



Sensory Evaluation of Finger Millet and Bean Products in Hoima Uganda

Report of Field Work conducted 6-12 September 2019

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Cover Photo: Different culinary products made from finger millet in Hoima Uganda.

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List of abbreviations

CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
FGD	Focus Group Discussion
NARO-BUZARDI	Bulindi Zonal Agricultural and Research Development Institute of the National Agricultural Research Organization
NARO-PGRC	National Plant Genetic Resources Centre of National Agricultural Research Organization
NWO	The Netherlands Organization for Scientific Research
PELUM	Participatory Ecological Land Use Management (Uganda)

Executive summary

Sensory evaluation, also known as organoleptic testing, involves evaluating food through the senses of taste, touch, smell and sight to determine its quality. The testing involves assessing a food product for its aroma, flavour, sensation in the mouth and appearance. This is one of the activities carried out in Hoima, Uganda for finger millet and bean varieties, under a project funded by the Netherlands Organization for Scientific Research (NWO) titled *Citizen's Science approach to climate-smart and nutrition-sensitive seed value chains for food and nutrition security in Uganda and Ethiopia*. This activity was conducted as a follow up to previous crowdsourcing trials and participatory varietal testing of 34 bean and 43 finger millet varieties by 300 farmers in Hoima, between 2017 and 2019, that identified seven bean and seven finger millet varieties selected by farmers as having most of the attributes needed for adaptation to climate change, including faster maturity, drought resistance, pest and disease resistance and high yields. One of the targeted activities under the Citizen Science project funded by NWO was to conduct sensory evaluation for culinary and organoleptic attributes on these prioritized PGRFA varieties that are important food security crops in Uganda.

Six traditional Ugandan food products—porridge, *malwa* and *kwete* (alcoholic beverages), *kalo* (bread) and *obushera* (a fermented drink) were made from seven varieties of finger millet, as well as bean sauce prepared from seven selected varieties of beans, for the tests. A total of 101 (54 men and 47 women) farmers from Hoima community were invited to provide feedback on their level of satisfaction of these products made from the selected varieties, using a five-point Likert Scale (1=Very poor, 2=poor, 3=fair, 4=good and 5=very good). Mean scores were used to rank the varieties and determine the selected ones for each product.

Generally, the results indicated that none of selected bean and finger millet varieties emerged as the best for the preparation of all types of culinary products tested. For finger millet products, the varieties with highest scores include TZA-3934(3.69) for *Kalo*, TZA-1701(4.28) for porridge, TZA-4146(3.83) for *Kwete*, UNGB-2321(3.69) for *Obushera* and UNGB-2321(3.87) for *Malwa*. For beans, the variety with highest mean was FR2, which was a farmer's or local variety. This information is important as it provides farmers with knowledge on the suitability of particular crop varieties in relation to the preparation of local traditional food products that are both highly nutritious and climate resistant. Since these varieties had been pre-selected by same farmers for climate change adaptation, the additional sensory and culinary information can further be used to target specific varieties for the purpose of crop improvement

Introduction and overview

This report summarizes the results of one activity conducted under the project ‘Citizen’s Science approach to climate-smart and nutrition-sensitive seed value chains for food and nutrition security in Uganda and Ethiopia’, funded by the Netherlands Organization for Scientific Research (NWO), led by the Alliance of Bioversity International and CIAT in collaboration with Bulindi Zonal Agricultural and Research Development Institute of the National Agricultural Research Organization (NARO-BUZARDI), the National Plant Genetic Resources Centre of National Agricultural Research Organization (NARO-PGRC), Participatory Ecological Land Use Management (PELUM) Uganda and Mekele University in Ethiopia. The overall goal/objective of this three-year project, running between January 2018 and December 2020, is to increase farmers’ ability to cope with the negative impacts of climate change by increasing the availability of climate-smart varieties of resilient crops by scaling out citizen science approaches to test genetic resources from national genebanks and international collections, for climate change adaptation and nutrition suitability, in selected communities in Ethiopia and Uganda. In this report we focus specifically on one of the activities of organoleptic testing that was conducted in Uganda for beans and finger millet. A similar activity is expected to be conducted in Ethiopia in 2020 for wheat products.

In pursuit of the overall project objective, the following activities were carried out in Uganda:

- Identifying potentially adapted materials from a pool of 34 bean and 43 finger millet varieties in Uganda. The seven varieties of beans and seven of finger millet being tested under this grant in Uganda were previously identified between 2017 and 2018 through crowdsourcing¹ and participatory varietal selection under project funded by the Food and Agriculture Organization of the United Nations (FAO) titled *Promoting Open Source Seed Systems for beans, forage legumes, millet and sorghum for climate change adaptation in Kenya, Tanzania and Uganda*.
- Testing the performance of the selected varieties in farmers’ fields and ‘on station’ using participatory, crowdsourcing methods that engage farmers as citizen scientists
- Identifying useful agro-morphological attributes through diverse participatory varietal selection activities with farmers.
- Organoleptic testing of materials identified as having high potential for consumer uptake
- Nutritional analysis and testing of promising climate-adapted varieties
- Creating catalogues with information to help farmers use a portfolio of best performing varieties with desirable agronomic, nutritional and organoleptic attributes
- Disseminating the selected varieties to farmers beyond the project using channels such as community seed bank networks, seed fairs and exhibitions, and through farmer field school events.

¹ First experiences with a novel farmer citizen science approach: crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies (tricot)

<https://pdfs.semanticscholar.org/5ebb/c4eb3d46d7bd721bdfb25b7cd0f93edcbd56.pdf>

- Promoting the selected varieties through value chains for increased incomes to farmers.

Finger millet is an extremely important food security crop, as it is one of the main sources of carbohydrates with a high iron and calcium content. It is gluten free and makes a perfect food for weaning babies, while beans are the most common source of proteins for most rural folk in Africa. Beans and finger millet are also considered to be resilient crops for climate change adaptation and hence were selected. This report presents a summary of the sensory evaluation exercise conducted to ascertain farmers' varietal preferences for seven bean and seven finger millet landrace varieties obtained from genebanks in Uganda, Kenya and Tanzania compared with 3 Ugandan farmers' varieties of finger millet and 2 farmers' varieties of beans.

Sensory evaluation is a key activity in supporting the successful uptake by farmers of hardy adapted varieties. To gather insights on farmers' perceptions and preferences regarding taste and acceptability of the finger millet and bean varieties that had performed well in agronomic evaluation, we conducted a sensory evaluation exercise that engaged 101 farmers (54 men and 47 women). Our farmers' were asked to taste a variety of local food products prepared from the selected finger millet and bean varieties and provide feedback on taste, texture, consistency, aroma, cooking time, colour and general acceptance. The exercise was also aimed at promoting the benefits derived from the consumption of finger millet, especially in weaning infants, in the provision of important nutrients for lactating mothers.

The six products made from finger millet and bean that were tested were:

- *Malwa*: a local alcoholic beverage, made from a mixture of dry finger millet flour and fermented finger millet flour.
- *Kwete*: a local alcoholic beverage brewed from a mixture of fermented finger millet and maize with boiled water.
- Hot porridge prepared from finger millet flour mixed with hot water to make breakfast meal.
- *Kalo*: a finger millet bread, which is dark brown and sticky, and does not crumble like normal wheat bread.
- *Obushera*: a traditional beverage made by mixing fermented finger millet flour and boiled finger millet flour.
- Bean sauce: a typical accompaniment to most meals; prepared by separately boiling the seven varieties of beans in a pot. During the cooking, ingredients and spices can be added, such as royco and green pepper, but for the purposes of organoleptic testing, salt was the only ingredient added for taste after cooking.

Farmers provided feedback on the best varieties for making each finger millet product and the best bean varieties for making the sauce. The results indicated that no single variety contained all of the desirable traits for making all of the dishes, thus farmers will have to select a particular variety based on the dish they wish to prepare. This information is also relevant for value addition, specifically for Obushera, which is a commercially- produced product in Uganda. It is also relevant in selecting the bean varieties for large-scale production targeting big consumer markets and for breeders.

Selecting farmers for sensory evaluation testing

On 8 August 2019, a group of 30 farmers (14 men and 16 women) were selected and invited to a meeting at NARO Bulindi research centre to participate in a focus group discussion (FGD). The criteria used to select the farmers included those:

- engaged in farming and production of finger millet and beans
- specifically selling finger millet and beans at the local markets, including preparation and sale of products from finger millet, like porridge, *Obushera* and local brews
- who showed high interest in the project and who had achieved outstanding trials of beans and finger millet during the crowdsourcing trials conducted from August 2017 to June 2019.

Farmers from two districts, Masindi district and Hoima District (Figure 1) were selected. In Hoima district, the selected farmers came from eight villages (Kibaire, Kasinina, Kiranga, Kyamongi, Nyakaihura, Katikara, Mparangasi and Nyakakonge), while those from Masindi district came from the villages of Kinyara and Budongo.

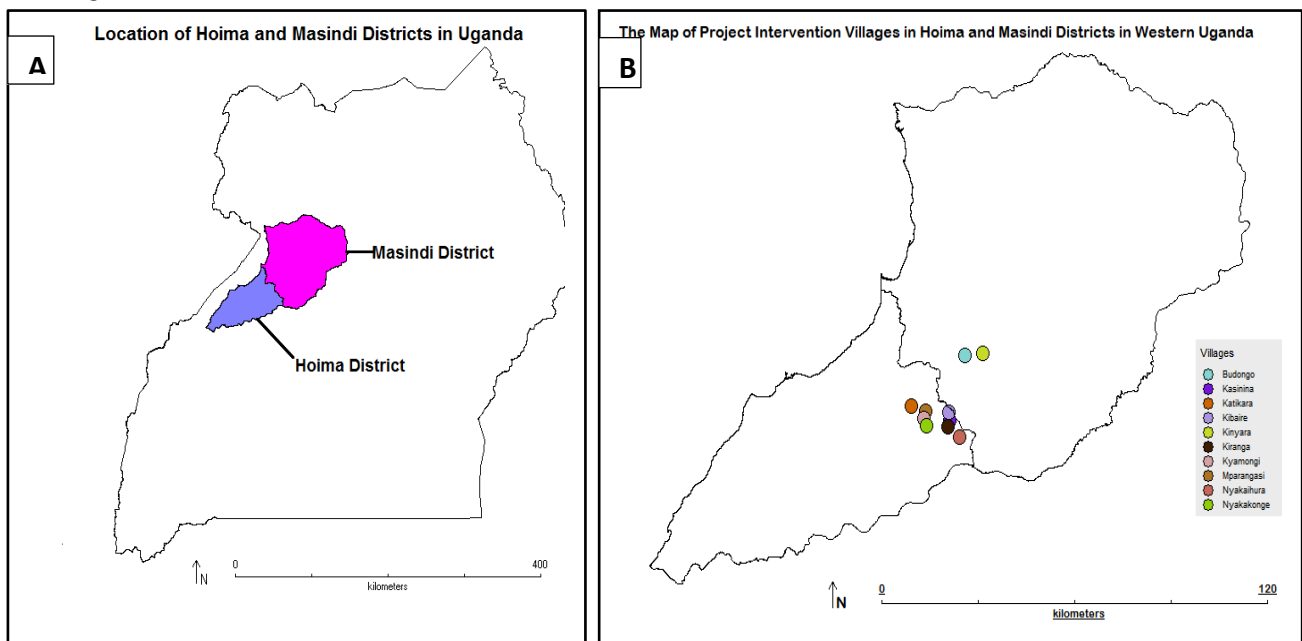


Figure 1: a. Location of Hoima and Masindi districts in Western Uganda; b. the specific project villages participating in the field trials

Farmers invited to participate in the FGDs provided information about the products that can be made from finger millet and beans, including the different methods used to prepare them. The six products that were identified were: *kalo*, *obushera*, *malwa*, *kwete*, hot porridge and bean sauce. A group of food preparers and cooks were selected to prepare the specific products using the same methods and ingredients as they would use in their homes. The ingredients for these dishes were supplied to them.

Agronomic attributes of the selected varieties

Table 1: Agronomic traits of the bean varieties used for the project's organoleptic tests

Name of variety	Country of origin	Plant growth habit	Days to 85% maturity	Seed coat colour	Seed shape	Yield (Kg/Ha)
FR2 ¹	Uganda	Indeterminate bush with erect branches	73	Whitish	Cuboid	15,000
UNGB-2364 ²	Uganda	Determinate bush	67	Pale-cream to buff	Oval	15,000
FR1 ¹	Uganda	Indeterminate with moderate climbing ability and pods distributed evenly up the plant	70	Brown, pale to dark	Kidney shaped	5,000
TZA-4174 ²	Tanzania	Determinate bush	70	Whitish	Oval	25,000
TZA-3100 ²	Tanzania	Indeterminate bush with erect branches	67	Pale-cream to buff	Oval	25,000
TZA-3990 ²	Tanzania	Determinate bush	67	Pale-cream to buff	Oval	26,000
TZA-3165 ²	Tanzania	Indeterminate bush with erect branches	70	Purple white	Kidney shaped	15,000

¹ local landrace, ² Introduced landrace

A diverse selection of bean varieties was used for sensory evaluation (Table 1), representing a range of seed types, from different seed coat colours, shape and growth habits. Two farmers varieties FR1 and FR2 performed competitively and were included alongside five introduced landraces UNGB-2364 from the national genebank in Uganda and TZA-4174, TZA-3100, TZA-3990 and TZA-3165 from the national genebank of Tanzania.

Indeterminate bush varieties like FR1, FR2, TZA-3100 and TZA-3165 were characterized by node and leaf production for several weeks after flowering had begun. These types of beans have a high tendency to lodge in high yielding environments. Determinate varieties like UNGB-2364, TZA-4174 and TZA-3990 usually flower over a short period of time and yields can be sharply reduced if this period coincides with a period of water scarcity. Luckily, the ones used for our organoleptic tests were grown during the long rain season from March to June 2019. Generally, the early maturing bean varieties are of a bush type that take up to 70 days to mature, whereas most trellised varieties need up to 110 days. Apart from FR1, all varieties fall under the bush type and are characterized by fast maturity. The high-yielding varieties included TZA-3100 and TZA-3990 with 2,500 and 26,000 kg ha⁻¹ respectively.

Table 2: Agronomic traits of the finger millet varieties used for sensory evaluation

Variety name	Country of origin	Days to flowering	Spikelet colour	Number of spikelets	Days to 90% maturity	Yield (kg/ha)
TZA-1701	Tanzania	57	White	6-7	73	4,810
UNGB-2321	Uganda	54	White	7-8	91	2,880
TZA-3676	Tanzania	52	White	7	71	4,440
TZA-3934	Tanzania	55	White	6	68	4,180
TZA-1693	Tanzania	54	White	8	69	2,100
UNGB-4146	Uganda	58	White	6-7	74	4,150
GBK-000920	Kenya	56	Brown	6-8	73	2,180

There were no locally-produced finger millet varieties that had been selected during the crowdsourcing trials from 2017 to 2019. All the varieties in Table 2 are landraces from the national genebanks of Kenya, Tanzania and Uganda. The early maturing varieties of finger millet take between 70 to 80 days. All of the accessions included in Table 2, except UNGB 2321, were considered to be faster maturing. The high-yielding varieties with a capability to provide over 4,000 kg/ha⁻¹ were TZA-1701, TZA-3676, TZA-3934 and UNGB-4146.

Product preparation for sensory evaluation tests

Finger millet products

On 5 September 2019, five days prior to organoleptic testing, 14 preparers (10 women, 4 men) charged with the preparation of *obushera*, *kwete* and *malwa* alcoholic beverages were provided with 2 kgs of each of the seven finger millet varieties for each of the three products. Finger millet varieties included TZA-3676, TZA-1701, TZA-3934, TZA-1693, UNGB-4146, UNGB-2321 and GBK-000920. These products took 5 days to be fully processed. The first three days were used for fermenting the finger millet.

Obushera is a common traditional beverage produced in southwestern Uganda. According to farmers, there are two ways of preparing *Obushera* for example, in one method millet flour is used and in the other sorghum flour is used. For the Hoima study, they prepared the one from millet flour. The production process for *Obushera* took 4 days (6–9 September 2019). Of the 2kgs of each variety given to farmers, 1kg of finger millet was fermented for 3 days, dried in the sunshine and then grind into flour. The remaining 1kg was ground and used on the fourth day, when it was mixed with cold water in a clay pot and placed over the fire. Hot boiled water was added and stirred rapidly to produce a smooth thick porridge with bubbles and then removed from the fire. The boiling takes up to 30 minutes. It was then left to cool and once cold, 0.5 kgs of fermented millet flour was added. The mixture was then kept in the same clay pot and the product was ready by the following day. Fresh *Obushera* has very low alcohol content, but if kept for long, the alcohol content will become high.

Malwa is a local alcoholic beverage made from finger millet. Its production process takes 7 days to be fully processed and was produced between 6 and 12 September 2019. 1kg of the finger millet grain was fermented for 3 days, dried under the sun and ground into flour. An additional 1kg was also ground and the flour was kept in a damp area in their houses for 24 hours, after which it was wrapped using fresh banana leaves and stored underground for 4 days. Afterwards, it was removed, heated on the fire using a traditional pot and put under the sun to dry for one day. Then some water was added together with fermented millet flour while stirring at an interval of 2 to 3 hours for 1 day (24 hours) and the *Malwa* was ready for consumption the next morning.

Kwete is a local alcoholic beverage particularly consumed by the Lugbara people from the West Nile region in Uganda. The entire production process for this particular product took 6 days (prepared between 6 and 10 September 2019). 1kg of finger millet was fermented for 3 days then ground into flour. Meanwhile, a mixture of old maize flour (from the previous season) and water was mixed and covered for 5 days. On the last day, the mixture was mixed with hot boiling water on a fire until its colour changed to brown, it hardened and formed crumbs. The breadlike crumbs were then spread on fresh banana leaves to cool. They were later mixed with cold water which made it look like a brown porridge. Fermented finger millet flour was added into the porridge-like mixture and covered till next morning by which time it had started to bubble. The porridge was then placed in a sack and squeezed to extract a whitish, fairly thick liquid called *Kwete*. *Kwete* becomes more alcoholic and sourer if kept for about 6 days. In addition to that, the squeezed-out bi-product or waste is used to feed chickens, cows, pigs and other animals.

Kalo is a type of sticky bread made from finger millet and is very common in western, eastern and northern parts of Uganda. 1kg of finger millet flour was mixed with 0.5kg of cassava flour and amalgamated using boiling water. Meanwhile, 0.25 kgs of millet flour was mixed with cold water then poured into boiling water and stirred for a minute; cassava flour was then added and mixed until it hardened. The entire preparation process for making *Kalo* takes 3-5 minutes depending on the finger millet variety used.

Porridge is a food commonly eaten as a breakfast cereal dish. It is often served with added flavourings such as sugar or honey to make a sweet cereal. 1kg finger millet flour was added to hot boiling water and stirred using a mixing spatula until it becomes thick and bubbly. The preparation process for making porridge takes about 3-5 minutes depending on the finger millet variety.

Beans

Seven varieties of dried beans were sorted and shrivelled or discoloured beans were discarded. The beans were washed and each variety placed into separate cooking pots, covered completely with water and placed on the fire to cook. When the beans had cooked for 2.5 hrs, one or two were tested by mashing one bean with a fork or between the fingers. Once they split or softened, it was a sign that the cooked beans were ready to be consumed (Image 1). During the cooking, ingredients and spices can be added, such as royco and green pepper, but for the purposes of organoleptic testing, salt was the only ingredient added for taste after cooking.



Image 1 : Cooked beans ready for tasting. Credit: Alliance of Bioversity International and CIAT/ D.Mubiru

Data Collection

The tasting exercise took four days at NARO Bulindi and was conducted from 9 to 12 September 2019 with a total of 101 volunteering participants of which 50 came from Hoima and 39 Masindi districts in Uganda, 10 from Nyando Kenya and 2 from Hombolo Tanzania (Table 3).

Table 3: Organoleptic tests by product, crop and participants

Date	Product	Crop	No. of men	No. of women
9/9/2019	Porridge	Millet	10	10
9/9/2019	Bushera	Millet	4	10
10/9/2019	Kalo	Millet	6	12
11/9/2019	Bean sauces	Beans	11	9
11/9/2019	Kwete	Millet	9	3
12/9/2019	Malwa	Millet	14	3
		TOTAL	54	47



Photo 3: Tasting and scoring of Malwa and Kwete alcoholic drinks by farmers. Credit: Alliance of Bioversity International and CIAT/T.Recha

The participants were given scoring cards with a five point Likert scale, enabling them to express how much they agree or disagree with a particular statement. A Likert scale assumes that the strength/intensity of an attitude is linear, i.e. on a continuum from strongly agree to strongly disagree, and makes the assumption that attitudes can be measured. In addition to measuring statements of agreement, Likert scales can measure other variables such as frequency, quality, importance, and likelihood, etc. In this exercise, the scale was used to measure the relative quality and palatability of the products prepared based on farmers' perceptions based on the scale of 1 to 5 (Table 4). The participants gave feedback on how they perceived the quality of the products and gave a score.

Table 4: The qualitative scoring points of the five-point Likert scale used by the project team for the organoleptic testing

Very bad	Bad	Fair	Good	Very good
1	2	3	4	5

Likert Scales have the advantage of not expecting a simple yes or no answer from the respondent, but rather allow for degrees of opinion, and even no opinion at all.

Farmers provided feedback on the quality of the products based on the variables in Table 5

Table 5: Variables used to assess the quality of the products during organoleptic testing

Finger millet products		
Product	Quality assessment variables	Questions to assess preferences in product taste and aroma, and responses provided on product consistency
Hot porridge	Aroma before tasting	How is the aroma before tasting?
	Aroma in the mouth	How is the aroma in the mouth?
	Consistency in smoothness	How smooth is the consistency?
	Thickness	How is the thickness?
	Taste	How tasty is it?
	General acceptability	General acceptability
Kalo	Elasticity when pinched	How elastic is it when you pinch it?
	Aroma before tasting	How is the aroma before tasting?
	Taste	How does it taste?
	Aroma after tasting	How is the aroma after tasting?
	Texture smoothness	How smooth is the texture in the mouth?
	General acceptability	General acceptability
Obushera	Colour/ appearance	How is the colour?
	Consistency of the mixture	How is the consistency of the mixture?
	Lightness	How light is it?
	Aroma before tasting	How is the aroma before tasting?
	Level of sweetness	How sweet is it?
	Aroma in the mouth	How is the aroma in the mouth?
	Texture in the mouth	Does it leave flour particles in your mouth?
	General acceptability	General acceptability
Malwa	Colour/appearance	How do you like the external appearance?
	Smoothness	How does it feel in the mouth?
	Thickness of the mixture	How is the thickness?
	Aroma before drinking	How is the aroma before drinking?
	Aroma in the mouth	How is the aroma in the mouth?
	Taste	How does it taste?

	Easy to make someone drunk (high alcohol content)	How strong is it?
	General Acceptability	General Acceptability
Kwete	Colour/appearance	What is the colour?
	Aroma before tasting	How is the aroma before tasting?
	Aroma after tasting	How is the aroma after tasting?
	Taste	How sweet is the taste?
	Easy to make someone drunk (high alcohol content)	How strong is it?
	Thickness of the mixture	How is the thickness?
	Bubbling attribute	How bubbling is it?
	General acceptability	General acceptability
Beans		
Bean varieties	Colour/appearance	What is the colour of the soup?
	Thickness of the soup	Soup thickness?
	Ability to split after cooking	Have the beans split after cooking?
	Aroma before tasting	What is the aroma before taste?
	Softness of the beans	How soft are the beans?
	Aroma after tasting	What is the aroma after taste?
	Taste	Do you like the taste?
	General Acceptability	General Acceptability

Participants were given sufficient time to assess each of the samples by tasting, smelling, touching and observing. They rinsed their mouths with water before tasting each sample in order to clean their palate and remove any residue tastes from previous samples.

Test results and varietal ranking

Farmers' varietal preferences by specific products tasted

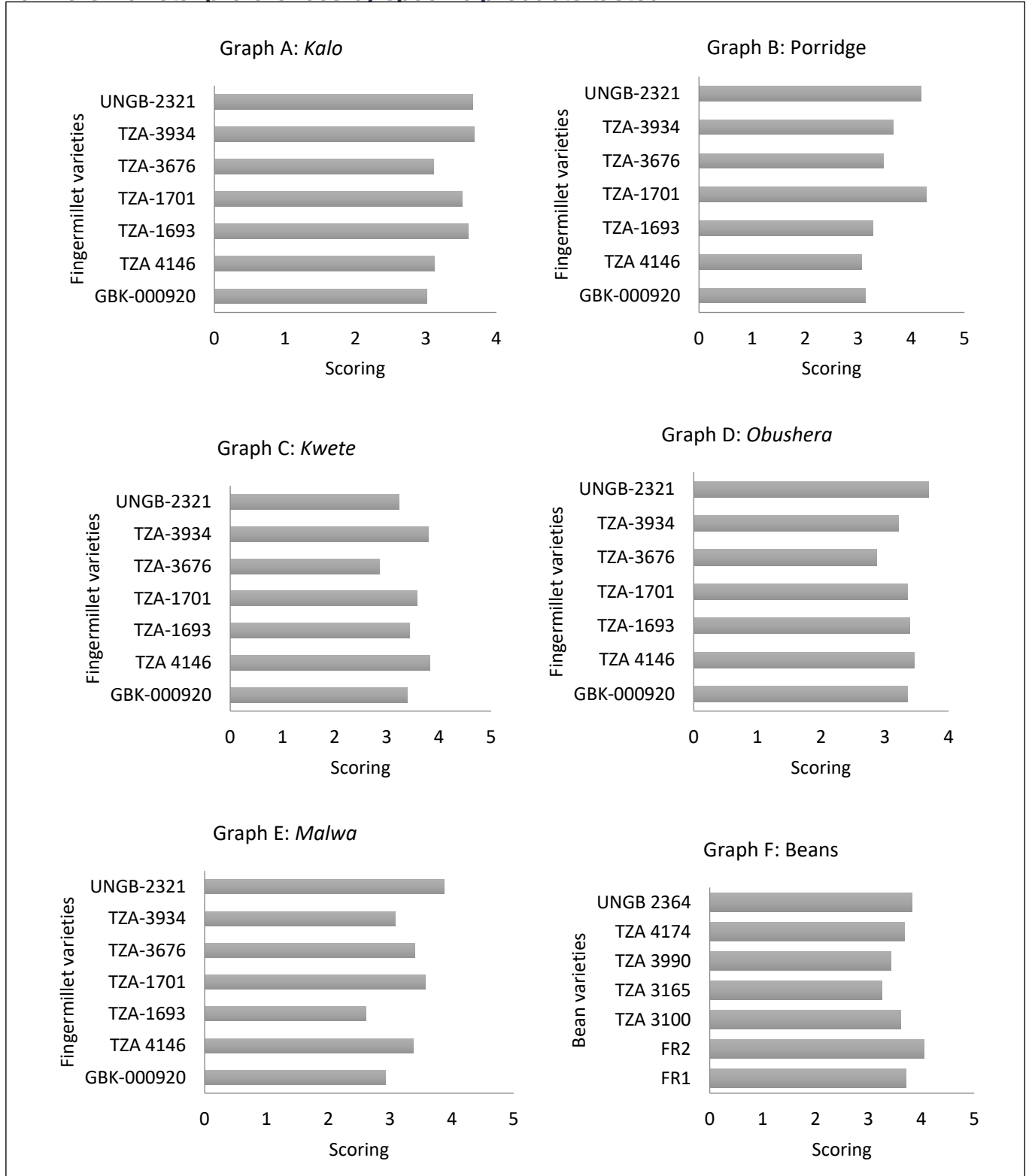


Figure 2. Farmers' variety preferences for specific products

Graphs A to E show results for products that were made from finger millet and graph F shows the overall results of the cooked beans organoleptic tests. Graph A, for *Kalo*, shows that varieties TZA-3934 and TZA-1693 were ranked best for making *Kalo*, with a mean score of 3.69 and 3.60 respectively. Farmers ranked them higher due to their good elasticity, good texture and colour with a pleasant aroma. The least preferred varieties were GBK-000920 and TZA-3676 with a mean score of 3.01 and 3.11, respectively, to which farmers preferring local varieties over elite breeding lines. The main setback for GBK-000920 and TZA-3676 were poor texture, colour and less pleasing taste.

In graph B for porridge, TZA-1701 was the most preferred by farmers with a general acceptability mean of 4.28, followed by UNGB 2321 with a mean of 4.18. They both had a good aroma and attractive colour, and were smooth in the mouth with favourable thickness. GBK-000920 and TZA-4146, with respective mean scores of 3.13 and 3.07 were the least popular with reported poor taste, irregular smoothness and less attractive colour.

Graph C for *Kwete* shows that TZA-4146 and TZA-3934 were the most preferred with a mean score of 3.83 and 3.79, respectively. They were ranked highly due to their ability to bubble continuously while kept in the pot, good colour and sweet taste, with a desired thickness and ability to make one drunk. TZA-3676 and UNGB-2321 were regarded undesirable because of their unattractive colour and bad taste in the mouth with less alcoholic strength so one would need to drink more of it to feel drunk.

Graph D for *Obushera* indicates that UNGB-2321 variety was the most preferred by farmers with an average score of 3.69 followed by TZA-4146 with a score of 3.46. These two varieties scored well for consistency of the mixture, attractive colour, good aroma and sweet taste. The lowest scoring varieties were TZA-3934 and TZA-3676 with an average score of 3.21 and 2.87, respectively, due to their bad taste, unattractive colour and inconsistency of the mixture during consumption.

Graph E for *Malwa* shows that UNGB-2321 and TZA-1701, with an average score of 3.87 and 3.57, respectively, were the preferred finger millet varieties for this popular alcoholic beverage. They scored well all round for taste, colour, palatability and alcoholic strength (i.e. making one drunk easily). The least preferred varieties were TZA-1693 and GBK-000920 with an average score of 2.61 and 2.93, respectively. They were rejected because of their bad taste and aroma, bad sensation in the mouth and low alcoholic strength.

Lastly, Graph F, providing results on sensory evaluation of bean source obtained by boiling the beans and adding salt to taste. Graph F shows that bean varieties FR2 and UNGB-2364 were highly ranked by farmers with a general acceptability of 4.05 and 3.83, respectively. They had attractive colour, good thickness in soup, good taste, appealing aroma and they generally after they have been cooked. TZA-3165 and TZA-3990 were the least preferred by farmers, scoring a lower average of 3.26 and 3.42 because of their colour, which was considered to be less attractive, bad taste and poor ability to split after cooking.

Overall variety ranking and acceptability by farmers

Table 6 shows the selection and ranking of for bean and finger millet varieties based on the overall scoring per variety per variable.

Table 6: The overall ranking results of beans and finger millet varieties

Rank	Beans	Score	Finger millet	Score
1	FR2	4.05	UNGB-2321	3.728
2	UNGB-2364	3.83	TZA-1701	3.658
3	FR1	3.71	TZA-3934	3.486
4	TZA-4174	3.68	TZA-4146	3.372
5	TZA-3100	3.61	TZA-1693	3.262
6	TZA-3990	3.42	GBK-000920	3.162
7	TZA-3165	3.26	TZA-3676	3.142

For beans, FR2 and UNGB-2364 were the two top ranking varieties based on farmers' preferences expressed during the sensory evaluation of bean sauces made from these varieties. The highly ranked bean varieties possess the majority of the traits of interest, which include attractive colour, good thickness in soup, good taste and appetizing aroma and good ability to split after cooking.

For finger millet, the two top-ranking varieties were introduced landraces UNGB-2321 from Uganda National genebank and TZA-1701 from Tanzania National Genebank with a mean acceptability score of 3.73 and 3.66, respectively. These varieties present most of the qualities that are considered best by farmers. They include good aroma, attractive colour, good taste, good alcoholic strength and good texture in the mouth. However, GBK-000920 with a mean of score of 3.16 and TZA-3676 (the lowest) with a mean score of 3.14 ranked lowest and were therefore considered the least desirable.

Conclusion

Our study was aimed at supporting the dissemination and uptake of best performing climate-smart varieties of millets and beans that form the basis of important staple foods and alcoholic beverages in Hoima, Uganda, based on farmers' preferred traits. This report presents the results of sensory evaluation tests conducted on seven bean and seven finger millet varieties pre-selected from an initial pool of 34 bean and 43 finger millet varieties selected by farmers against desirable attributes. Millet is a rich source of vitamins and minerals that are supportive of a nutritious diet and has a wide range of uses within the communities, although each variety may only be suitable for the preparation of certain products, not all. Although some varieties on average performed/fared better than others, none of them emerged as the best for all types of culinary products tested. Since these varieties have also performed well against desirable agronomic

attributes, such as days to maturity, yield, pest and disease resistance and drought tolerance, their acceptability from a culinary and cultural perspective is essential for their uptake by local communities. We therefore recommend a “portfolio approach” in which farmers maintain a diverse portfolio of crops and varieties as an important management tool that allows farming to survive climate variations. With portfolio diversity, many components that do not appear particularly productive for much of the time can suddenly assume key importance when others fail, while also offering a much needed diversity on the plate and increased nutritional benefits. This activity contributes to CCAFS work in promoting a food secure world through the provision of science based efforts that support sustainable agriculture and enhancing livelihoods while adapting to climate change and conserving natural resources and environmental services. Specifically, it contributes to Theme 1 on Adaptation to Progressive Climate Change.

The results of this exercise will be used to provide information to be included in seed and varietal catalogues, which are being developed to provide farmers with knowledge on the suitability of particular varieties for climate change adaptation and for various local traditional products. The same information from the catalogues can also be used by breeders to pre-select candidate lines for crop improvement.

Appendix 1: Questionnaires

BIOVERSITY INTERNATIONAL ORGANOLEPTIC TESTING FOR PORRIDGE

General information

Name of respondent.....Date of interview.....

Sex.....

Age.....Village.....

Instructions: Before you start, rinse your mouth using the water provided and sip a little to clear your throat. REPEAT this after each product and before embarking on the next product. Please rate all products according to the following attributes using the provided scale. Note that there are 10 samples of porridge and you will not be provided standard serving but a portion that is adequate to establish its sensory attributes.

Provide information on the level of satisfaction of finger millet lines for the following traits (Codes: 5=Very good 4= Good, 3= fair, 2= Poor, 1=Very poor)

Sample Code	How is the aroma before tasting?	How is the aroma in the mouth?	How smooth is the consistency?	How is the thickness?	How tasty is it?	What is the colour? _____ Do you like the colour?	General acceptability
1							
2							
3							
4							
5							
6							
7							
8							
9							
1							

0							
---	--	--	--	--	--	--	--

BIOVERSITY INTERNATIONAL

ORGANOLEPTIC TESTING FOR *BUSHERA*

General information

Name of respondent.....Date of interview.....

Sex.....

Age.....Village.....

Instructions: Before you start, rinse your mouth using the water provided and sip a little to clear your throat.

REPEAT this after each product and before embarking on the next product. Please rate all products according

to the following attributes using the provided scale. Note that there are 10 samples of Bushera and you will not be provided standard serving but a portion that is adequate to establish its sensory attributes. Provide information on the level of satisfaction of finger millet lines for the following traits
(Codes: 5= Very good, 4= Good, 3= fair, 2= Poor, 1= Very poor)

	Sample Code	How is the colour? (the best is almost transparent)	How is the consistency of the mixture? Does it separate?	How light is it? (best when light)	How is the aroma before tasting?	How sweet is it?	What is the aroma in the mouth?	Does it leave flour particles in your mouth? Yes no Rate for texture in the mouth	General Acceptability
1									
2									
3									
4									
5									
6									
7									
8									

9									
10									

**BIOVERSITY INTERNATIONAL
ORGANOLEPTIC TESTING FOR KWETE**

General information

Name of respondent.....Date of interview.....

Sex.....

Age.....Village.....

Instructions: Before you start, rinse your mouth using the water provided and sip a little to clear your throat.

REPEAT this after each product and before embarking on the next product. Please rate all products according to

the following attributes using the provided scale an. Note that there are 10 samples of Kwete and you will not

be provided standard serving but a portion that is adequate to establish its sensory attributes.

Provide information on the level of satisfaction of finger millet lines for the following traits (Codes:

5=Very good ,4= Good, 3= fair, 2= Poor, 1=Very poor)

	Sample Code	What is the colour? _____ _____ How do you like the colour? Rate from 1-5	How is that aroma before taste?	How is the aroma after taste?	How sweet is the taste?	How strong is it? Does it make you drunk?)	How is the thickness ? (Thick is best)	How bubbling is it?(non-stop bubbling is the best)	General Acceptability
1									
2									
3									
4									

5									
6									
7									
8									
9									
10									

**BIOVERSITY INTERNATIONAL
ORGANOLEPTIC TESTING FOR MALWA**

General information

Name of respondent.....Date of interview.....

Sex.....

Age.....Village.....

Instructions: Before you start, rinse your mouth using the water provided and sip a little to clear your throat.

REPEAT this after each product and before embarking on the next product. Please rate all products according

to the following attributes using the provided scale . Note that there are 10 samples of Malwa and you will not be provided standard serving but a portion that is adequate to establish its sensory attributes.

Provide information on the level of satisfaction of finger millet lines for the following traits

(Codes: 5=Very good 4= Good, 3= fair, 2= Poor, 1=Very poor)

	Sample Code	How do you like the external appearance? Colour?	How is the mouthfeel? (smooth on the throat)	How sour is it?(Sour is best)	How is the thickness ? (Watery is best)	How is the aroma before drinking?	How is the aroma in the mouth?	How does it taste ?	How strong is it? Does it make you feel drunk?	General Acceptability
1										
2										

3										
4										
5										
6										
7										
8										
9										
10										

**BIOVERSITY INTERNATIONAL
ORGANOLEPTIC TESTING FOR BEANS**

General information

Name of respondent.....Date of interview.....

Sex.....

Age.....Village.....

Instructions: Before you start, rinse your mouth using the water provided and sip a little to clear your throat.

REPEAT this after each product and before embarking on the next product. Please rate all products according to

the following attributes using the provided scale . Note that there are 10 samples of Beans and you will not be

provided standard serving but a portion that is adequate to establish its sensory attributes.

Provide information on the level of satisfaction of bean lines for the following traits

(Codes: 5=Very good 4= Good, 3= fair, 2= Poor, 1=Very poor)

	Sample Code	What is the colour of the soup? Do you like it? Rate it from 1-5?	Soup Thickness? How thick is the soup?	Have the beans split after cooking? Yes No Rate the wholesomeness from 1-5	What is the aroma before taste? rate	How soft are the beans?	What is the aroma after taste?	do you like the taste?	Taste	General Acceptability
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										



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