana is influenced by, to a big extent, market opportunities and relative performance of the cultivars across a range of agro-ecological criteria and, to a less extent, by dietary preference and food security dynamics (Okech *et al*., 2005). Farmers in the Eastern Province have better connectivity with Kigali City (the biggest market for cooking banana), encouraging them to grow more cooking banana whereas farmers in the western regions prefer brewing banana which has a better market locally (for local beer and beverages) given the difficulties to access Kigali markets.

The recent shifts are results of market growth for cooking banana from the mid-nineties driven by population growth, urbanization, and the return of Rwandans from high banana eating countries like Uganda around 1995-2000 (Ferris *et al*., 2002). It was also reported that the GoR promoted and invested in more production of cooking banana at the expense of beer banana for food security purposes in the recent past (Gaidashova *et al*., 2005). However, it was also reported that beer banana is slowly picking up again, driven by a flourishing beer and wine industry growing by more than 23% in turnover annually (NIRDA, 2017). Interactions with stakeholders revealed that in the southern province some farmers are replacing poorly yielding cooking cultivars with improved beer cultivars. Beer banana cultivars are also said to be more tolerant to poor soils and stress in general than cooking ones (Gaidashova *et al*., 2005, Okech *et al*., 2005), which could be another reason for resurgence.

Banana cultivars in Rwanda exist under local names (except a few improved ones such as FHIA hybrids) and often within limited distribution. Despite existence of many landrace cultivars in farmers' fields, the majority of farmers have few cultivars in their fields. In fact, the more a farmer is serious about banana production, the less cultivars they have. This low banana diversity is partly related to BXW outbreaks and forced uproot of entire banana fields (as a control measure) leading to variety disappearance and replacement by narrow range of currently available cultivars on the seed market. Some of the remote areas, which were less affected by BXW and centralized

efforts for its control, still have earlier banana diversity. It is reported that some landrace cultivars have significantly become rare or even disappeared due the above-mentioned reasons as well as land pressure, other diseases, and poor conditions such as poor soils (Okech *et al*., 2005, Nsabimana *et al*., 2008). Moreover, despite a slow pace of introduction of new varieties, some new varieties have been introduced and others have evolved as mutants from within the existing cultivars. Cooking banana has known the least addition with only one variety introduced (*Mpologoma*) in the recent past. Some beer and dessert cultivars (FHIA-25 and FHIA-17, respectively) have been successfully introduced with quite good adoption, albeit with government intervention such as distributing planting material during the fusarium wilt crisis and replacing the old Kayinja cultivar. The same situation has happened with the dessert cultivar FHIA-17. The problem with the introduced dessert varieties is that many urban consumers who were used to *Gros Michel and Kamaramasenge* do not like their taste, which has resulted in them being relegated to poor consumers. Of course, rural consumers in their production areas eat them, especially that those areas are often not favorable for *Gros Michel and Kamaramasenge.*

Cooking banana cultivars are dominated by a well-adapted, long-fingered, loosely clustered bunch cultivar known locally as *Injagi (see photo in annexes)*. It is found nearly everywhere under different names such as *Injagi*, *Incakara,* and *Barabeshya*. *Injagi* is the most liked cultivar by many banana consumers. It is loved for its taste, soft texture, and long fingers. Long fingers, loose clusters, and big bunch are traits admired by Rwandan banana consumers because, they say, the banana bunch looks good and presentable with those traits (elegant). It is socially important because banana, in addition to being a common food, is offered as a gift in different cultural functions such as when family members visit a family with a newborn baby (*Guhemba*), weeding (*Gutwikurura*), and other ordinary family visits such as when the visit has some supportive aspects e.g., funerals, natural disaster, etc. Another important use of *Injagi* is banana roasting in bars, restaurants, and hotels. In Rwandan bars and hotels, roasted banana (and potato), are very common foods from rural to urban areas. Because of its taste and perceived 'presentable' image, it is almost the only variety roasted (there is also Mujuba which is not very common). Stakeholders explained that *Injagi* cooks well and fast (inside the finger) compared to other cultivars because of its small-to-medium width (diameter) and long shape of fingers. These social-cultural values that *Injagi* possesses makes it an elite variety in Rwanda. If one is to introduce an alternative cultivar to *Injagi*, it must have those key traits, for example, with a bigger finger but still cooking fast.

In terms of variety preference, *Injagi* is followed by another well-adapted, short-to-medium finger, yellow pulp, compact bunch cultivar known locally as *Nkazikamwa*. It has many of *Injagi*'s qualities except slightly shorter and thicker fingers (which makes a difference). However, it is also liked for its yellowish pulp, which is a key trait for a Uganda-originated dish known as '*Umunyigi'* from '*Omunyige'* in Luganda language. In preparing it, peeled banana fingers are wrapped in banana leaves and steamed or just boiled until tender and then kneaded into paste-like form when still hot. This dish has become very common in Rwanda. After *Injagi* and *Nkazikamwa*, there comes a group of landrace cultivars that are widely grown under many names but commonly known together as '*Ibinyarwanda*.' Most common cultivars in this group include *Ingaju* and *Ingenge*. Some of their common features are small and short fingers, white pulp, and compact and small to medium bunch. These cultivars are known to be more tolerant to intercropping, wind, and stresses, but also low yielding.

Banana production is threatened by the devastating and widespread presence of three major diseases: Banana Xanthomonas Wilt (BXW), banana bunchy top virus, and Fusarium Wilt, which

affect many of the available cultivars. However, efforts to combat the spread of BXW through the implementation of the Single Diseased Stem Removal (SDSR) technique have shown good results[4] and the magnitude of this threat has recently reduced. Moreover, different cultivars have their own additional production challenges. *Injagi* is grown all over Rwanda but it performs poorly in sandy soils without regular organic manure applications. It is also susceptible to pests. Additionally, it has a very tall pseudostem, making it vulnerable to wind and bunch damage during harvesting. As such, it is hard to harvest especially for female farmers as it often requires physical strength to lower the bunch gently. *Nkazikamwa* is sensitive to pests, but it is an escaping cultivar to BXW (due to persistent male flowers preventing insect contamination of BXW through floral axis wounds), which gives it an advantage. Many landraces, *Ibinyarwanda,* are well-adapted but have very low yields and often without the preferred traits previously mentioned, making them less demanded on market. *Mpologoma*, which is a newly introduced variety (from Uganda), looks more like *Injagi* but with shorter pseudostem, hence tolerant to wind. It is sensitive to stress though, thus grown in a small eastern area.

Preference for dessert banana is dominated by two highly preferred landraces: *Kamaramasenge* and *Gros Michel*. The former, also known as apple banana', has short fingers (about 10cm) and a sweet tangy taste. *Kamaramasenge* is very much liked by consumers because of its taste, resulting in higher demand and prices on markets. The latter has long fingers and a good, sweet taste, and they are highly liked by consumers as well. The two cultivars are well adapted and produced across the country with various degrees of adaptability from region to region. However, from a production point of view, dessert banana is dominated by two cultivars namely FHIA-17and *Poyo*. There are also a variety of brewing banana cultivars in farmers' fields across the country, with the Western region predominating in both quantities and variety of cultivars. Two cultivars namely FHIA-25 and *Indaya* are highly common in farmers' fields. We recommend further research to explore their traits, production, consumer preference, and usage as this study focused on dessert and cooking banana.

Marketing and Trading

Banana is a key income source for banana farmers because of its high consumption in both rural and urban areas in the three forms of food, dessert/fruit, and beverage (juice, beer, and wine). As a result, banana trading is a huge business activity in Rwanda with multitude of players. Trading of cooking and dessert banana has similar supply chain features and trends as they come from production to consumption areas. Beer banana seems to have different market dynamics. After production, beer banana mainly follows one of the two channels (1) local processing within the producing community mostly with traditional tools (at a limited scale because it is now officially prohibited due to safety concerns) and (2) industrialized processing with more modern equipment. Majority of products from (1) is unpackaged beverages consumed by locals around the production areas whereas products from (2) are well-packaged and standardized beverages sold in various places. Many processing plants are located in banana production areas, but some are far away, and banana has to be transported long distances in its fresh form. Beer banana marketing and trading surround those realities. In the rest of this section, we will focus on trading of cooking banana (which is not very different for dessert as already mentioned).

[4] Novel and effective technique to control Banana Xanthomonas wilt is suitable for Rwandan agroecology. https://www.iita.org/news-item/novel-and-effective-technique-to-control-banana-xanthomonas-wilt-is-suitable-for-rwandan-agroecology/

Despite nearly all districts of Rwanda growing cooking banana, banana in Kigali markets comes from few districts. Those are all Eastern Province districts (Kirehe, Ngoma, Kayonza, Nyagatare, Gatsibo, Rwamagana, and Bugesera), few in the northern province (Gakenke, Gicumbi, Burera), and very few in the Western province (Rubavu, Nyabihu, Karongi). Results from this study indicate that the Eastern Province supplies around 80% of all cooking banana consumed in Kigali. Majority of banana produced in other districts is consumed in the same district and neighboring ones. There are also some exports to DRC from Rubavu and Rusizi districts (but we do not have much information about it). Eastern Province also supplies significant quantities of banana to other towns including in the Northern (e.g., Musanze), Southern (e.g., Muhanga), and Western (e.g., Rubavu) provinces. Traders transport banana from the Eastern Province to those towns, most often through Kigali. Interestingly though, consumers and traders revealed that banana from other producing districts are of better quality than the one from the Eastern Province due to effects of colder weather. They say banana from other places cooks well and the texture is softer (after cooking). More research is needed to confirm this and understand the underlying factors.

Banana farmers usually sell to more than one market option (i.e., open markets in village and open district markets, (small & big) aggregators, farmer cooperatives, or farming contracts). The majority of farmer respondents sells surplus to 'small open markets in villages' where they live and 'big district open markets'. These two options take more than 55% of sold quantities. Individual aggregators and cooperatives (mostly in the East) are also important options. The Market option choice is often driven by price, transport costs (road condition, availability of transport options e.g., bicycle, trucks), quantity to be sold, distance to market, time available to family members, and gender. Choices are very dynamic, changing from day to day depending on many socio-economic realities of the household. One farmer can sell to many options within one season or month. Transport costs is the main reason respondents prefer selling in their own villages (open markets, aggregators, cooperatives). For instance, gender and number of people at home play a role in deciding market options. If there are more people who can take banana to market on bicycle (mostly men), bigger and far markets may be preferred in contrast to family with fewer members and females, which are likely to prefer to sell nearby. Generally, especially in the eastern region, there seems to be fairly good connectivity between urban and rural markets as farmers said that there is no big difference in prices between village markets and big open district markets since both are attended by traders from Kigali and other towns, making the price competitive. Nonetheless, transport costs still take a significant share in the transaction costs. The availability to farmers of many market options is a positive element in the value chain performance as it makes the price competitive and farmers less dependent on one buyer.

Traders source banana from various sources, especially from individual farmers in villages (on farm and small open markets), and large open markets in the districts. Banana traders were classified into 6 functional categories: (i) wholesaler in Kigali, (ii) wholesaler in district towns and open markets, (iii) middleman trader who buys from small aggregators in villages and from farmers in open markets in districts and sells to wholesalers in Kigali and other towns, (iv) aggregator who buys directly from farmers in their villages to resell in district open markets or to other traders both in rural areas and Kigali, (v) Kigali retailer (markets and shops in neighborhoods), (vi) retailer in district towns or markets. Each category has different business realities, and some actors can be classified into two or more categories depending on function e.g., one can be a wholesaler in Kigali (i) but also a trader who buys from farmers, rural markets, or cooperative to Kigali (iii), another can be an aggregator (iv) who buys from farmers and sells to wholesalers in Kigali and towns (iii). In fact, many traders in Kigali buy directly from farmers

(especially big ones) and cooperatives to shorten the chain for quality and shelf-life reasons. The majority of banana come to urban areas through wholesalers, (intermediaries/middleman) traders, and aggregators.

Retailers in Kigali are both in official markets and neighborhood shops. They source banana from two main sources; (1) middleman traders and aggregators who deliver sometimes to their shops or they meet them at markets when they offload products and (2) wholesalers whom they find at their selling sites, mainly at big markets such as Nyabugogo, Kimironko, Zinia, Kabuga, etc in Kigali. In contrast, retailers in smaller towns source banana directly from farmers in villages and in open markets. The biggest difference in shopping cooking and dessert banana is that the former is mainly procured in markets and neighborhood shops whereas dessert is more sourced from shops, supermarkets and moving vendors.

It is reported that banana is no longer significantly imported into Rwanda as it used to be. This is mainly because of increased local production and temporarily interrupted business environment between Rwanda and Uganda around 2019. In the past, significant quantity of banana eaten in Kigali used to be imported from Uganda (Ferris *et al*. 2002).

Consumption

Banana is consumed in all parts of the country by all categories of people. Stakeholders think that consumption of cooking banana is on a continuous rise among Rwandans. In fact, despite Rwanda being a big producer of cooking banana, it has also been a net importer for many years (until recently as mentioned above). Stakeholders also think that women like to eat banana more than men.

Cooking banana is consumed as a prepared food in many different dishes or cooking ways. Key dishes include (1) boiled (or fried) alone or mixed with legumes (beans, cow peas, groundnuts), (2) boiled (or fried) and mixed with meat commonly known as '*Agatogo'* (which is a Uganda-originated name), (3) deep fried, (4) *Umunyigi* (also Uganda-originated name), and (5) roasted banana. These dishes are influenced by many socio-cultural factors including where people live e.g., urban vs rural, incomes, and origin i.e., people who lived or grew up in Uganda or DRC have specific dishes they are fond of (which has effect on production e.g., varieties, harvesting time, etc). 98% of interviewed consumers reported they eat *boiled (or fried) alone or mixed with legumes*, 54.5% A*gatogo*, 45.5% *Umunyigi,* 32.7% deep fried, and 12.7% roasted banana. The choice of dish varies at household level depending on the circumstance such as the time of the day or the event. For example, *Agatogo* is more common in the morning hours, roasted banana is often eaten in the evening in bars and restaurants, while 'boiled (or fried) alone or mixed with legumes' is a lunch or dinner dish.

Generally, stakeholders think that the most common dish eaten by Rwandans at home is (1). It is also the most common in rural areas. Dishes (2) and (3) are more common in urban homes and restaurants and hotels, but uncommon in rural areas. Dish (4) is becoming more and more common especially in urban areas both in homes and restaurants and hotels. This dish was introduced around 1994-2000 by people who lived in Uganda, but it is spreading in the entire population, especially in cities. It is often eaten in restaurants and hotels and social functions than in homes because it requires specialty skills and tools to cook properly. And that is where most people are first introduced to it. *Inkazikamwa* is the best variety for this dish because of its taste, soft texture, and yellow pulp. *Ingaji* is also good for it. Dish (5), roasted banana, is a special dish in the Rwandan society. People eat it in specific circumstances - when they are 'out'. Banana is

roasted - single finger roasted with the peel on until it cooks inside, then the peel is removed to be served plain or seasoned with spices - in almost all bars, restaurants, and hotels in Rwanda (see photos in annexes). It is eaten as an accompaniment to alcohol and non-alcohol beverages and often goes with roasted meat (Kebab, locally known as 'brochette'). This dish is more common in urban areas than rural areas because of a combination of factors such as urban lifestyles including frequent eating in bars, restaurants and hotels and greater purchasing power. *Injagi* (and similar cultivars) fits well this dish because of its long and small-to-medium fingers (allowing it to cook fast and well) and taste.

Cooking banana is eaten many times in a week in a typical Rwandan home. Interviewed respondents, majority from Kigali, said that they eat banana more than three times in a week while they eat it 3.5 times individually (including outside home) on average. We do not have enough data to compare different regions or urban and rural consumers. However, it is likely that in areas where cooking banana is produced such as the east region, people eat it more often.

The only obvious difference between banana consumption in homes and bars, restaurants and hotels are dishes. In terms of traits and varieties, consumers have similar preferences. Urban consumers preferences for cooking banana are very much similar and narrow. However, choices at the market are highly differentiated by banana prices. For both cooking and dessert, even though consumers wish to eat a few specific varieties, they end up buying (and eating) very different varieties because of prices. For cooking, affluent consumers eat *Injagi* and *Nkazikamwa* while poor consumers eat a variety of local cultivars '*Ibinyarwanda'*. For dessert, affluent consumers eat *Kamaramasenge* and *Gros Michel* while poor consumers eat FHIA-17 and *Poyo*.

Consumption of dessert banana has been growing steadily in Rwanda. Dessert banana is consumed in two main forms: dessert and juice. Majority of it is consumed as ripen banana fruit, and at any time of the day. A small quantity is processed into juices, often mixed with other fruits. Very small quantities are used as ingredients for making cakes in restaurants, hotels, and other food producers as well as to make beer alongside beer banana. This latter happens when a farmer has dessert banana and the price is not good enough or there is no market at all, which is rare.

6. Cooking banana value chain

This section provides a description of the cooking banana value chain focusing on actors, structure, relationships, and the flow of products. The cooking banana value chain is made up of the following key players: producers (small, medium, big farmers, and farmer cooperatives), aggregators, middlemen traders, transporters, wholesalers, retailers, and consumers entities (bars, restaurants, and hotel), and individual or home consumers. The value chain operations are supported by market infrastructure and functions such as the famous open markets, transport logistics, research and extension, and actor associations such as farmer and trader cooperatives.

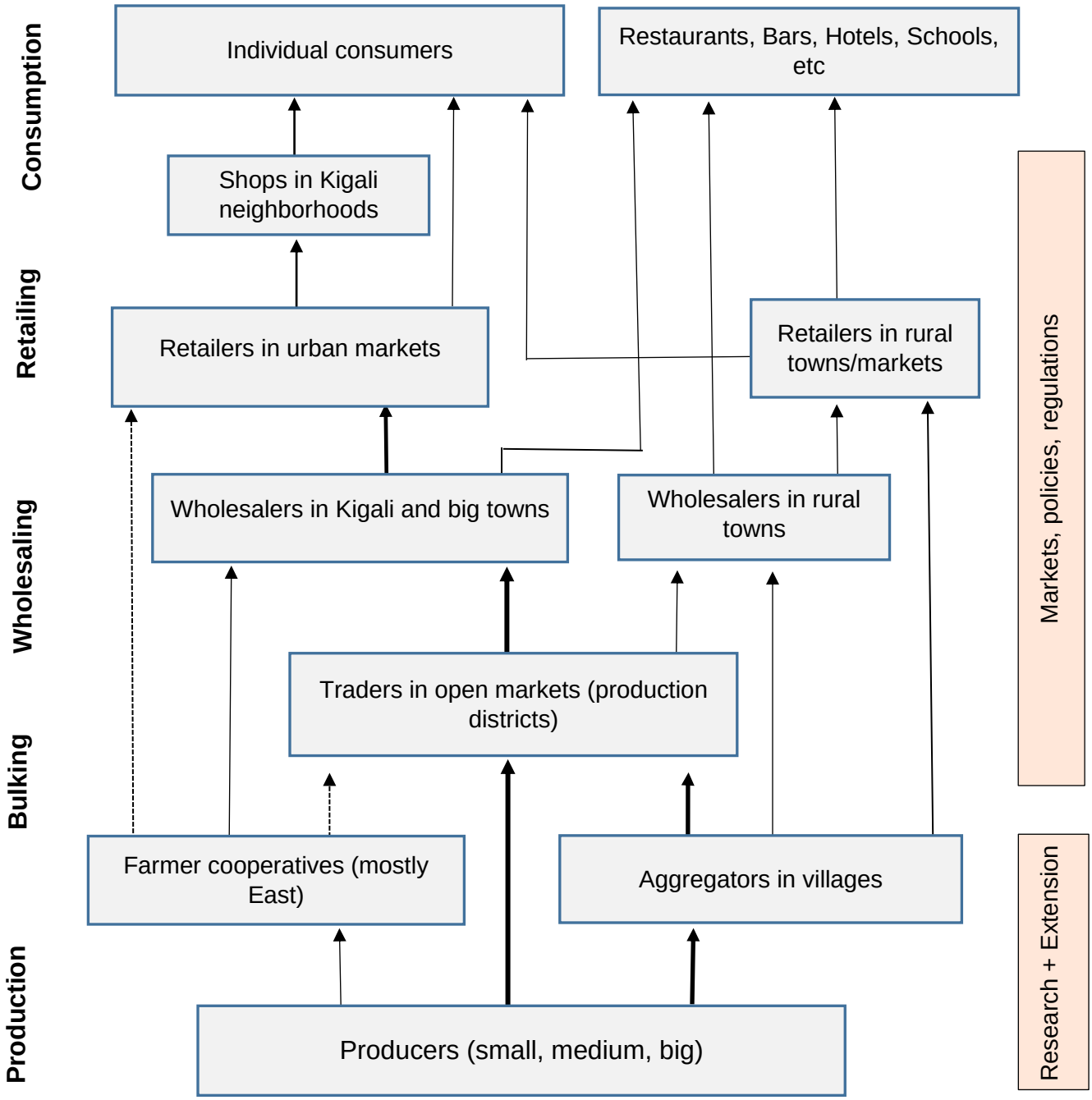


Figure 29: Structure of cooking banana value chain in Rwanda

7. Market segmentation and Banana product profiles

7.1. Market segmentation

Market segmentation gives an opportunity to identify specific needs for specific markets. Just like for other products, banana consumers are different in many ways e.g., where they live, how they cook banana, use of banana in social-cultural events, social value attached to banana, etc. This makes their demands for banana different as well, which presents an opportunity for research for development programs to create impact by offering solutions that fit different market needs.

Based on data collected in this study on production, trading, and consumption of cooking and dessert banana, we analyzed who wants what which led to categorization of consumers - or market segments - for cooking and dessert banana. Additionally, based on production data and other information from workshops and literature on brewing banana, basic market segments for brewing banana were also identified, but without details of what each segment demands for in terms of traits (need further research). The figure below summarizes the analysis of segments.

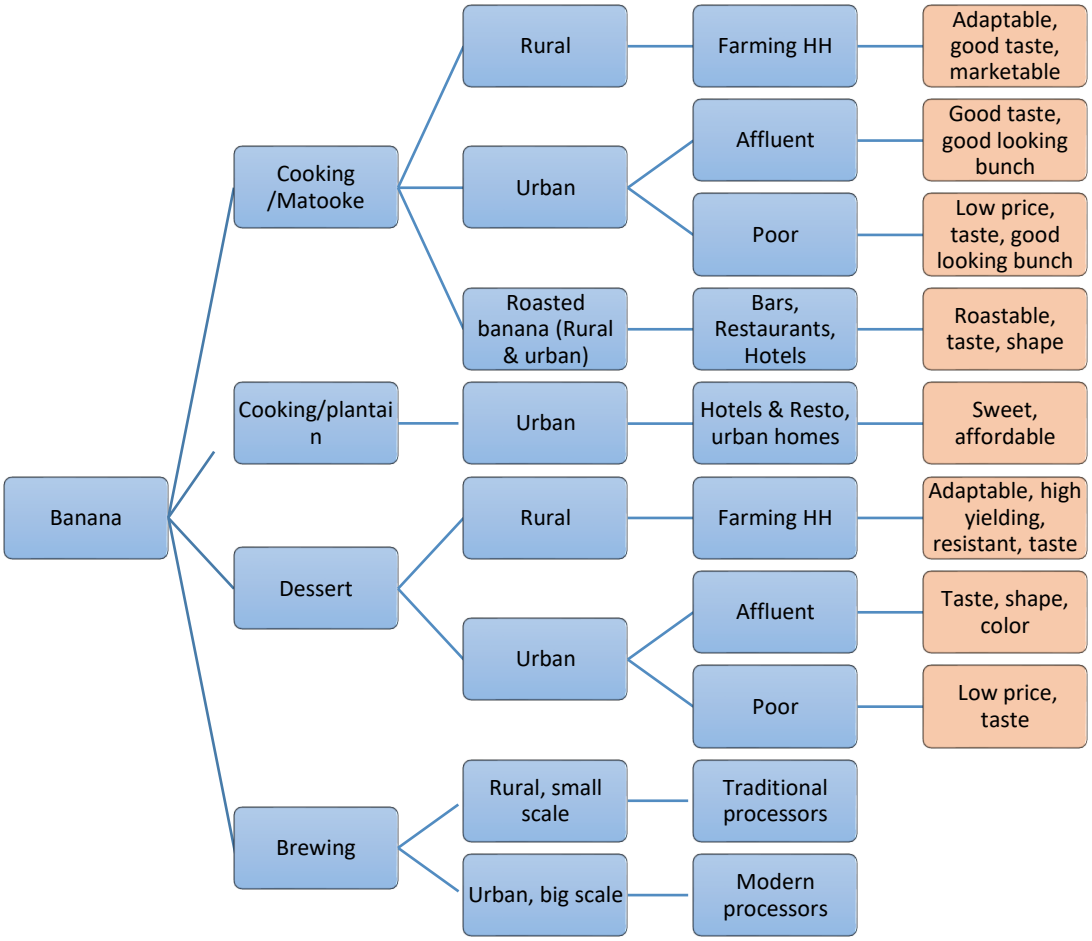


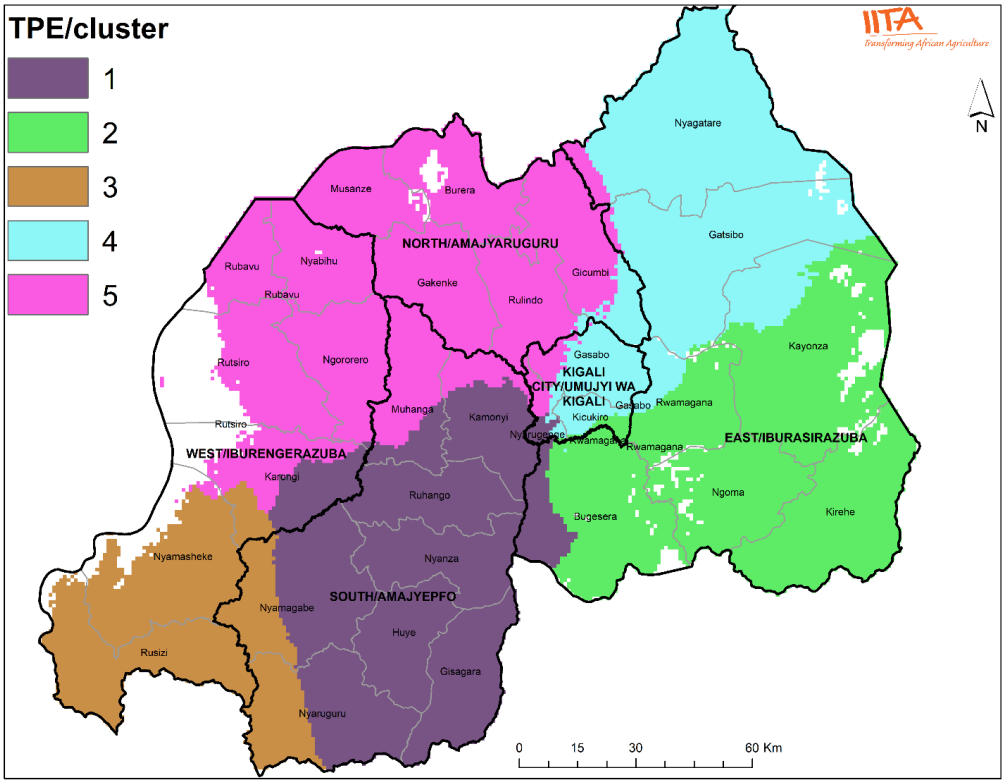
Figure 30: Identified banana market segments.

From the analysis above, the identified segments are as follows:

1. Cooking banana - consumers in rural areas - farming households
2. Cooking banana - affluent urban consumers (Kigali & other towns) - home and restaurants & hotels
3. Cooking banana - poor urban consumers (Kigali & other towns) - home and restaurants & hotels
4. Cooking banana - banana for roasting (rural and urban) - Bar, Restaurant, Hotel
5. Cooking banana - plantain - urban consumers - Restaurants, Hotel, and homes
6. Dessert – rural consumers - farming households
7. Dessert - affluent urban consumers - home and restaurants & hotels
8. Dessert - poor urban consumers - home and restaurants & hotels
9. Brewing – rural - rural traditional processors
10. Brewing – urban – industrialized/modern.

7.2. Banana product profiles

A better understanding of target environments is essential for various interventions targeting different segments of the value chain such as the market (consumer diets, preferences, etc) or production i.e., banana breeding efforts for product development and varietal testing. The ABBB program uses spatial tools to characterize banana production environments into homologous mega-environments, having operational significance for breeding research. In Rwanda, five environments were identified (Fig.31), for which target product environments (TPE) can be developed.



Source: For data source see footnotes, map by IITA researchers

Figure 31: Target product environments developed for Rwanda.

The analysis utilized spatial data on socioeconomic, climatic, soil and remote sensing vegetation indices and terrain attributes from different sources[5]. It provides quantifiable information on where and how the Banana crop is cultivated and under what conditions. The results of this analysis can guide the design of target product profiles (TPP) to include specific traits and steer variety deployment to the appropriate agroecology. TPE 2 and 4, in the eastern part of the country, have many similar production features (low rainfall, low altitude, high mean temperature, less acidic soil (high pH, etc) as well as TPE 3 & 5 in the west (high altitude, high rainfall, more acidic soils (low pH), etc). The two TPEs in the pair could have closely related target product profiles. TPE 1, which is in the middle of the two pairs, would need its own TPP, but also could use the TPP from the two pairs to some extent. Studies to develop smaller TPEs and more detailed target product profiles for Rwanda are recommended.

Nonetheless, from our analyses, we suggest the following basic target product profiles as a starting point. The proposed TPP were developed based on the identified market segments (section 7.1) and production environments whereby products are developed to meet the market needs of specific market segments through production in the identified environments. The identified TPP are as follows:

1. Rwanda – Banana - Matooke - Cooking - long finger - Eastern region (TPE 2 & 4)
2. Rwanda – Banana - Matooke - Cooking - short to medium finger - Eastern region (TPE 2 & 4)
3. Rwanda – Banana - Matooke - Cooking - long finger - Western region (TPE 3 & 5)
4. Rwanda – Banana - Matooke - Cooking - short to medium finger -Western region (TPE 3 & 5)
5. Rwanda – Banana - Matooke - Cooking - long finger - Southern region (TPE 1)
6. Rwanda – Banana - Matooke - Cooking - short to medium finger - Southern region (TPE 1)
7. Rwanda – Banana - Matooke - Cooking - Plantain (all TPE)
8. Rwanda – Banana - Dessert – long finger with *Gros Michel* (AAA) taste - all regions (all TPE)
9. Rwanda – Banana - Dessert – medium length, big finger, big bunch with *Kamaramasenge* (AAB) taste - all regions (all TPE)
10. Rwanda – Banana – Brewing – Eastern region (TPE 2 & 4)
11. Rwanda – Banana – Brewing – Western region (TPE 3 & 5)
12. Rwanda – Banana – Brewing – Southern region (TPE 1)

Key trait recommendations for crop improvement for developing the proposed TPP is summarized in the table below. They are key traits to address farmers' and consumers' concerns and preferences.

[5] Varieties of climatic data from daily and monthly CHIRPS and Worldclim data (1960-2021) were downloaded, processed, and analyzed for the banana production environments in Africa. ISRIC soil fertility, depth, texture, and acidity data at a spatial resolution of 250m were also downloaded and processed for analysis.

Table 2: Guiding specifications for TPP development for Rwanda

Banana type	TPE	Key feature	Key traits to tackle	Current closest variety
Cooking	East (TPE 2 & 4)	Long finger, big bunch, less compact bunch (good looking), easy to roast	Resistance to wind (strength of stem), easy of harvesting (shorter stem), tolerance to diseases, bigger finger, yellowish pulp, easy roasting	*Injagi*
	East (TPE 2 & 4)	Medium finger, big bunch, yellow pulp	Big bunch, resistance to stress and pests	*Nkazikamwa*
	West (TPE 3 & 5)	Long finger, big bunch, less compact bunch (good looking)	Resistance to wind (strength of stem), easy of harvesting (shorter stem), tolerance to disease, bigger finger, yellowish pulp, easy roasting, adaptation to west conditions	*Injagi*
	West (TPE 3 & 5)	medium finger, big bunch, yellow pulp	Big bunch, resistance to stress and pests, adaptation to west conditions, yield	*Ibinyarwanda*
	South (TPE 1)	Long finger, big bunch, less compact bunch (good looking)	Resistance to wind (strength of stem), easy of harvesting (shorter stem), tolerance to disease, bigger finger, yellowish pulp, easy roasting, adaptation to TPE conditions	*Injagi*
	South (TPE 1)	medium finger, big bunch, yellow pulp	Big bunch, resistance to stress and pests, adaptation to TPE conditions, yield	*Ibinyarwanda*
Dessert	All TPE	Long finger, good taste, big bunch	Size of finger, size of bunch, resistance to fusarium and other diseases	*Gros Michel (AAA)*
	All TPE	Medium finger, good taste, big bunch	Big size of bunch, resistance to fusarium and other diseases	*Kamaramasenge (AAB)*
Brewing	East (TPE 2 & 4)	Short to medium finger	Yield, bunch size, juice qualities (quantity & quality), resistance to diseases, adaptation to East conditions	*Imbihire, Intuntu, Ingumba, Indaya, Kayinja*
	West (TPE 3 & 5)	Short to medium finger	Yield, big bunch size, juice qualities (quantity & quality), resistance to diseases, adaptation to West conditions	*Imbihire, Intuntu, Ingumba, Indaya, Kayinja*
	South (TPE 1)	Short to medium finger	Yield, bunch size, juice qualities (quantity & quality), resistance to diseases, adaptation to South conditions	*Imbihire, Intuntu, Ingumba, Indaya, Kayinja*

East: less rains, warmer, lower altitude, more fertile soils. ***West***: high rains, colder, higher altitude, poorer soils. **South**: in-between the two former ones.

8. Conclusion & recommendations

Banana's importance as a food and cash crop continues to grow with time in Rwanda. With the influx of people from high banana eating countries in the nineties and early 2000, the consumption of cooking banana has widened both in quantity and variety of cooking ways (dishes). This has also created demands for new products i.e., new varieties or traits. For instance, people who lived in Uganda and are used to *Umunyigi* dish like yellow pulp and soft-after-cooking varieties (*Inkazikamwa* comes closest now). This dish also requires banana harvested very late, close to ripening. This reduces the shelf-life of banana, which is important for the supply chain from production to consumption areas. Moreover, there are other dishes in Rwanda which require banana harvested a bit early. This present a challenge and an opportunity for niche markets that could be exploited by value chain actors once properly understood.

Consumption of dessert banana has also been rising resulting in increased cultivated area and production quantities over time. As urbanization is not likely to slow down any soon, it is almost certain that demand for dessert banana will continue to grow. Production of dessert banana is even a more profitable option for farmers because their price per volume/weight unit is higher. Once farmers have high yielding and diseases tolerant varieties, dessert types will continue to compete for lands with other types with an advantage.

Although statistics show that land allocated to beer banana has reduced over time, it still occupies the biggest share, and its status does not show signs of declining much further in the near future. Its processing into local beverages popularly known as '*urwagwa'* in the rural areas and their role in the social life of rural people remains unmovable. Moreover, its role goes beyond rural areas as more modern processing plants have been established and their products in form of beer and wine continue to be highly consumed in urban areas.

On the other hand, banana also faces many challenges from production to consumption. Key challenges include lack of improved varieties with high yields and short cycle, poorly functioning seed systems to enable farmers to access quality planting materials (of improved varieties), lack of good markets for some farmers depending on where they live, poorly developed logistic infrastructure, limited value addition to banana to add value and extend shelf life, and poorly coordinated value chain among others. When thinking about improved varieties, agricultural development partners often consider farmers as the end-users of varieties, hence targeting them during crop improvement. However, it has been realized that the needs and preferences of consumers are as or even more important when a value chain development perspective is considered. When the needs of the markets are understood and met, everyone benefits from producers to consumers and the economy in general. This is why this study, although commissioned by a CGIAR crop development initiative, focused on the market segments and value chain analysis and product profiles for the identified market segments. The study highlights that there is need for better and deeper understanding of the banana value chains. Key areas for include the following:

- Better understating of volumes and proportions that different value chain segments and actors handle e.g., how much banana goes to Kigali and other towns, how much is consumed locally, total volumes, and value traded, etc. This can guide investment planning and resource allocation,

- Prices and transaction costs. It would be good to understand the transaction costs along the value chain and where the biggest share could be occurring and why. This can help identify the value chain nodes that are most inefficient, hence guide interventions,
- Diversity and geographical distribution of germplasm in the country need to be studied and understood in order to make good use of it during crop development and conservation efforts both locally and regionally,
- Profiling of available varieties, particularly varieties under the *Ibinyarwanda* name, is needed to understand them better and their importance e.g., in terms of biodiversity, etc.
- This study focused on cooking and dessert bananas, but only covered the production part of beer banana. Given the importance of the latter in the banana sub-sector in Rwanda, there is a need to conduct a more comprehensive study of its value chain.
- There are insufficient crop development capacities at RAB, which has resulted in no release of improved varieties for cooking banana for a long time. Moreover, good progress has been made in the region in this aspect. With little efforts, Rwanda can benefit from these achievements. For this to happen, there is a need for better regional collaboration, as well as financial and technical support. This includes the development of a strategy (including a methodological framework) on how to prioritize, design, and involve different value chain actors in the introduction, testing, and evaluation of new germplasms.

The government of Rwanda recognizes the importance of banana, as it is among the eight designated priority crops for investment. This is a commendable move as it places banana on the national agenda for potential interventions across different value chain levels from production to processing and value addition to consumption. However, banana continues to be significantly under-supported by development partners. Apart from the government's research and extension efforts, mainly directed at the management of diseases, there isn't much going on in other key areas such as breeding of new improved varieties, germplasm collection and maintenance, seed production and quality assurance, and value chain coordination. Besides public institutions such as RAB and the National Agricultural Export Development Board (NAEB), other key partners currently include IITA, which has partnered with GIZ[6] and other local partners to deliver interventions on surveillance, management, and control of BXW disease through digital technologies[7], and other few NGOs such as Food for the Hungry which intervenes in seed system and extension. In the past, FAO and USAID also supported the banana sub-sector, although the support did not last long enough to make lasting impact and covered limited locations. Nonetheless, from a private sector perspective, banana business is a sizeable economic activity thanks to its importance as food as well as raw materials for beer and wine industries. Therefore, there is evident potential for impact at scale through development of the banana sector in Rwanda.

[6] https://www.giz.de/en/html/index.html

[7] https://www.ict4bxw.com/; https://www.iita.org/news-item/iita-rwanda-releases-a-digital-application-in-the-fight-against-bacterial-wilt-disease-in-bananas/

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Annexes

Banana photos

1. Popular cooking varieties

Injagi		
Nkazikamwa		

Ibinyarwanda		
Umuzuzu / Plantain		

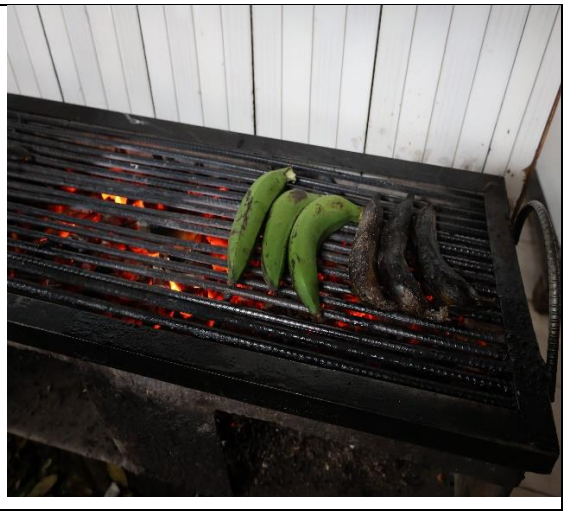
2. Popular dessert banana varieties

Kamaramasenge		
Gros Michel		

FHIA-17		
Poyo		

Gisukari		

3. Banana roasting (*Injagi* variety)



All photos used, including the one on the front page, were taken during the study by the IITA team including Ms. Bumwe Ritha and Mr. Samuel Mugambi.

END