

# Participatory Processing Diagnosis of Matooke in Uganda

Understanding the Drivers of Trait Preferences and the Development of Multi-user RTB Product Profiles, WP1, Step 3

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Ethics: The activities, which led to the production of this manual, were assessed and approved by the CIRAD Ethics Committee (H2020 ethics self-assessment procedure). When relevant, samples were prepared according to good hygiene and manufacturing practices. When external participants were involved in an activity, they were priorly informed about the aim of the activity and explained that their participation was entirely voluntary, that they could stop the interview at any point, and that their responses would be anonymous and securely stored by the research team and used for research purposes. Written consent (signature) was systematically sought from sensory panelists and consumers taking part in activities.

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# ABSTRACT

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This study explores the perceptions of processors on raw matooke traits that influence the consumption quality and preference for steamed-mashed matooke as well as the losses and gains associated with each step in the processing of steamed-mashed matooke. Four female experienced small-scale matooke processors from a high banana producing district (Mbarara) and four from a low banana producing district (Nakaseke) were selected to take part in the participatory processing demonstrations. The set of four different cooking banana varieties selected for processing included officially released and unreleased hybrids; local varieties commonly produced and consumed in each study district; lastly, the most and least preferred varieties identified in previous sensory evaluation studies. Specifically, in Nakaseke, Nakitembe, Mpologoma, M30, and NARITA 21 were processed while Nakitembe, Kibuzi, M30, and NARITA 2 were processed in Mbarara. The local varieties (Nakitembe, Kibuzi, and Mpologoma) were sourced from farmers in the surrounding, unreleased hybrids (NARITAs 21 and 2) obtained from research fields managed by National Agricultural Research Organization in Kawanda and Mbarara while the officially released hybrid (M30) was obtained from National Agricultural Research Laboratories, Kawanda and a big farmer in Mbarara. Processors were presented approximately 2kg of each variety and were required to prepare steamed-mashed matooke following steps each one normally undertook in their usual preparation routine. Interviews were conducted at each step of processing using a structured questionnaire and analysis done using means and ANOVAs in XLSTAT. The findings show that: commonly, ten steps namely, harvesting, de-clustering, de-fingering, peeling, washing pulp, wrapping pulp in banana leaves and fibers, steaming, pressing, simmering, and serving are undertaken to process steamed-mashed matooke. Big bunch size, compact clusters, full and straight fingers, ease of peeling, thin, smooth and shiny-green-peel color, maturity, freshness, and overall resemblance to the perceived appearance of indigenous preferred varieties were the major perceived traits of raw cooking banana that would yield good quality processed matooke. The peeling yield was lowest (53% and 48%, respectively) for NARITAs 2 and 21 and highest (65%) for M30. Local varieties had higher peeling productivity. Steaming productivity ranged from 0.5kg to 1.0kg while the mashing and simmering productivity ranged between 0.9kg to 1.7kg. Overall, processors in Mbarara preferred local varieties while their counterparts in Nakaseke preferred M30 for making steamed-mashed matooke. NARITAs 21 and 2 had the least acceptance for processing in both districts.

**Key Words:** steamed-mashed *matooke*, participatory processing, quality characteristics, processing steps, Uganda



# 1 INTRODUCTION

Within the framework of Work Package, 1 (WP1) of the RTBfoods project, participatory processing (also referred to as Activity 4) was conducted with commercial processors from two districts in Uganda. This was a follow up to the Gendered food mapping exercise (Activity 3<sup>1</sup>) that was conducted with farmers. During this study, the key processing unit operations important for the quality of steamed-mashed matooke were identified by the processors. The aim was to get a better understanding of the processors' quality characteristic preferences while preparing steamed-mashed matooke. Some of the information on preferred and non-preferred characteristics was incorporated into the consumer questionnaire that was used for Activity 5 (Consumer testing).

Participatory demonstrations and consultations were done with eight small scale women processors from surrounding towns in Mbarara and Nakaseke districts (four in each district) to collect their opinion on the quality characteristics of banana varieties at the different preparation steps for steamed-mashed matooke. Each processor prepared four varieties: (Nakaseke: Nakitembe, Mpologoma, M30 and NARITA 21; Mbarara: Nakitembe, Kibuzi, M30 and NARITA 2). Nakitembe, Mpologoma, and Kibuzi are popular local cooking varieties grown in the study areas and produced for both home consumption and the market. M30 (Syn. 'NAROBAN5' or 'NABIO 808') is a hybrid that was officially released in 2019. NARITA 21 and NARITA 2 are hybrid varieties that have not been officially released and are still under evaluation. The analysis was done using means and ANOVAs in XLSTAT. For each of the districts, there were no significant differences ( $p < 0.05$ ) between the varieties in the peeling, washing, wrapping, steaming, pressing, simmering, mashing, and global cooking productivity. Differences were, however, observed in the preferred varieties by the district where processors in Mbarara preferred the local varieties (Kibuzi and Nakitembe), while those in Nakaseke had a higher preference for the hybrid variety M30. Furthermore, findings from the processors in the study highlight the influence of variety and each processing step during the preparation of steamed-mashed matooke on consumer's perception of the final product. As such, the sensory evaluations of the processed product (steamed-mashed matooke) underscored soft texture, good matooke smell, yellow colour, and good matooke taste as some of the desired traits in steamed-mashed matooke.

## 2 METHODOLOGY

### 2.1 Study Area

Participatory processing demonstrations were conducted with eight 'small-scale' processors from surrounding towns in two districts: 4 from Mbarara and 4 from Nakaseke districts. Mbarara district is in western Uganda and was selected as a representation of high production areas while Nakaseke district in central Uganda was selected as a representation of low production areas. In each of these sites, a team visited in advance to find the best processors who were willing to take part in the processing demonstrations and schedule the date and time for the activity. For a detailed description of the sampling and methodology refer to Fliedel et al 2018 Activity 4 manual<sup>2</sup>.

### 2.2 Raw Material Choice

Steamed-mashed matooke was prepared using 4 banana varieties per site (**Nakaseke:** *Nakitembe*, *Mpologoma*, *M30* and *NARITA 21*; **Mbarara:** *Nakitembe*, *Kibuzi*, *M30* and *NARITA 2*) (Figure 1).

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<sup>1</sup>Refer to activity 3 report for more details

<sup>2</sup>G Fliedel, L Fosythe, H Tufan, A Bouniol, 2018. RTBfoods Work Package 1 Manual. Activity 4: Participatory Processing Diagnosis and Quality Characteristics. Montpellier (France). RTBfoods Project Report, 26 p.

*Nakitembe*, *Mpologoma*, and *Kibuzi* are popular local cooking varieties grown in the study areas and produced for both home consumption and the market – these varieties were also mentioned as preferred in the RTBfoods Gendered food mapping exercise (Activity 3). M30 (Syn. ‘NAROBAN5’ or ‘NABIO808’) is a recently introduced hybrid that was officially released in 2019. NARITA 21 and NARITA 2 are hybrid varieties that have not been officially released and are still under evaluation. NARITA 21 was chosen because it produces very poor quality matooke based on previous sensory evaluations with farmers and information provided by field data collectors in the NARITA fields. NARITA 2 was selected because it produces moderately acceptable food based on previous sensory evaluations with farmers and discussions with field data collectors. The local varieties were sourced from farmers in the surrounding villages. NARITA hybrids were obtained from the research fields managed by the National Agricultural Research Organisation in Kawanda and Mbarara. M30 was sourced from the National Agricultural Research Laboratories (Kawanda) and from a big farmer in Mbarara.



Figure 1: Banana varieties used in Mbarara (a: Kibuzi, b: M30, c: NARITA 2, d: Nakitembe)

## 2.3 Product Profile Processing

Eight processors prepared steamed-mashed matooke from four varieties each using the same process they normally do as shown in Figure 2. Several parameters were measured at each stage of processing to understand the preferred characteristics. Mature bunches were harvested and weighed. Each variety was coded and then each processor was asked to observe and comment on distinct characteristics of each bunch (e.g., general appearance, suitability for making steamed-mashed matooke, ease of detaching the hands, etc.). The processors were then given approximately 2kg per variety for processing. At each processing step, the processors were asked to indicate the characteristics that they perceive as indications that a banana variety will make a good or poor quality steamed-mashed matooke. In addition, during processing, several parameters were measured (refer to Table 1 for a full list and Annexe 7 for calculations). During the evaluation of the final cooked product, a sample from each variety was assessed and the processors indicated their perception when looking, touching, and tasting. In the final stage of the exercise, the processors had to indicate the sample with the best quality, worst quality, and a ranking in order of preference.

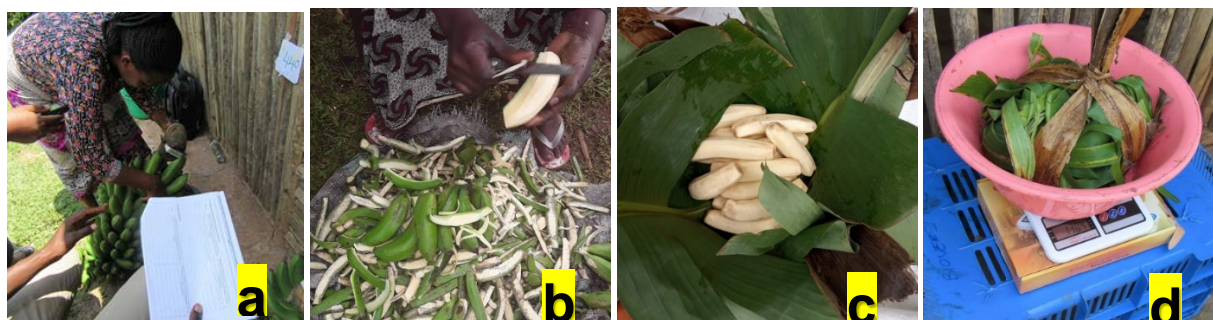






Figure 2: Operational process for production of steamed-mashed matooke

(a: De-clustering, b: Peeling, c: Wrapping banana fingers into a bundle, d: Weighing of the bundle, e: Bundle placed in a saucepan layered with banana leaves, f: Wrapped matooke ready for steaming, g: Water added for steaming, h: Local steaming process, i: Temperature at end of steaming, j: Temperature at end of simmering, k: Mashing, l: Good quality steamed-mashed matooke)

Table 1: Parameters measured at each operation step

Operation step	Weights (kg)	Temperature recordings (°C)
1. Peeling	Weight of fingers after peeling	<b>NO TEMPERATURE RECORDING NECESSARY AT THESE STEPS</b>
	Weight of peels	
2. Washing (if done in the area)	Weight of fingers after washing:	
3. Wrapping in banana leaves	Weight of leaves & fibres used for wrapping	
	Weight of wrapped bundle	
4. Prepare saucepan for steaming (put peduncle/stalks at the bottom, add water)	Weight of water	
5. Steaming	Weight of bundle after steaming	Temperature when water starts boiling
		Temperature in the middle of steaming
6. Pressing/mashing	Weight of bundle after mashing	Temperature after steaming before pressing
		Temperature after mashing
7. Simmering	Weight of bundle after simmering	Temperature after simmering
8. Serving		Temperature (of the sample) at serving

## 3 RESULTS

### 3.1 Raw Material Characteristics

#### 3.1.1 Bunch weight

The banana varieties used in this study were obtained from two representative areas in Uganda: Mbarara, a high producing area, and Nakaseke, a low producing area. Bunches from the different varieties and localities were of different average weight. Mpologoma, a local processing variety from Nakaseke district, had the highest average weight of 45kg. On the other hand, M30 which is a recently introduced variety had the lowest average weight of 19kg (Figure 3). Generally, it was noted that local varieties from Nakaseke had relatively high bunch weight as compared to their counterparts from Mbarara district. It is also important to note that local varieties (Nakitembe, Mpologoma, and Kibuzi) had a higher average bunch weight compared to the hybrid varieties (M30, NARITA 21, and NARITA 2). General preferred and non-preferred raw material characteristics are presented in Annex1.

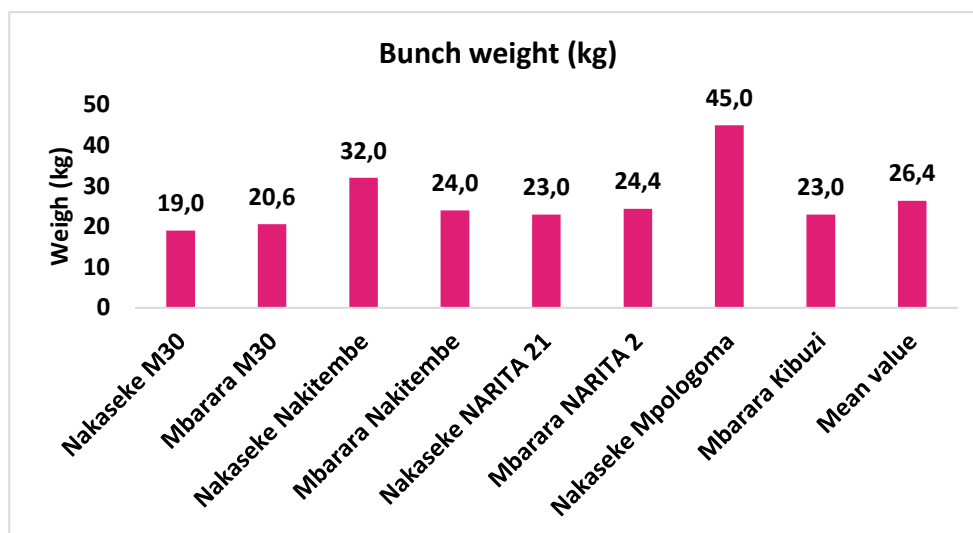


Figure 3: Average bunch weight (kgs) for each variety under study

#### 3.1.2 Dry matter content

The dry matter content of the different varieties is presented in figure 4. The dry matter content of the raw pulp ranged from 22.6% to 28.3%. This is an important trait during banana processing. High dry matter content makes the banana fingers subtle, smooth to touch, easy to peel, fast to cook, and easy to mash. These are some of the important traits preferred by consumers and processors as identified in Activity 3. The values presented for Nakaseke were from the samples that were used in the field. However, for Mbarara, it was not possible to keep the samples until return to Kawanda hence estimates from evaluations that had been done with other samples from the NARL laboratory are presented. The varieties with relatively higher dry matter content above 25% (NARITA 2 and Nakitembe-Nakaseke) were associated with hard texture when chewing of the steamed-mashed matooke (Annex 2).

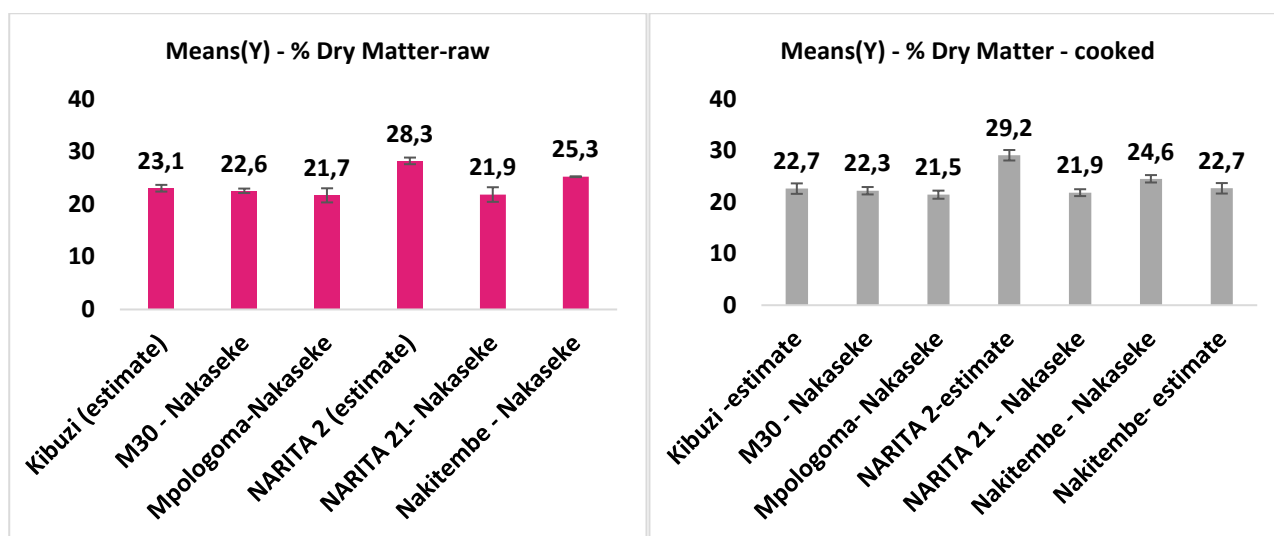


Figure 4: Proportion of dry matter content in raw and cooked banana samples

### 3.1.3 Qualitative information collected on the raw material

During the data collection process, the processors identified some of the characteristics they generally notice when they must select a certain banana variety for their processing needs. During this evaluation, they not only consider the preferred characteristic but also the non-preferred characteristics. It was noted that they look for mature (37.5%), straight (50%) and shiny (37.5%) fingers that form compact clusters (50%) of medium to big bunches (87.5%). In addition to this some of the processors also indicated that they would not select varieties that had small (12.5%) and curved (12.5%) fingers with black patches (12.5%) that do not cluster well (12.5%).

When presented with the varieties considered in this study, the processors identified different quality traits that are summarised in table 2. The data collected indicated differences in the quality of the banana varieties used in this study. For instance, Nakitembe variety from Mbarara had many good qualities for bananas used to make steamed mashed matooke while Nakitembe variety from Nakaseke did not have such good qualities. This can be related to the maturity level of the variety and other environmental factors.

Among the varieties evaluated in Mbarara, N2 was the most disliked by all the 4 processors. Some of the reasons for this was based on the physical evaluation of the banana fingers and bunches presented to them. For instance, the bunches had cracked (1) and bad (2) fingers that were small (4) and looked immature (2) and unattractive (2). In Nakaseke, on the other hand, the Nakitembe variety was the most disliked among the 4 processors as the fingers looked immature (1) with a hard (1), rough (1), and thick (1) peel. Just based on the appearance, some processors (2) could tell that the resultant matooke will not be soft.

Besides the specific evaluation of the varieties presented to the processors, Table 3 summarizes the raw material characteristics identified in the two districts and identified characteristics common in both districts.

Table 2: Raw material characteristics - qualitative information obtained from the questionnaire interview during processing

Mbarara – Kibuzi	Mbarara – Nakitembe	Mbarara - M30	Mbarara - NARITA 2
<ul style="list-style-type: none"> <li>× Looks mature</li> <li>× There are signs of freshness (fresh sap)</li> <li>× Looks like it will give nice food</li> </ul>	<ul style="list-style-type: none"> <li>× Good fingers</li> <li>× Big bunch</li> <li>× Shiny fingers</li> <li>× Straight and easy to peel fingers</li> <li>× Compact clusters</li> <li>× Small-medium fingers</li> <li>× Looks like it will give soft food when cooked</li> <li>× Looks smooth</li> <li>× Good finger colour (green)</li> <li>× Full fingers</li> <li>× Easy to cook</li> <li>× Elastic food when cooked</li> </ul>	<ul style="list-style-type: none"> <li>× Looks immature</li> <li>× Small bunch</li> <li>× Fingers not well filled</li> </ul>	<ul style="list-style-type: none"> <li>× Easy to peel</li> <li>× Small fingers</li> <li>× Not attractive</li> <li>× Bunch not compact</li> <li>× Looks like it will be watery when steamed</li> <li>× Looks like it will be mealy when cooked</li> <li>× Spaced fingers</li> <li>× Dark green finger colour</li> <li>× Looks immature</li> <li>× Looks like Embidde</li> <li>× Bad fingers</li> <li>× Fingers do not look like those of usual matooke</li> <li>× Looks like Bogoya</li> </ul>
Nakaseke - Mpologoma	Nakaseke – Nakitembe	Nakaseke - M30	Nakaseke - NARITA 21
<ul style="list-style-type: none"> <li>× Bunch is mature enough</li> <li>× Thin peel</li> <li>× Smooth appearance of fingers</li> <li>× Big fingers</li> <li>× Big bunch</li> <li>× Compact bunch</li> <li>× Light green colour</li> </ul>	<ul style="list-style-type: none"> <li>× Doesn't look mature</li> <li>× Food will not be soft</li> <li>× Hard peel</li> <li>× Rough peel</li> <li>× Thick peel</li> <li>× May make food that is not tasty</li> <li>× May make matooke that separates</li> </ul>	<ul style="list-style-type: none"> <li>× Full fingers</li> <li>× Thin peel</li> <li>× Well-formed clusters</li> <li>× Big fingers</li> <li>× Big bunch</li> <li>× Appealing appearance</li> <li>× Compact bunch</li> <li>× Mature</li> </ul>	<ul style="list-style-type: none"> <li>× Very small fingers</li> <li>× Curved fingers</li> <li>× Fingertips are sharp and long</li> </ul>

## 3.2 Product Profile Process Description

### 3.2.1 Unit operations of product profile process

The schematic process for the preparation of steamed-mashed matooke is shown in Figure 5. The processing steps involve harvesting the bunch, removing the hands, removing the fingers, peeling, washing the fingers (in some areas no washing is done), wrapping the fingers using banana leaves to form a 'bundle'. The bundle is then steamed for about one and half hours, mashed, and simmered for approximately 30 minutes before serving. Not all preparers/processors will harvest, dehand, or definger because raw materials can be bought in different forms (bunches, hands, or fingers). The unit operations that the next sections will focus on starting from the peeling stage. Note that during the participatory processing, each sample was wrapped separately in banana leaves, secured with banana fibres to form a bundle and coded.

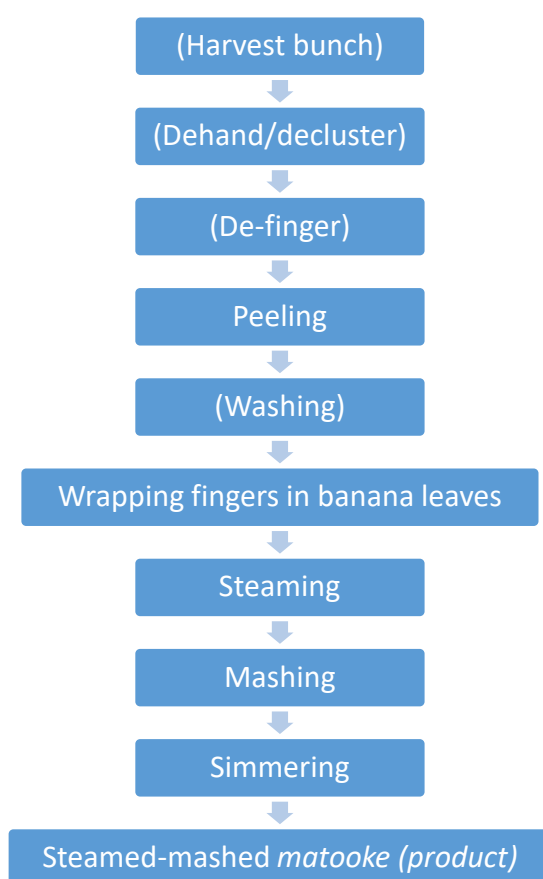


Figure 5: Flow diagram of steamed-mashed matooke making process.

### 3.2.2 Unit operations characterization

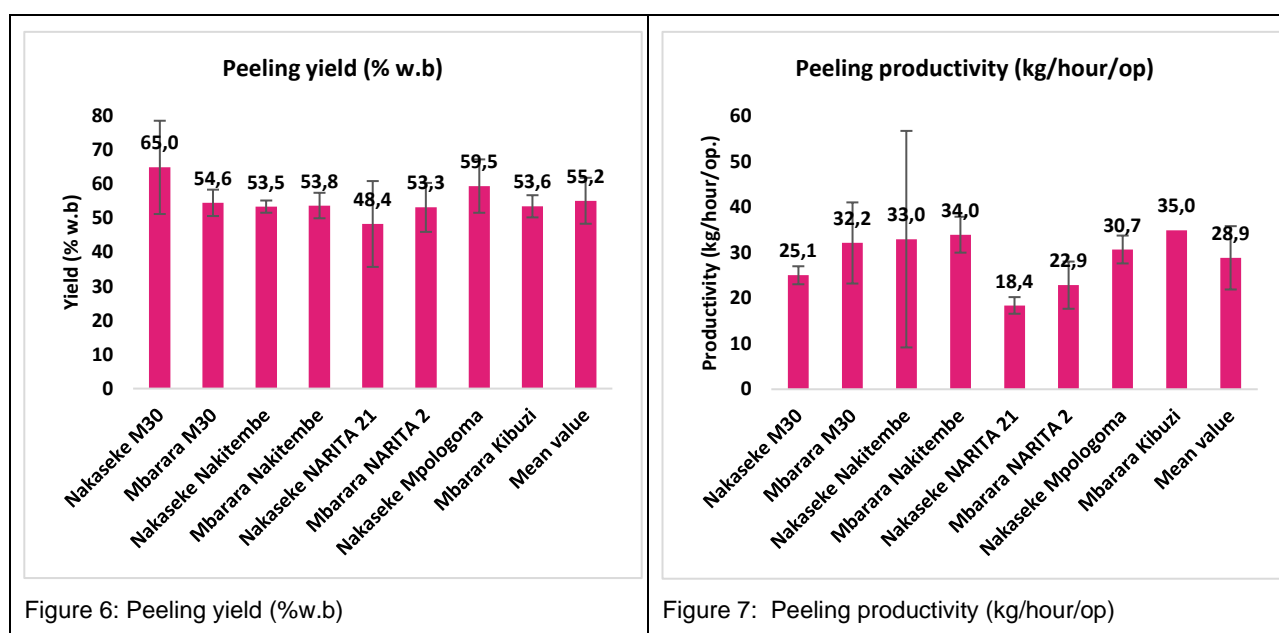
#### **Peeling**

Peeling involves removing the banana skin from the banana fingers. It is one of the preliminary processing steps for making steamed-mashed matooke. Evaluation of the peeling yield from the 8 varieties considered in this study showed that the recently introduced hybrid variety, M30, obtained from Nakaseke had the highest peeling yield (65%) while the other two hybrid varieties, NARITA 21 and NARITA 2, had the lowest peeling yield of 48.2% and 53.3% respectively. In general, while these



results show a variation in percentage peeling yield among the varieties (Figure 6), the difference is not considered statistically significant.

The peeling productivity relates to the amount in kilograms of bananas peeled in an hour by a single operator. The peeling productivity for the varieties under this study varied from 18.4kg/hour/op to 35kg/hour/op with a mean value of 28.9kg/hour/op (Figure 7). Hybrid varieties NARITA 21, NARITA 2, and M30 (Nakaseke) had the lowest peeling productivity of 18.4 kg/hour/op, 22.9 kg/hour/op, and 25.1 kg/hour/op, respectively. In general, varieties obtained from Mbarara had higher peeling yields as compared to their counterparts obtained from Nakaseke. For instance, the recently introduced variety, M30, from Mbarara had peeling productivity of 32.2 compared to 25.1 productivity for its Nakaseke counterpart. It's also important to note that local cooking varieties had higher peeling productivity compared to the hybrid varieties. This could be attributed to the ease of peeling, amount of sap, and finger size/length where in general hybrids such as NARITA 21 and NARITA 2 were described as having 'peel hard to detach from pulp', 'too much or a lot of sap', 'small fingers after peeling'. However, in all cases within the district, the differences were not considered statistically different.



## Washing

The washing productivity relates to the average quantity of peeled bananas washed in an hour by an operator. Washing is meant to remove sap from the peeled bananas. In general bananas with high sap content will have lower washing productivity. The washing productivity for the varieties analysed ranged from 35.9kg/hour/op to 214kg/hour/op with mean productivity of 112.3kg/hour/op (Figure 8). Mpologoma, a local variety, had the highest washing productivity hence the lowest amount of sap. The other local varieties used in the study had the lowest productivity hence they have high sap content.

The proportion of water used compared to the quantity of peeled pulp washed also indicates the amount of sap contained in the pulp. Nakitembe variety from Nakaseke had the highest proportion of water used to wash a specific quantity of pulp at 2.2 while the lowest ratio of 1.3 was obtained from M30, a hybrid variety from Mbarara (Figure 9). In general, there was no significant difference in the amount of water used to wash the pulp for all the varieties from both districts.

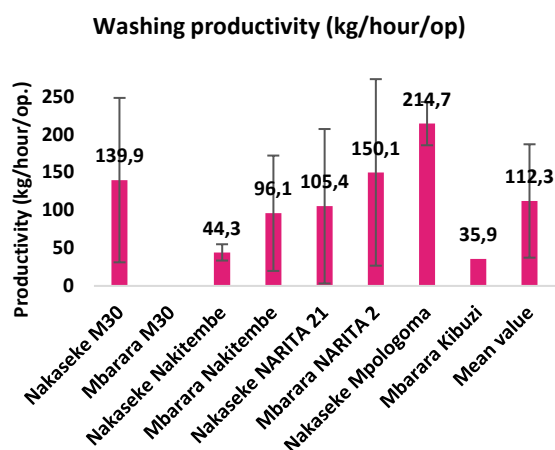


Figure 8: Washing productivity of peeled fingers

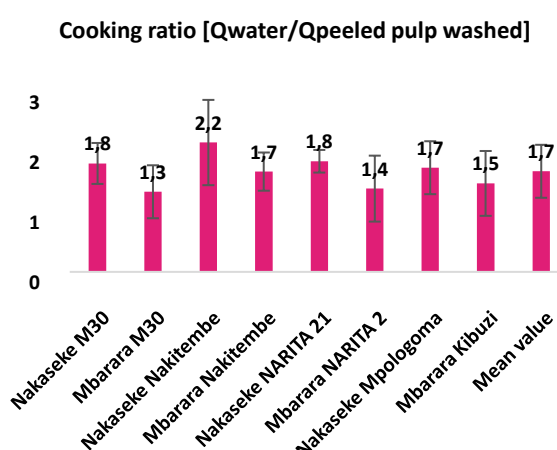


Figure 9: Cooking ratio (Qwater/Qpeeled pulp washed)

## Wrapping

The washed pulp is normally wrapped in banana leaves before steaming. The percentage of leaves used in wrapping the bundles before cooking ranged from 22.54% (M30 from Mbarara) to 33.42% (Nakitembe from Mbarara) (Figure 10, Annexes 2a and 2b). However, there were no significant differences in the number of leaves used for wrapping in all the banana varieties evaluated. This may be due to the small amount of banana fingers (~2kgs) given to the processors for processing. There was a variation in the wrapping productivity from 20kg/hour/op to 41.4kg/hour/op with a mean value of 30.2kg/hour/op (Figure 11). Wrapping productivity is influenced by the number and size/length of fingers. According to the processors, bigger (and therefore fewer) fingers were easier to wrap.

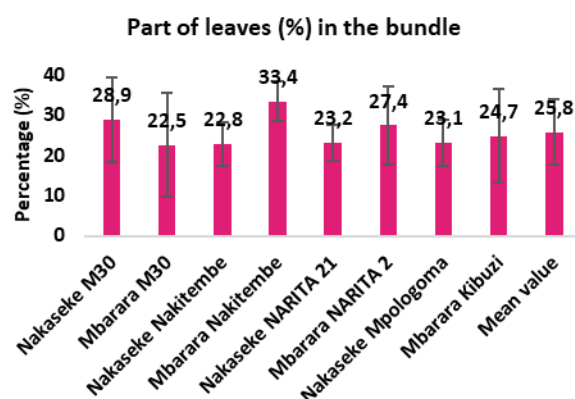


Figure 10: Part of leaves in bundle

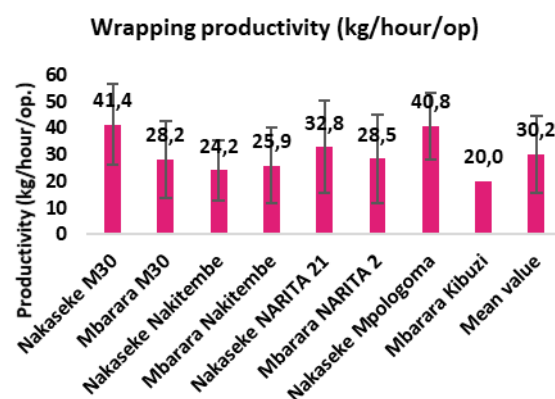


Figure 11: Wrapping productivity.

## Steaming

Steaming is a cooking technique whereby the wrapped banana bundle is heated in steam from boiling water. There was a relatively high steaming yield from all the varieties considered in this study with no significant differences. The range was from 73.6%, for Nakitembe variety from Mbarara, to 84.9%, for M30 from Nakaseke, with a mean value of 78.3% (Figure 12). The steaming productivity for the varieties ranged from 0.5kg/hour/op to 1.0kg/hour/op with a mean value of 0.7kh/hour/op, however, the differences were not statistically significant (Figure 13).

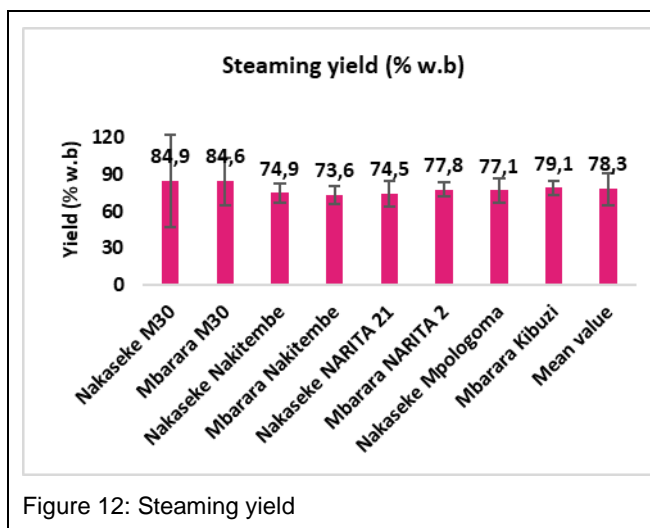


Figure 12: Steaming yield

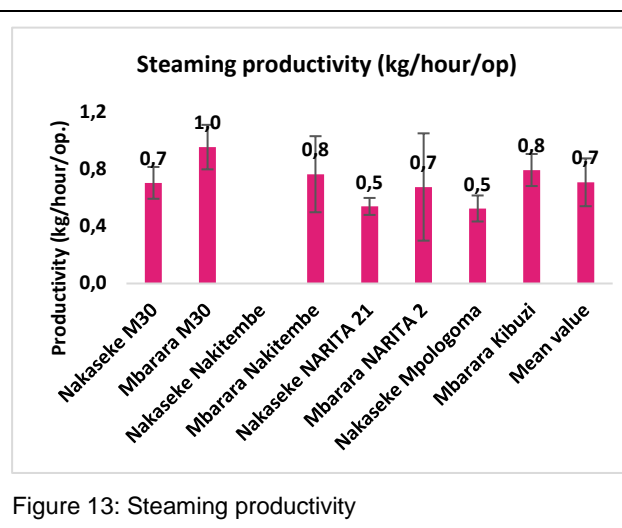


Figure 13: Steaming productivity

## Mashing/pressing and Simmering

For the varieties used in this study, NARITA 21 had the highest simmering and mashing yield of 113.2% while M30 had the lowest simmering and mashing yield (Annexes 2a,2b). It was also noted that varieties from Nakaseke produced higher mashing & simmering yields (ranging from 102.4 to 113.2 % w.b) as compared to those from Mbarara (yields ranged from 95.3 to 99.8 % w.b). This might indicate differences in the structure of the pulp in the various varieties. Pressing productivity relates to the amount of steamed-mashed matooke prepared by an operator in an hour. The mean pressing productivity for the varieties tested was 20.9kg/hour/op. Mpologoma variety had the highest pressing productivity of 32.5kg/hour/op while NARITA 2 had the lowest pressing productivity of 14.3kg/hour/op (Figure 14). In general, the pressing productivities obtained for the different varieties tested in this study varied though the differences were not statistically significant.

The simmering productivity is defined as the cooked-pressed amount of matooke obtained after simmering to the required temperature by an operator in an hour. The banana varieties tested had simmering productivities ranging from 0.9kg/hour/op to 1.7kg/hour/op with a mean value of 1.3kg/hour/op (Figure 15).

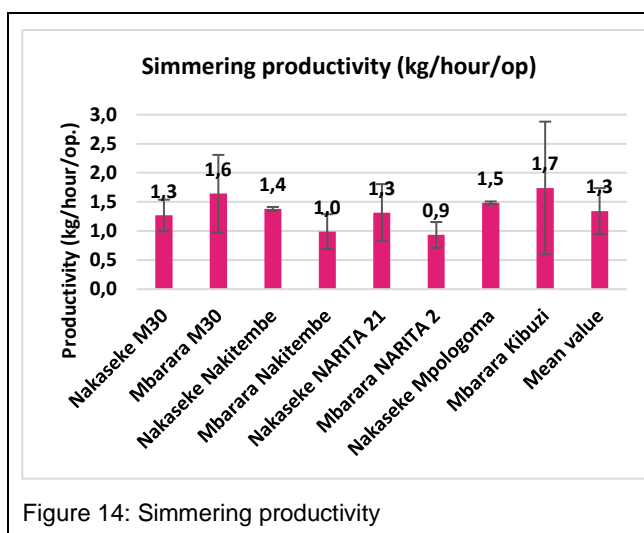


Figure 14: Simmering productivity

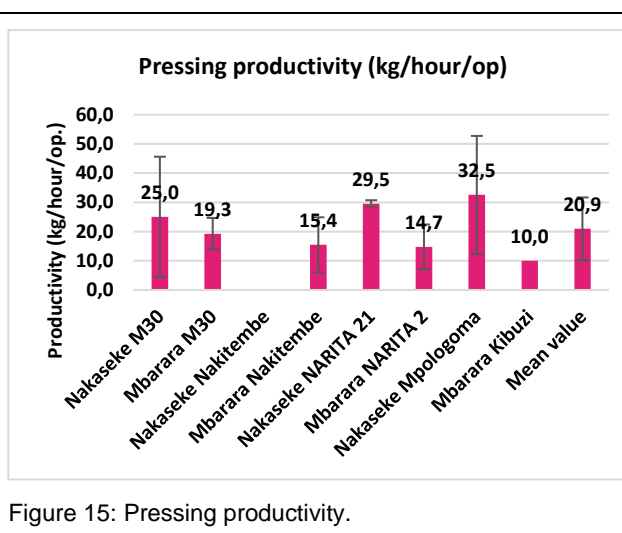


Figure 15: Pressing productivity.

A summary of the technological characteristics for the varieties used at each processing step is given in Table 3. This information can be used to identify the varieties that have the desired traits in each processing step.

Table 3: Summary of technological characteristics at each processing step (refer to Annex 3 for details on the number of processors who mentioned each specified characteristic)

Variety	Cluster compactness on the bunch	Peeling	Washing	Preparation of the bundle	Mashing	Simmering
Nakitembe-Mbarara	Good fingers (full and mature) Fresh sap Low-medium sap content Easy to de-cluster	Soft pulp Yellow pulp Easy to peel. Fresh (sap present) Good yellow colour Sticky	Sap removed after washing. Colour of the pulp becomes clear	Fingers are fairly big thus easy to tie.	Looks nice when mashing. Sticks together when mashing. Soft (by touch and sight) Not watery Easy to mash. Good yellow colour Shiny	Visually appealing Good food Yellow colour Appetizing
NARITA 2-Mbarara	Needs energy to dehand Difficult to de-cluster High sap content Immaturity (indicated by a lot of sap) Hard middle part	Straight fingers Soft peel Easy to peel. Hard pulp Dry peel Colour not attractive after peeling. White colour/pale yellow pulp Small fingers after peeling. Top side of fingers soft while bottom is hard during peeling. A lot of sap	Washing improves colour. No real difference at this stage	Easy to tie because few fingers. Easy to tie because leaves were dry	Soft on mashing Easy to mash. Sticks together. Hard surface (entiima) on pressing. Pale colour Bad appearance (not shiny) Sticky	Compact Has two colours (yellow and white) Gives enough food during simmering
Kibuzi-Mbarara	Easy to detach from peduncle due to maturity. Fresh sap indicating freshness. Easy to de-cluster showing that food will be soft. Easy to de-finger Low sap content showing that food will be soft	Easy to peel. Soft pulp Fresh when peeling Enough sap Mature (indicated by soft peel, creamy yellow pulp) Soft skin when peeling Pop sound when peeling Yellow pulp (will give good quality mashed matooke) Big pulp size	No sap after washing	Easy to tie and remain in one place because fingers are big	Soft on mashing Has not darkened. Does not stick to the leaves. Attractive yellow colour Easy to mash (soft) Sticks together	Not watery even after adding a lot of water. Remains clear mubumba Very good matooke Uniform colour Gives enough food during simmering
M30-Mbarara	Fresh sap (it is fresh) Good full fingers Yellow colour Medium sap (shows that it is not diseased)	Soft peel Long fingers (easy to peel) Big fingers Looks like it will give a lot of food. Soft pulp (shows that food will be soft)	Improves the colour. There is still some sap after washing	Easy to be wrapped. Long fingers that were easy to arrange	Looks soft. Soft on pressing. Easily mashable Sticks together (kyakwatagye)	Doesn't look good. Ekitima in the pulp Black spots

Variety	Cluster compactness on the bunch	Peeling	Washing	Preparation of the bundle	Mashing	Simmering
	Hard to detach from peduncle. Not mature enough (still maturing) Difficult to de-cluster (the steamed matooke might be hard) Hard to de-finger Looks like the food will be watery	Pulp doesn't remain on peel. Medium sap Looks mature. Not diseased Pulp is thin. It is sticky. White pulp Steamed food may be whitish. Pulp has ekitima Colour not good like usual matooke Looks mature on the outside but looks funny inside. Pop sound when peeling Thin peel	even if there was less sap at washing		Whitish colour after opening. Not attractive Black seeds Crumbles It is hard. Colour is confusing (not good) Looks like immature matooke	
M30-Nakaseke	Easy to de-cluster Not very sappy Thin skin Cluster easily separates from the peduncle. Very easy to dehand Feels soft when de-handing. Curved fingers that are easy to peel Releases a lot of sap on de-clustering. Matooke will be good because banana is mature	Smooth Easy to peel. Mature (indicated by creamy pulp colour) Less sap Peel comes off easily	No sap after washing. No difference	Easy to wrap.	Soft Yellow Easy to mash. Matooke aroma	Attractive on plate Soft Good aroma
Mpologoma-Nakaseke	Feels mature. Will make good food. Feels hard when dehanding	Big fingers (fills up the cooking pot quickly) Little sap (will not brown quickly) Easy to peel. Thin peel Knife slides because the peel is soft. Quick to peel.	No sap after washing. No difference		Soft to mash Yellow but not like M30 Easy to mash	Attractive on plate Soft



Variety	Cluster compactness on the bunch	Peeling	Washing	Preparation of the bundle	Mashing	Simmering
		Not yellow enough (might require a lot of time to simmer and become golden brown like normal matooke)				
Nakitembe-Nakaseke	Less sap Will be easy to peel. Feels soft. Easy to detach from bunch. Fingers remain attached. Hard thick peel Hard to decluster A lot of sap Heavy fingers Rough fingers	*Easy to peel, hard to peel (mixed responses from processors) Soft peel *Looks mature (creamy yellow pulp colour) *White inside even though mature, doesn't have a good yellow pulp colour. Too much sap Takes more fingers to fill the cooking pot. Matooke will be hard. Thick/hard peel Hard to detach peel from pulp. When cut the fingers are hard. <i>**mixed responses from processors</i>	Washing removes sap	Easy to tie because fingers remain intact	Soft to mash Easy to mash. White colour of mash Holds together easily. Soft	Soft Good aroma Good colour
NARITA 21-Nakaseke	Very small fingers Resistance from bunch Easy to de-cluster Feels soft. Fingers separate quickly. Too much sap Hard to separate from bunch. Small fingers	Blackish particles Black particles in the middle Peel hard to detach from pulp. Easy to peel. Soft Less sap Hard like cassava White like cassava Looks like mbidde It is beer banana because it has mixed colours (brown streaks) Pulp is pasty	Washing removes sap	Easy to tie.	Soft Easy to mash. Holds together after mashing. No matooke flavour Bad colour(pinkish) like mbidde	Soft Good aroma Good colour

## 3.3 Processors' Appreciation of End-product

### 3.3.1 End-products descriptors

Samples from the steamed-mashed matooke from the 8 varieties were evaluated by the processors to provide attributes that describe the end-products. In addition, processors were asked to rank their preferences (refer to section 3.3.2). The traits evaluated for each variety were related to colour, texture, smell, and taste (Annex 4). Soft texture, good matooke smell, yellow colour, and good matooke taste are some of the desired traits in steamed-mashed matooke. Based on the sensory characteristics of the cooked product, high- and low-quality sensory characteristics were identified and summarised in Table 4. For an overview of the general high and inferior sensory characteristics of steamed mashed matooke in general refer to Annex 5.

Table 4: High and inferior sensory characteristics of steamed-mashed matooke

Colour		Textural		Taste		Flavour	
High quality	Inferior quality	High quality	Inferior quality	High quality	Inferior quality	High quality	Inferior quality
Visually appealing Yellow colour (like egg yolk) Homogeneous appearance	White/ Pale yellow Visible black seeds Has mixed colour; - black, yellow, white. Doesn't look good (has black spots) Has ekitima (hard middle part) in the pulp	Soft feel in mouth Smooth on fingers Easy to cut Firm texture Elastic No hard particles Sticky in hands Mouldable	Feels hard by touching. Feels hard and dry when eating	Good taste Sweet in mouth Sharp taste	Poor/ Flat taste	Good smell i.e. smells like it's been cooked in banana leaves	No steamed banana smell No aroma



Figure 16 Steamed-mashed matooke samples (product)

### 3.3.2 Preferred and non-preferred varieties

Based on the evaluation of different technological qualities of raw banana during processing and the sensory evaluation of the processed product (steamed-mashed matooke), the processors ranked the varieties from 1-4 with 1 representing the most preferred variety while 4 represented the least preferred variety (Table 5). Processors from Mbarara preferred the local varieties over the hybrid varieties while processors in Nakaseke had a higher preference for the hybrid variety (M30). From both regions, the processors did not like the hybrid varieties NARITA 2 and NARITA 21. However, these varieties had not been introduced to the market at the time of this study.

Table 5: Overall preference ranking of the banana varieties based on the overall processing and steamed-mashed matooke quality.

Rank in order of preference	Mbarara	Nakaseke
1	Kibuzi	M30
2	Nakitembe	Mpologoma
3	M30	Nakitembe
4	NARITA 2	NARITA 21

## 3.4 Global Process Yield

### 3.4.1 Global cooking yield (% w.b)

Global cooking yield is the proportion of steamed-mashed matooke relative to the initial amount of raw banana fingers used. The global cooking yield for the evaluated varieties varied from 111% to 146.6 % w.b (Figure 16). Nakitembe, a local variety obtained from Nakaseke had the highest global yield. Among the hybrid varieties tested, NARITA 21 had the highest yield of 142.2% while M30 variety obtained from Mbarara had the lowest yield of 118.8%.

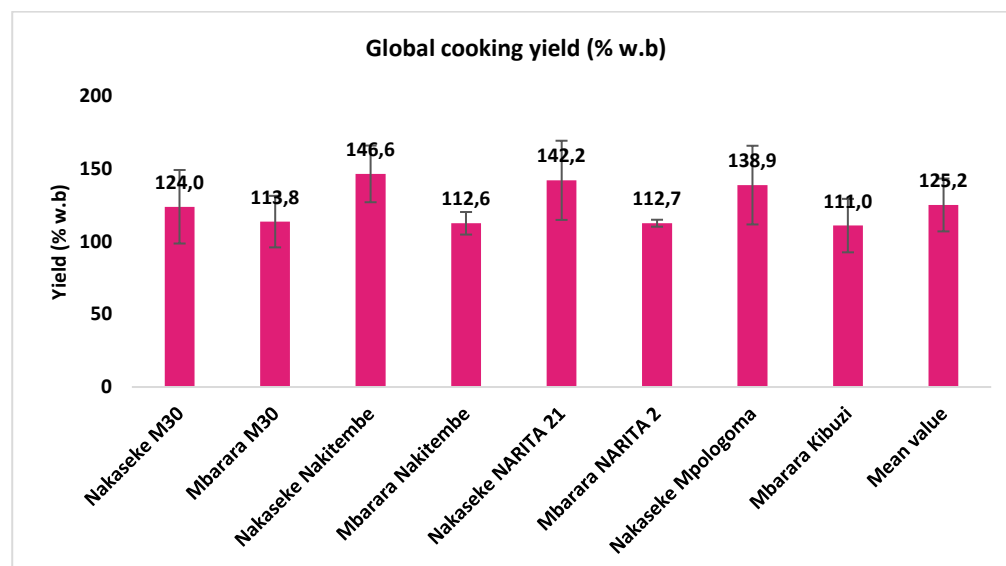


Figure 17: Global cooking yield

## 4 DISCUSSION AND CONCLUSION

The findings from the eight processors who participated in this study show that every processing step during the preparation of steamed-mashed matooke is important as it relates to the final process yield and product quality. A summary of the preferred characteristics at each processing stage are presented in Annex 6. Bunch weight is an important quality trait for banana varieties for cooking and

processing. Consumers and processors prefer banana varieties with a higher bunch weight thus it is an important trait during breeding. In this study, the local varieties Mpologoma and Nakitembe had the highest bunch weights of 45 and 32 kg respectively.

Peeling yield and peeling productivity were used to measure the peeling efficiency. Peeling yield relates to the proportion of fruit processed when the banana skin is removed. This parameter is important as it determines the quantity of steamed-mashed matooke produced compared to the bunch weight. The hybrid varieties had the lowest peeling yield. The peeling productivity, on the other hand, relates to the amount in kg of bananas peeled in an hour by a single operator. This is an indicator of how hard or soft the banana skin is. Bananas with soft peel are more desirable for processing as they contribute to high peeling efficiency which in turn leads to high peeling productivity. Peeling productivity is also influenced by the dry matter content on the bananas. Bananas with high dry matter content are easy to peel thus high peeling productivity can be attained from such varieties. However, dry matter content above 25% has a negative impact on the textural characteristics of the end product (steamed-mashed matooke). The local varieties considered in the study had higher peeling productivity compared to the hybrid varieties.

During the washing step, we consider washing productivity and the ratio of water used relative to the number of peeled bananas obtained. This ratio is directly related to the amount of sap in the peeled banana fingers. Bananas with high sap content require higher amount of water for washing. We aim for varieties that have higher washing productivity and whose ratio of water to the amount of bananas used is small. This ensures low costs and efficiency of the process. After washing, the bananas are wrapped in leaves which is perceived to improve the aroma of the steamed product. The wrapping productivity is the amount of pulp wrapped in bundles in an hour per operator. It generally relates to the efficiency of the wrapping process. In general, it is desirable to have varieties that allow high wrapping efficiency i.e. those that allow an operator to wrap in a bundle efficiently within a short time.

After wrapping of pulp into bundles, they are steamed. Steaming yield is the percentage proportion of pulp obtained after steaming relative to the raw pulp used. On the other hand, steaming productivity relates to the efficiency of the steaming process. It is the amount of pulp steamed in an hour by a single operator measured in kg/hour/operator. Varieties that produce high steaming yield and allow high steaming productivity are preferred.

After steaming for some time, the matooke is mashed and returned to the fire for simmering. Varieties obtained from Nakaseke produced a higher simmering and mashing yield as compared to the varieties obtained from Mbarara. This may be due to the differences in the varieties used in this study and the differences related to the climate in the two regions from which the varieties were obtained. Mbarara and Nakaseke districts are in different agro-ecological zones.

Comparison of the quality of raw materials (bananas) i.e., among the different varieties and between similar varieties from the two regions considered in this study showed some differences. Similar varieties from Nakaseke and Mbarara i.e. Nakitembe and M30 indicated differences in the quality traits. This may be an indication that the different agro-ecological conditions including temperature, rainfall, soil fertility, maturity level, and quality of the bananas used for making steamed-mashed matooke. For instance, Nakitembe variety from Mbarara had more preferred quality traits as compared to its counterpart from Nakaseke. In general, varieties from Mbarara seemed to have superior qualities compared to those obtained from Nakaseke. Breeders should take into account the stability and vulnerability behaviour of varieties based on the genotype and environmental factors (GXE interaction).

Sensory evaluation of the finished product is also a key step as these quality characteristics influence the consumer perception of the product. Processors want to use banana varieties that yield a product with soft texture, good aroma, yellow colour, and good taste. They do not prefer varieties that produce steamed-mashed matooke that has a hard texture, is too soft or watery, pale yellow, or have a flat taste.

In conclusion, evaluation of the desired/preferred quality traits in bananas to be used for making steamed-mashed matooke is critical in the production of hybrid varieties that give a superior product. The desired polygenic and monogenic traits, from the different varieties, can be identified and introduced in hybrid varieties during breeding to produce raw materials of high quality for processing.



## 5 APPENDICES

### 5.1 Annex 1: Summary of General Raw Material Characteristics Identified by Processors in Mbarara and Luwero Districts

High quality		Poor quality	
Mbarara District			
Maturity (4) Soft peel (easy to peel) (4) Compact clusters (3) Straight fingers (2) Big bunch (1) Big fingers (1)		Poorly formed fingers (4) Immature (3) Not attractive (3) Small fingers (3) Hard peel (3) Poorly formed clusters (1) Small bunch (1) Black patches on peel (1)	
Luwero District			
Big fingers (few fingers fill the saucepan) (4) Compact bunch (4) Easy to peel (4) Easy to decluster (3) Straight fingers (2) Big bunch (2) Well filled fingers (2) Thin peel (2) Big bunches (2) Quick to peel (2) Mature (2) Long fingers (2)	Soft (2) Smooth fingers (2) Bright fingers (1) Well-formed fingers (1) Soft peel (1) Compact clusters (1) Light green color (1) Appealing appearance (1) Full fingers (1) Spaced clusters (1) Variety looks easy to peel (1) Variety looks like it will give soft food (1)	A lot of sap (3) White (3) Hard (2) Difficult to peel (2) Hard to separate from bunch (2) Curved fingers (1) No space between clusters (1) Fingers not big enough (takes many to fill the saucepan (1)	Pale appearance (1) Looks immature (1) Fingers not fully filled (1) Not appealing (1) Small fingers (1) Hard to peel (1) Peel hard to detach from pulp (1)
ALL			
Maturity (6) Soft peel (easy to peel) (8) Compact clusters (4) Straight fingers (2) Big bunch (5)	Well filled fingers (3) Thin peel (2) Long fingers (2) Smooth fingers (2) Bright fingers (1) Light green colour (1)	Poorly formed fingers (4) Immature (4) Not attractive (4) Small fingers (5) Hard peel (6) Black patches on peel (2)	A lot of sap (3) White (3) Hard to separate from bunch (2) Curved fingers (1) No space between clusters (2) Fingers not fully filled (1)

High quality		Poor quality	
Big fingers (few fingers fill the saucepan) (5)	Appealing appearance (1)	Difficulty in peeling (3)	Small bunch (1)
Compact bunch (4)	Full fingers (1)		
Easy to decluster (4)	Variety looks like it will give soft food (1)		
Straight fingers (2)			

## 5.2 Annex 2a: Summary Table of Quantitative Data

### 5.2.1 Annex 2a: Summary Table of Quantitative Data (Mbarara)

	Raw material characteristics	Processing											
Varieties	Fingers weight (g)	Peeling yield (% w.b)	Peeling productivity (kg/hour/op)	Washing productivity (kg/hour/op)	Part of leaves (%) in the bundle	Wrapping productivity (kg/hour/op)	Ratio [Qwater/Q peeled pulp washed]	Steaming yield (% w.b)	Steaming productivity (kg/hour/op)	Mashing & simmering yield (% w.b)	Pressing productivity (kg/hour/op)	Simmering productivity (kg/hour/op)	Global cooking yield (% w.b)
Kibuzi	172.597 a	53.586 a	35.319 a	94.875 a	24.737 a	27.361 a	1.476 a	79.084 a	0.830 a	96.925 a	19.520 a	2.192 a	111.024 a
M30	167.327 a	54.604 a	32.374 a	252.207 a	22.540 a	26.350 a	1.337 a	84.564 a	0.916 a	95.264 a	22.700 a	1.980 a	113.759 a
Nakitembe	161.401 a	53.811 a	30.698 a	67.170 a	33.420 a	26.427 a	1.673 a	73.552 a	0.726 a	99.376 a	20.188 a	1.207 a	112.609 a
NARITA 2	127.167 b	53.268 a	21.362 a	124.468 a	27.443 a	22.806 a	1.389 a	77.847 a	0.715 a	99.804 a	14.349 a	1.037 a	112.656 a
Pr > F(Model)	0.003	0.981	0.422	0.646	0.494	0.981	0.761	0.595	0.897	0.766	0.834	0.296	0.993
Significant	Yes	No	No	No	No	No	No	No	No	No	No	No	No

<sup>a</sup> indicates membership is significantly different value groups with a P-value < 0.05

### 5.2.2 Annex 2b: Summary Table of Quantitative Data (Nakaseke)

	Raw material characteristics		Processing											
Varieties	Fingers weight (g)	Dry matter raw (%)	Peeling yield (% w.b)	Peeling productivity (kg/hour/op)	Washing productivity (kg/hour/op)	Part of leaves (%) in the bundle	Wrapping productivity (kg/hour/op)	Ratio [Qwater/Q peeled pulp washed]	Steaming yield (% w.b)	Steaming productivity (kg/hour/op)	Mashing & simmering yield (% w.b)	Pressing productivity (kg/hour/op)	Simmering productivity (kg/hour/op)	Global cooking yield (% w.b)
Mpologoma	219.340 a	21.735 b	59.532 a	30.738 a	214.650 a	23.108 a	40.809 a	2.256 a	128.811 a	31.536 a	107.492 a	32.544 a	89.056 a	138.874 a
M30	145.626 b	22.600 b	65.029 a	25.071 a	139.930 a	28.868 a	41.392 a	2.290 a	130.278 a	42.299 a	102.306 a	24.979 a	76.067 a	123.984 a
Nakitembe	120.563 b	25.283 a	53.494 a	33.009 a	44.327 a	22.778 a	24.176 a	2.790 a	130.357 a	43.504 a	112.369 a	26.614 a	82.763 a	146.576 a
NARITA 21	109.808 b	22.626 ab	48.387 a	18.435 a	105.371 a	23.217 a	32.818 a	2.301 a	125.123 a	32.398 a	113.233 a	29.523 a	79.032 a	142.157 a
Pr > F(Model)	< 0.0001	0.027	0.164	0.691	0.203	0.562	0.484	0.569	0.984	0.117	0.878	0.955	0.853	0.618
Significant	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No	No

<sup>a</sup> indicates membership in significantly different value groups with a P value < 0.05

### 5.2.3 Annex 2c: Summary Table of Quantitative Data (Dry matter content)

Varieties	Dry matter content - raw (%)	Dry matter content-cooked (%)
NARITA 2 (estimate)	28.298 a	29.151 a
Nakitembe – Nakaseke	25.283 b	24.576 b
Kibuzi (estimate)	23.090 c	22.664 bc
M30 — Nakaseke	22.600 c	22.253 c
NARITA 21- Nakaseke	21.889 c	21.879 c
Mpologoma-Nakaseke	21.735 c	21.486 c
Pr > F(Model)	<0.0001	<0.0001
Significant	Yes	Yes
Pr > F(% Dry Matter)	<0.0001	<0.0001
Significant	Yes	Yes

<sup>a,b,c</sup> indicates membership in significantly different value groups with a P value < 0.05

## 5.3 Annex 3: Summary of Technological Characteristics at Each Processing Step Identified by Processors for Each Evaluated Variety

Variety	Cluster compactness on the bunch	Peeling	Washing	Preparation of the bundle	Mashing	Simmering
Nakitembe-Mbarara	Good fingers (full and mature) (1) Fresh sap (1) Low-medium sap content (2) Easy to de-cluster (4)	Soft pulp (1) Yellow pulp (1) Easy to peel (4) Fresh (sap present) (1) Good yellow colour (1) Sticky (1)	Sap removed after washing Colour of the pulp becomes clear	Fingers are fairly big thus easy to tie (1)	Looks nice when mashing (1) Sticks together when mashing (1) Soft (by touch and sight) (3) Not watery (1) Easy to mash (2) Good yellow colour (1) Shiny (1)	Visually appealing (1) Good food (1) Yellow colour (1) Appetizing (1)
NARITA 2-Mbarara	Needs energy to dehand (4) High sap content (2) Immaturity (indicated by a lot of sap (1) Hard middle part (1)	Straight fingers (3) Soft peel (3) Easy to peel (2) Hard pulp (1) Dry peel (1) Colour not attractive after peeling (1) White colour/pale yellow pulp (1) Small fingers after peeling (1) Top side of fingers soft while bottom is hard during peeling (1) A lot of sap (1)	Washing improves colour No real difference at this stage	Easy to tie because few fingers (1) Easy to tie because leaves were dry (1)	Soft on mashing (1) Easy to mash (1) Sticks together (1) Hard surface (entiima) on pressing (1) Pale colour (1) Bad appearance (not shiny) (1) Sticky (1)	Compact (1) Has two colours (yellow and white) (1) Gives enough food during simmering (1)
Kibuzi-Mbarara	Easy to detach from peduncle due to maturity (1) Fresh sap indicating freshness (2) Easy to de-cluster showing that food will be soft (3) Easy to de-finger (1) Low sap content showing that food will be soft (2)	Easy to peel (3) Soft pulp (2) Fresh when peeling (1) Enough sap (1) Mature (indicated by soft peel, creamy yellow pulp) (1) Soft skin when peeling (1) Pop sound when peeling (1) Yellow pulp (will give good quality mashed matooke) (1) Big pulp size (2)	No sap after washing	Easy to tie and remain in one place because fingers are big (1)	Soft on mashing (3) Has not darkened (1) Does not stick to the leaves (1) Attractive yellow colour (1) Easy to mash (soft) (1) Sticks together (1)	Not watery even after adding a lot of water (1) Remains clear mubumba (1) Very good matooke (1) Uniform colour (1) Gives enough food during simmering (1)
M30-Mbarara	Fresh sap (it is fresh) (1) Good full fingers (1)	Soft peel (1) Long fingers (easy to peel) (1)	Improves the colour	Easy to be wrapped (1)	Looks soft (2) Soft on pressing (1)	Doesn't look good (1) Ekitima in the pulp (1)



Variety	Cluster compactness on the bunch	Peeling	Washing	Preparation of the bundle	Mashing	Simmering
	<p>Yellow colour (1)  Medium sap (shows that it is not diseased) (1)  Hard to detach from peduncle (1)  Not mature enough (still maturing) (1)  Difficult to de-cluster (the steamed matooke might be hard) (2)  Hard to de-finger (1)  Looks like the food will be watery (1)</p>	<p>Big fingers (1)  Looks like it will give a lot of food (1)  Soft pulp (shows that food will be soft) (1)  Pulp doesn't remain on peel (1)  Medium sap (1)  Looks mature (1)  Not diseased (1)  Pulp is thin (1)  It is sticky (1)  White pulp (1)  Steamed food may be whitish (1)  Pulp has ekitima (1)  Colour not good like usual matooke (1)  Looks mature on the outside but looks funny inside (1)  Pop sound when peeling (1)  Thin peel</p>	<p>There is still some sap after washing even if there was less sap at washing</p>	<p>Long fingers that were easy to arrange (1)</p>	<p>Easily mashable (1)  Sticks together (kyakwatagye) (1)  Whitish colour after opening (1)  Not attractive (1)  Black seeds (1)  Crumbles (1)  It is hard (1)  Colour is confusing (not good) (1)  Looks like immature matooke (1)</p>	<p>Black spots (1)</p>
M30-Nakaseke	<p>Easy to de-cluster (2)  Not very sappy  Thin skin (1)  Cluster easily separates from the peduncle (2)  Very easy to dehand (1)  Feels soft when de-handing (1)  Curved fingers that are easy to peel (1)  Releases a lot of sap on de-clustering (1)  Matooke will be good because banana is mature (1)</p>	<p>Smooth (1)  Easy to peel (3)  Mature (indicated by creamy pulp colour) (1)  Less sap (1)  Peel comes off easily (1)</p>	<p>No sap after washing  No difference</p>	<p>Easy to wrap (1)</p>	<p>Soft (2)  Yellow (2)  Easy to mash (1)  Matooke aroma (1)</p>	<p>Attractive on plate (1)  Soft (1)  Good aroma (1)</p>
Mpologoma-Nakaseke	<p>Feels mature (1)  Will make good food (2)  Feels hard when dehanding (2)</p>	<p>Big fingers (fills up the cooking pot quickly) (1)  Little sap (will not brown quickly) (1)  Easy to peel (2)  Thin peel (1)</p>	<p>No sap after washing  No difference</p>		<p>Soft to mash (3)  Yellow but not like M30 (1)  Easy to mash (2)</p>	<p>Attractive on plate (1)  Soft (1)</p>

Variety	Cluster compactness on the bunch	Peeling	Washing	Preparation of the bundle	Mashing	Simmering
		Knife slides because the peel is soft (1) Quick to peel (1) Not yellow enough (might require a lot of time to simmer and become golden brown like normal matooke) (1)				
Nakitembe-Nakaseke	A lot of sap (1) Will be easy to peel (1) Feels soft (1) Easy to detach from bunch (1) Fingers remain attached (1) Hard thick peel (1) Hard to decluster (1) Less sap (2) Heavy fingers (1) Rough fingers (1)	*Easy to peel, hard to peel (mixed responses from processors) (3) Soft peel (2) *Looks mature (creamy yellow pulp colour) (1) *White inside even though mature, doesn't have a good yellow pulp colour (1) Too much sap (3) Takes more fingers to fill the cooking pot (1) Matooke will be hard (1) Thick/hard peel (2) Hard to detach peel from pulp (2) When cut the fingers are hard (1) <i>**mixed responses from processors</i>	Washing removes sap	Easy to tie because fingers remain intact (1)	Soft to mash (4) Easy to mash (1) White colour of mash (1) Holds together easily (1) Soft (2)	Soft (1) Good aroma (1) Good colour (1)
NARITA 21-Nakaseke	Very small fingers (1) Resistance from bunch (1) Easy to de-cluster (3) Feels soft (1) Fingers separate quickly (1) Too much sap (1) Hard to separate from bunch (1) Small fingers (1)	Blackish particles (2) Peel hard to detach from pulp (2) Easy to peel (4) Soft (1) Less sap (1) Hard like cassava (1) White like cassava (1) Looks like mbidde (1) It is beer banana because it has mixed colours (brown streaks) (1) Pulp is pasty (1)	Washing removes sap	Easy to tie (1)	Soft (2) Easy to mash (2) Holds together after mashing (1) No matooke flavour (1) Bad colour (pinkish) like mbidde (1)	Soft (1) Good aroma (1) Good colour (1)

\*In parenthesis () are number of processors who mentioned that specific characteristic

## 5.4 Annex 4: Overview of Sensory Characteristics of the Steamed-mashed matooke for Each Evaluated Variety

Variety	When you look at (Colour)	Texture when you touch	When you smell	Taste in mouth	Texture when you chew	After-taste
Nakitembe-Mbarara	Attractive yellow colour Non-uniform colour (pale yellow like a potato in some parts) but becomes attractive yellow after additional simmering), Visually appealing Yellow colour (like egg yolk) Homogeneous appearance Has some small black seeds (normal for matooke) Looks like normal matooke Appetizing Looks soft Food looks good Shiny surface No black dots	Firm texture Elastic No hard particles Sticky in hands Starchy Smooth Mouldable Slimy Soft Not watery	Good matooke smell like of local varieties (not like NAADS) Smells better than other varieties	Good matooke taste like usual matooke) Tastes better than other varieties Very little sweet taste (of usual matooke not ripened)	Sticky in mouth Elastic in mouth Mouldable in mouth Smooth mouthfeel (during and after chewing) Smooth when swallowing Easy to swallow (slides easily down the gut)	Good matooke taste
NARITA 2-Mbarara	Has ebikaba (mixed colours), yellow, black, white, cream) Visible black seeds (ebijuma) Looks hard because it is not compact Has visible particles Looks like beer banana Visible black spots Not attractive/ appealing Yellow colour not appealing Looks compact (according to one processor) Looks soft (according to one processor)	Non uniform texture Hard middle part (entiima) which separates from the other surface and is hard even when pressed with a lot of energy. Mouldable Not soft enough Not compact enough (doesn't hold together) even when mashed Not sticky, according to one processor) Sticky (according to one processor) Outer surface is soft but middle surface is hard Cools quickly	Fairly good smell Good matooke smell  No smell (according to one processor) Normal matooke smell	Real matooke taste (mild sugary taste) Sweet in mouth Sharp taste Good matooke taste	Soft in mouth Not mouldable Takes long to chew hard particles Hard particles like for gonja (roasting banana) Sticky in mouth	Easy to swallow Some particles remain in mouth

Variety	When you look at (Colour)	Texture when you touch	When you smell	Taste in mouth	Texture when you chew	After-taste
		Soft but not too soft (according to one processor) Compact (according to two processors)				
Kibuzi-Mbarara	Good deep yellow colour (shows its mature enough) Visually attractive (appetizing) Homogeneous colour Remains a clear muwumbo (mashed matooke) Looks soft Looks better than other varieties Not deep yellow (according to one processor)  Shiny	No kitima (hard middle part) Sticky on fingers (a good characteristic) Starchy Mouldable in hand Soft between fingers Slimy Not watery	Good matooke smell (not of banana leaves)	Good matooke taste Brings saliva into the mouth (omuranzi) Usual matooke taste Tastes sweet like ripening mango or gonja (roasting banana) that is neither raw nor ripe	Smooth mouthfeel Sticky in mouth Soft like I matooke should be	
M30-Mbarara	Not appealing (looks like it was mashed by a stick) Colour not attractive (whitish/ pale yellow) Looks immature. Visible black seeds Has mixed colour; -black, yellow, white. Doesn't look good (has black spots) Has ekitima (hard middle part) in the pulp. Yellow colour is too light which is not good. It looks hard. Looks like lyatera/ muwutta (glassy) Looks half-cooked even though it is ready. Colour looks like cooked premature banana	Starchy (nikyikwata) Has black and seed-like lumps that are hard when pressed Compact Soft between fingers (according to one processor) Non uniform texture Cools quickly and hardens then crumbles Smooth when touched Not compact	Good matooke smell (no smell of banana leaves, smells like unripe Bogoya) Good matooke aroma in mouth	Tastes like real matooke (the taste lasts in the mouth) Good matooke taste Astringent/ slightly sappy (according to one processor) Tastes like beer banana Bad taste (according to one processor)	Rough in mouth Crunchy like muwutta (glassy) Smooth when swallowing Slightly hard in the mouth Soft	Taste lasts in the mouth
M30-Nakaseke	Looks great Good yellow colour Looks soft like real matooke Very attractive	Soft	Good aroma	Good matooke taste Tastes like real matooke	Smooth mouthfeel	Tastes like real matooke

Variety	When you look at (Colour)	Texture when you touch	When you smell	Taste in mouth	Texture when you chew	After-taste
Mpologoma-Nakaseke	Good yellow colour Enough yellow colour Looks impressive Soft	Soft Smooth between fingers	Good aroma	Good matooke taste	Soft in mouth Soft when chewing Doesn't cool fast	Good taste
Nakitembe-Nakaseke	Good appearance Yellow colour similar to usual matooke Not enough yellow colour Visible black seeds Fairly appealing Colour not uniform (there is some faint black) Nice colour	Smooth and even between fingers Black particles present Hard between fingers (according to one processor)	No aroma	No banana taste Fair taste	Hard in mouth	Fair taste Tasteless
NARITA 21-Nakaseke	Looks soft Looks bad Colour not familiar Not attractive Mixed colours Looks like beer banana Has black spots	Soft in hand	No aroma	No taste Doesn't taste like usual matooke	Soft in mouth	Tasteless

## 5.5 Annex 5: High and Inferior Sensory Characteristics of Steamed Mashed Matooke In General

Colour/Appearance		Textural		Taste		Flavour	
High quality	Poor quality	High quality	Poor quality	High quality	Poor quality	High quality	Poor quality
<b>MBARARA DISTRICT</b>							
Yellow colour (4) Appealing/attractive (4) Uniform colour (3) Soft (3) Shiny (3)	Mixed colours (4) Sap (4) Black seeds/spots (3) Not appealing/attractive (3) White (3) Looks hard (2) Blackish (2) Deep yellow (1) Pale (1)	Mouldable (4) Smooth in hands (3) Soft (3) Sticky (3) Sticks together (2) Compact (2) Slimy (2) Elastic (2) Gives a lot of food (2) Not watery (2) Easy to mash (2) Thin pulp (1) Not watery (1)	Hard (when pressed) (4) Hard middle part (4) Not compact (4) Too sticky (2) Texture not homogeneous (4) Too soft (1) Hard to mash (1) Has particles (1) Give little food (1) Mealy when cooked (1)	Good matooke taste (3) Smooth mouthfeel (3) Goes down well while swallowing (3) Sticky in mouth (2) Real matooke taste (2) Soft in mouth (1) Sharp taste (1) Tasty (1) Tastes sweet (1) Brings saliva in the mouth (1) Mouldable in mouth (1) Elastic in mouth (1) No sappy taste (1)	Taste not good (2) Burnt food (1) Hard particles in mouth (1) Particles remain in mouth (1) Not mouldable in mouth (1) Astringency (1) Rough in mouth (1) Crunchy in chewing (1) Particles that take long to chew (1) Bad taste (1) A bit hard in mouth (1)	Nice smell (3) Normal/usual matooke smell (3) Good matooke smell (2) Good aroma (2) Smells like local varieties (1) No aroma of banana leaves (1)	No smell (1) Smell like <i>Bogoya</i> that is not ripe (1)
<b>LUWERO DISTRICT</b>							
Soft (4) Good yellow colour (4) Looks appealing (2) Usual colour of matooke (1) Looks impressive (1) Looks great (1)	Black seeds/particles (4) White colour (2) Colour not uniform (2) Not yellow enough (2) Light yellow (1) Bad colour (pinkish) (1) Brownish (1) Looks bad (1)	Soft (4) Does not crumble (1) Even texture between fingers (1) No particles (1) Elastic (1) Easy to mash (2) Smooth (1) Uniformly soft when pressed (1)	Hard particles on pressing (3) Hard (2) White (1) Hard between fingers (1) Crumbles (1) Black seeds (1) Rigid ( <i>Okukalambala</i> ) (1)	Good taste (3) Tastes like normal matooke (2) Does not cool fast (2) Not sappy (1) Fair taste (1) Smooth mouthfeel (1) Hot (1) Even while chewing (1)	Cools fast (2) Tasteless (2) Bad taste (2) No banana taste (1) Not tasty (1) Does not taste like normal matooke (1) Watery (1) Astringent (1)	Good aroma (4) Normal matooke scent (1) Aroma of local matooke (1) Good aroma of banana leaves (1) Strong aroma (1)	No aroma (4) No matooke flavour (1)



Colour/Appearance		Textural		Taste		Flavour	
High quality	Poor quality	High quality	Poor quality	High quality	Poor quality	High quality	Poor quality
	Colour not familiar (1) Sappy (1) Blackish (1)						
<b>ALL</b>							
Yellow colour (8) Appealing/attractive (7) Uniform colour (3) Soft (3) Shiny (3) Soft (4) Looks appealing (2) Usual colour of matooke (1)	Mixed colours (6) Sap (5) Black seeds/spots (7) Not appealing/attractive (3) White (5) Looks hard (2) Blackish (3) Deep yellow (1) Not yellow enough (4) Bad colour (pinkish) (1) Brownish (1) Looks bad (1) Colour not familiar (1)	Mouldable (4) Smooth in hands (4) Soft (8) Sticky (3) Sticks together (5) Slimy (2) Elastic (3) Gives a lot of food (2) Not watery (3) Easy to mash (4) Thin pulp (1) Even texture between fingers (1) No particles (1)	Hard (when pressed) (7) Hard middle part (4) Not compact (5) Too sticky (2) Texture not homogeneous (4) Too soft (1) Hard to mash (1) Give little food (1) Mealy when cooked (1) Hard particles on pressing (4) White (1) Black seeds (1) Rigid ( <i>Okukalambala</i> ) (1)	Good matooke taste (3) Smooth mouthfeel (4) Goes down well while swallowing (3) Sticky in mouth (2) Real matooke taste (4) Soft in mouth (1) Sharp taste (1) Brings saliva in the mouth (1) Mouldable in mouth (1) Elastic in mouth (1) No sappy taste (1) Good taste (5) Does not cool fast (3) Not sappy (1) Fair taste (1) Even while chewing (1)	Taste not good (5) Burnt food (1) Hard particles in mouth (2) Particles remain in mouth (1) Not mouldable in mouth (1) Astringency (2) Rough in mouth (1) Crunchy in chewing (1) Particles that take long to chew (1) Cools fast (2) Tasteless (2) No banana taste (2) Not tasty (1) Watery (1)	Nice smell (3) Normal/usual matooke smell (4) Good matooke smell (2) Good aroma (3) Smells like local varieties (1) No aroma of banana leaves (1) Good aroma (4) Normal matooke scent (1) Strong aroma (1)	No smell (1) Smell like <i>Bogoya</i> that is not ripe (1) No aroma (4) No matooke flavour (1)

\*In parenthesis ( ) are number of processors who mentioned that specific characteristic

## 5.6 Annex 6: Summary of Key Characteristics at Each Stage of Processing Steamed Mashed Matooke

Steps in matooke preparation	Key characteristics
Harvesting, cut a fully-grown banana bunch(es)	Mature big bunch, compact bunch/fingers
De-hand -remove hands from bunch and remove fingers from clusters	Well filled big fingers, yellowish/creamish pulp colour, shiny light green peel colour, disease free/spotless, long fingers
Peeling	Easy to peel, soft and yellowish pulp with fresh sap
Washing	Sap content (can be high or low) depending on consumer perceptions
Prepare saucepan – put strips of banana fibres and stalks as a foundation at the bottom of a cooking pan to avoid the boiling water touching the bundle of matooke being steamed	None
Prepare leaves – carefully slice off the midribs	None. Characteristics at this stage are related to the leaves and not the raw material Leaves that can fold easily e.g. from Sukali Ndizi and those from Kayinja which is perceived to influence aroma are preferred
Tying up the peeled and washed banana fingers in a bundle of banana leaves	Easy to wrap and tie because fingers are medium to big in size and long. The bundle also remains intact
Place tied bundle into a cooking pot on top of the fibres and/or stalks with enough water to steam the leaves	None required
Steaming for about 1hr? – depends on the type of firewood	None required
After steaming, smash cooked bananas by pressing with the palms of one's hands to make matooke	None. Processors indicate there are no characteristics and no differences among varieties during the pressing step
Let the matooke simmer for a little bit	None required
Serving matooke	Preferred characteristics of high quality steamed mashed matooke by both men and women in the two districts include soft texture, good smell, yellow colour, good matooke taste and compact in that order

## 5.7 Annex 7: Equations Used for Calculations

1. Peeling yield (% wb) =  $\frac{\text{Weight of fingers after peeling (kg)}}{\text{Weight of fingers (kg)}} \times 100$
2. Part of the leaves in the bundle (%) =  $\frac{\text{Weight of leaves and fibres used for wrapping(kg)}}{\text{Weight of wrapped bundles (kg)}} \times 100$
3. Ratio of Qwater/Qpeeled pulp washed =  $\frac{\text{Weight of water (litres)}}{\text{Net weight after steaming}}$
4. Steaming yield (%wb) =  $\frac{\text{Net weight after steaming}}{(\text{Weight of bundle after simmering (kg)})} \times 100$
5. Mashing & simmering yield (% wb) =  $\frac{\text{Net weight after simmering}}{\text{Net weight after steaming}} \times 100$
6. Global cooking yield (%wb) =  $\frac{\text{Net weight after simmering}}{\text{Weight of fingers after washing (Kg)}} \times 100$
7. Peeling productivity  $\frac{\text{kg}}{\text{hour}} / \text{op} = \frac{60 \times \text{Weight of fingers (kg)}}{\text{Time for peeling}}$
8. Washing productivity  $\frac{\text{kg}}{\text{hour}} / \text{op} = \frac{60 \times \text{Weight of fingers after peeling (kg)}}{\text{Time for washing}}$
9. Wrapping productivity  $\frac{\text{kg}}{\text{hour}} / \text{op} = \frac{60 \times \text{Weight after washing (kg)}}{\text{Time for wrapping}}$
10. Steaming productivity  $\frac{\text{kg}}{\text{hour}} / \text{op} = \frac{60 \times \text{Weight of fingers after washing (kg)}}{\text{Steaming time}}$
11. Pressing productivity  $\frac{\text{kg}}{\text{hour}} / \text{op} = \frac{60 \times \text{Weight of fingers after steaming (kg)}}{\text{Pressing time}}$
12. Simmering productivity  $\frac{\text{kg}}{\text{hour}} / \text{op} = \frac{60 \times \text{Weight of fingers after washing}}{\text{Simmering time}}$



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