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(TAFS-WCA)

SWEETPOTATO SENSORY EVALUATION IN RWANDA

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Citation

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2. BACKGROUND AND OBJECTIVE

Transforming Agrifood Systems in West and Central Africa (TAFS-WCA) is a regional initiative that aims to build a more resilient, climate-smart, nutritious, gender equitable, and viable food production system through the development and scaling of novel and inclusive production and post-harvest technologies, participatory decision-making and planning, and informed governance systems. By focusing primarily on food and nutrition security and making agrifood systems more climate-adapted, the Initiative seeks to contribute to the five Impact Areas of the One CGIAR. Access to quality, nutrient-dense seed, climate-smart good agricultural practices (GAP), and reduced post-harvest losses will positively impact food, nutrition, and health security.

Rwanda is a small, highly populated country with over 80% of the population engaged in the agricultural sector. The majority involved in agriculture are smallholder farmers with less than 0.5 hectares on average per farming household. Sweetpotato is a very popular staple in Rwanda, especially among the rural poor, with over 80 kgs produced per capita per year. In fact, in terms of metric tons produced, sweetpotato is the number one crop in the country. Farmers, however, do struggle to market their sweetpotato surplus, and gluts on the market can result in low prices. In addition, the dominant local varieties are white-fleshed, having no pro-vitamin A content.

To address these issues, the International Potato Center (CIP) has been collaborating with the Rwanda Agriculture and Animal Resources Development Board (RAB) for over 15 years to introduce and breed biofortified orange-fleshed sweetpotato (OFSP) varieties which are rich Vitamin A precursors and can significantly contribute to reducing vitamin A deficiency. Currently CIP and RAB are conducting yield trials in multiple locations to evaluate preferred varieties and promising clones to assess not only their yield under different agro-ecologies, but to assess organoleptic preferences of consumers and better understanding processing qualities for different products and processor preferences. Under TAFS-WCA, activities to boost sweetpotato value addition opportunities for small enterprises were also initiated through the introduction and testing of manually operated sweetpotato root chipping and puree making machines. Additionally, the business case for investment in orange-fleshed sweetpotato products such as puree, bakery items, and chips in Rwanda is being developed and refined. Products using the orange-fleshed types have an attractive golden color appreciated by consumers. This exploitation of value addition aims to transform sweetpotatoes from just being traditional staple crop consumed steamed or boiled into a versatile and appealing food ingredient, expanding the consumer base, increasing market demand, and creating new business opportunities along the value chain.

The objective of this study is to assess which of the improved orange-fleshed sweetpotato varieties are best suited for fries and crisps processing. This report will present the sensory assessment of different sweetpotato varieties into chips (fries) and crisps evaluated in two rounds during 2023 representing two agriculture seasons in Rwanda. Both local farmers and trained panelists from the University of Rwanda were engaged in the assessment.

3. SECTION I: ROUND ONE OF SENSORY EVALUATION

3.1. Introduction

Sweetpotatoes can be cultivated in all three agricultural seasons in Rwanda, ensuring their availability for consumption and processing throughout the year. During season A (October to December), the International Potato Center (CIP), in collaboration with the Rwanda Agriculture Board (RAB), established multiple sites for yield trials involving five orange-fleshed sweetpotato (OFSP) varieties. Apart from collecting yield data, the suitability and utilization of these varieties for processing purposes were tested to identify the most suitable variety. To assess their processing potential, sweetpotato crisps, fries, and steamed roots were prepared and evaluated by both trained and untrained panelists. The detailed results of these sensory evaluations are outlined in Section I of this report.

3.2. Methodology

3.2.1. Sample preparation

3.2.1.1. Steamed roots preparation

Sweetpotato roots harvested from three trial sites hosted by Pride Farms one day prior to preparation were washed thoroughly with clean water, cut into four approximately equal pieces, and steamed on the stove until well cooked (approximately 30min).

3.2.1.2. Chips (fries) preparation

Five varieties namely Kabode, Terimbere, Irene, Urukundo (55) and RW-130 were harvested from one Pride Farm trial site and were stored overnight in a dry and cool place. Roots of approximately same size (220-250 g) were selected, steam-blanched for 15 minutes and cut using the manual *Cut-a Chip* machine into equal size chips (approximately 7 cm long). Chips were then put in pre-heated sunflower oil for approximately 5 min under gas cooker and then removed, oil drained and put in clean plastic container.

3.2.1.3. Selection of untrained farmer panelists as assessors

As per Ofori et al. (2021), a farmer participatory approach was used. Twenty-five (25) assessors (12 men, 13 women) were selected from the local community around the trial farms and were briefed in Kinyarwanda on how the sensory evaluation would be conducted and the meaning of the different parameters to be assessed explained.

3.2.1.4. Sensory analysis of steamed root samples by farmer panelists

Steamed root samples from each variety were served to each panel member, who assessed them using a Likert scale of 1 to 5, with 1 representing “very poor” and 5, “very good”, for each of the following parameters: appearance, aroma, texture, flavor and overall liking.

Root samples of each variety were served to seated assessors in a small plastic box containing 2 pieces (piece = quarter), labeled with a three-digit code. The assessors were asked to independently score the attributes on pre-designed form.

3.2.1.5. Sensory analysis by farmer panelists of chips processing using *the Cut-a-Chip* machine

Every assessor was served with approximately 20 g of sweetpotato chips of each variety, produced using the *Cut-a-Chip* machine, and they were asked to score them on the scale of 1 to 5 with 1 representing "very poor" and 5, "very good", on the following parameters, appearance, aroma, texture, flavor, and overall liking.

3.2.1.6. Industrial produced crisps

Roots from two OFSP varieties, Kabode and Terimbere, were harvested from a trial farm managed by Wisdom School in Musanze. Before processing, the roots were stored overnight in a cool and dry location. Subsequently, the roots were transported to Hollanda Ltd, where they underwent washing, cutting, and frying in preheated sunflower oil at a temperature of 171°C for a duration of 151 seconds.

The equipment at Hollanda Ltd is of industrial quality. The minimum requirement for processing using this equipment is 20 kg per batch. Unfortunately, only two of the five varieties had sufficient amounts of material to be included in the trial. More varieties were included in the second round of sensory assessment.

3.2.1.7. Training and selection of student panelists

The sensory panelists were selected from a group of food science students from the University of Rwanda (UR) who had completed a sensory evaluation course.

In collaboration with a professor at the Food Science and Technology Department of UR, 16 students were selected to be including in a two-day training on sweetpotato sensory evaluation. They were objectively evaluated based on their performance during the training, and 12 students were chose to be on the trained panel to conduct a sensory evaluation of sweetpotato crisps.

The training focused on basic taste characteristics, sample screening, threshold detection, different sensory analysis methods, and a sweetpotato sensory analysis scale. Key aspects covered are described in detail below.

3.2.1.7.1. Basic Taste

The human sense of taste can be broken down into five fundamental sensations: sweet, sour, salty, bitter, and umami (savory) (Keast & Breslin, 2003). These basic tastes are detected by specialized receptors on the tongue and palate, each responding to specific chemical compounds in food. Sweetness is associated with sugars like glucose, sourness with acids like citric acid, saltiness with sodium ions, bitterness with toxins or alkaloids, and umami with glutamates found in meat, cheese, and broth (Gravina et al., 2013).

3.2.1.7.2. Food Sensory Attributes

When it comes to assessing food, sensory attributes play a pivotal role in consumer acceptance. These attributes span across appearance, odor, flavor, and texture, among others each contributing significantly to our food experience.

In food evaluation, appearance hinges on physical and psychological aspects. The physical factors involve geometrical attributes like size, shape, and intrinsic uniformity, as well as optical elements such as surface gloss, pigmentation, and light-scattering abilities. The goal is to transform the physical attributes into psychological perceptions (MacDougall, 2003).

Odor, driven by volatile compounds, contributes substantially to our perception of food. Factors like serving temperature, surface properties affecting diffusion, and enzymatic reactions impact the olfactory experience (Lawless, 1991).

Flavor is perceived during oral food processing with multiple simultaneous processes enhancing perception. Mastication releases volatile odor compounds that reach the nasal cavity via the nasopharyngeal passage, engaging the olfactory epithelium—a phenomenon known as retronasal olfaction. Simultaneously, tasting compounds in food dissolve in saliva, activating taste receptors in taste buds, eliciting perceptions of sweetness, sourness, bitterness, saltiness, or umami. Additionally, certain chemical compounds can stimulate nerve endings, causing sensations like astringency, metallic taste, spiciness, or cooling effects due to mucous membrane sensitivity in the mouth (Erasmus+, 2018).

Evaluating texture relies on a person's ability to articulate their sensations. Human perception of food texture considers three aspects: visual, tactile, and auditory. Visual perception draws from past experiences with similar foods, while tactile perception encompasses both oral (mouthfeel) and manual texture assessment. Auditory cues, such as food sounds, also contribute. For instance, low-pitched sounds relate to crunchiness, while high-pitched sounds correlate with crispiness in terms of food texture (Rustagi, 2020).

3.2.1.7.3. Threshold Detection

The absolute threshold is the quantifiable minimum energy level of a stimulus or concentration of a chemical that is perceivable (Lawless & Heymann, 2010). According to Macmillan & Creelman, (2005), threshold and sensitivity analysis are crucial aspects of consumer and sensory research. The concept of threshold, defining the minimum stimulus intensity that the sensory system can detect, is a longstanding pursuit in psychophysics. The threshold represents the boundary where the sensory system can perceive a stimulus, with intensities below it presumed to lack sufficient impact for perception. However, the actual threshold might not be a clear-cut boundary due to various psychological and physiological influences. These complexities make measuring and defining the threshold challenging, as the transition point between sensation and no sensation may fluctuate under different conditions despite the initial assumption of its independence (Bi, 2015). In contemporary threshold theory, the reaction to a stimulus, assessed through the accuracy of response, is seen as a variable that varies randomly. The threshold itself is described as the specific level of stimulus intensity that results in a predetermined likelihood of a correct response, determined by a dose-response model. These models, established statistical techniques, find extensive use across numerous domains, especially in biological assessment, toxicology, and pharmacology (Bi, 2015).

3.2.1.7.4. Sensory Analysis Methods

Methods for sensory analysis can be divided into 3 distinct categories: discriminative tests, descriptive tests, and affective tests. Discriminative tests encompass evaluations like the Triangle Test, Duo Trio Test, and Paired Comparison Test, aiming to identify differences among presented samples. Descriptive tests focus on detailing the magnitude of distinctions between products or determining the presence or intensity of a particular characteristic. The descriptive tests include the Flavor Profile Method (FPM), the Texture Profile Method (TPM), Quantitative Descriptive Analysis (QDA), and the Spectrum method. Affective tests, further categorized into Preference tests, Acceptance tests, and Hedonic Tests, gauge preferences and/or acceptance levels for a product (Carpenter et al., 2000; Erasmus+, 2018; Piggott et al., 1998).

3.2.1.7.5. Practices On Crisps Sensory Analysis

Throughout the training sessions, panelists had extensive practice on sensory evaluations, focusing on basic tastes such as sweet, bitter, sour, and salty. They also assessed various products with diverse textures, delving into the crispiness and crunchiness levels found in items like biscuits, cookies, and popcorn. The objective was to sharpen their abilities to discern textural disparities and their relationship with other sensory elements.

Additionally, the panelists were introduced to evaluating crisps crafted from both potato and sweetpotato varieties. The training spanned three days, with two daily sessions dedicated to these sensory evaluations.

3.2.2. PANEL TRAINING AND SELECTION

Sixteen (16) panelists were trained to evaluate sweetpotato crisps through a focus group discussion where the lexicon for appearance, aroma, flavor, oiliness, and texture was developed. Data were collected during training to evaluate the consistency of the panelists to use the attributes to differentiate the varieties and they were subjected to an evaluation to select the 10 best performers to conduct sensory evaluation.

To have consistency in the use of terminologies during sensory evaluation, the parameters were described as follows:

Appearance: Visual appeal of the crisps. Positive evaluations indicate that the crisps have an attractive color, shape, and size. If the results show a high score for appearance, it suggests that the crisps are visually appealing.

Aroma: Aroma evaluation focuses on the smell or fragrance of the crisps. A positive assessment suggests that the crisps have a pleasant and enticing typical aroma of fried sweetpotato crisps or slices.

Flavor: Flavor evaluation assesses the taste of the crisps. Positive results indicate that the crisps have a desirable and enjoyable flavor profile. This could mean that the crisps have a well-balanced combination of savory, sweet, or spicy flavors, depending on the variety being evaluated.

Crispness: Refers to the crisp texture, specifically their crunchiness. A high score for crispness suggests that the crisps have a satisfying and crisp texture.

Oiliness: Presence or perception of oil on the surface of the crisps. provide insights into the texture and mouthfeel of the crisps. A positive assessment suggests that the crisps have no visible oil on their outer layer.

3.2.3. SENSORY ANALYSIS

3.2.3.1. Evaluation room

The sensory analysis was conducted in the sensory evaluation laboratory of the University of Rwanda, School of Food Science and Technology.

3.2.3.2. Sample handling

Samples of processed crisps were taken from Hollanda Fairfood Ltd processing factory and brought to the sensory evaluation in a dry container. A three-digit code was generated using excel and allocated to each sample. A serving size of 25g of crisps of each variety was put on white plate and served to each panelist.

3.2.3.3. Evaluation Procedure

A method by Dery et al., (2021) was used to analyze 6 sensory parameters namely appearance, aroma, flavor, crispness, oiliness, and overall liking of the sweetpotato crisps. A 9 hedonic scale was used where liked extremely =9, liked much =8, liked moderately =7, liked slightly =6, neither liked/ nor disliked =5, disliked slightly =4; disliked moderately =3, disliked much =2 and disliked extremely =1

Panelists evaluated two samples (varieties) per session, with each sample tasted two times on different days. All panelists were given potable water at room temperature to cleanse their palate between tasting samples.

3.2.4. DATA PROCESSING

Data were collected using a pre-designed form and they were subjected to one-way analysis of variance (ANOVA) with means separation conducted using Tukey test at 5% significant level for each sensory attribute.

4. Results and discussion for Round I

4.1. Panelist's demographic data

4.1.1. FARMER PANELISTS

Twenty-five assessors participated in the assessment of chips and boiled roots. Among the assessors, 13 (52%) were female and 12 (48%) were male. They were desegregated into three age categories and 12% were below 20 years old, 32% were between 20 and 30 years old while 56% were above 30 years old.

Table 1: Age and gender of farmer panelists

	Gender		**Total**
	Male	Female	

Age	Below 20	Count	3	0	3
		% within Gender	25.0%	0.0%	12.0%
	20 to 30	Count	2	6	8
		% within Gender	16.7%	46.2%	32.0%
	Above 30	Count	7	7	14
		% within Gender	58.3%	53.8%	56.0%
Total		Count	12	13	25
			48%	52%	

In terms of education level, 44% have at least attended primary school, 40% have reached secondary school while only 4% have attended university level (Table 2).

Table 2: Education of farmer panelists

			Gender		**Total**
			Male	Female	
Education	Primary school	Count	4	7	11
		% within Gender	33.3%	53.8%	44.0%
	Secondary school	Count	4	6	10
		% within Gender	33.3%	46.2%	40.0%
	University	Count	4	0	4
		% within Gender	33.3%	0.0%	16.0%
Total		Count	12	13	25
		% within Gender	48.0%	52.0%	

4.1.2. Trained student panelists

For the steamed root evaluation, 12 students were trained and 10 (6 women, 4 men) were retained for sensory evaluation after their assessment.

4.1.3. STEAMED ROOTS SENSORY ANALYSIS

As shown in Figure 1, the steamed sweetpotato, Kabode (RGN-Kabode) from Rwamagana site was the most liked by the assessors followed by Irene from Rwamagana.

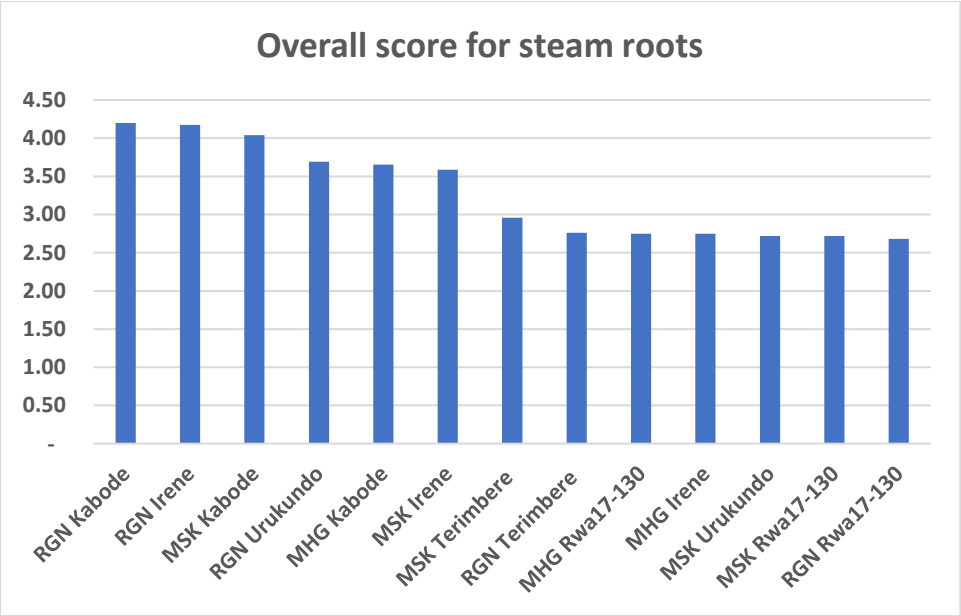

Figure 1: Scores of Steam Roots From 3 Different Pride Farm Sites (RGN-Rwamagana, MSK= Masaka, MHG= Muhanga)

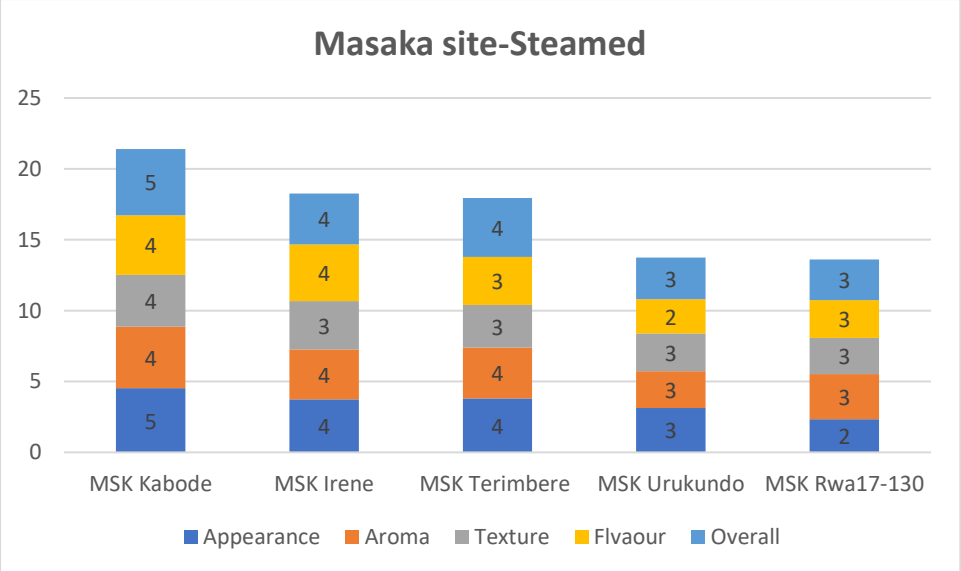

Figure 2: score for steamed roots from Masaka site

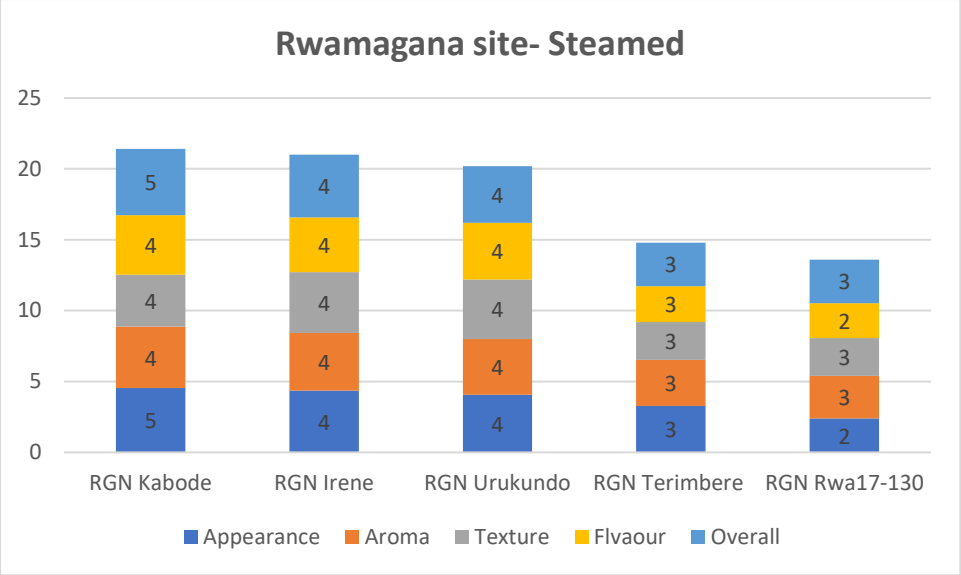

Figure 3: score for steamed roots from Rwamagana site

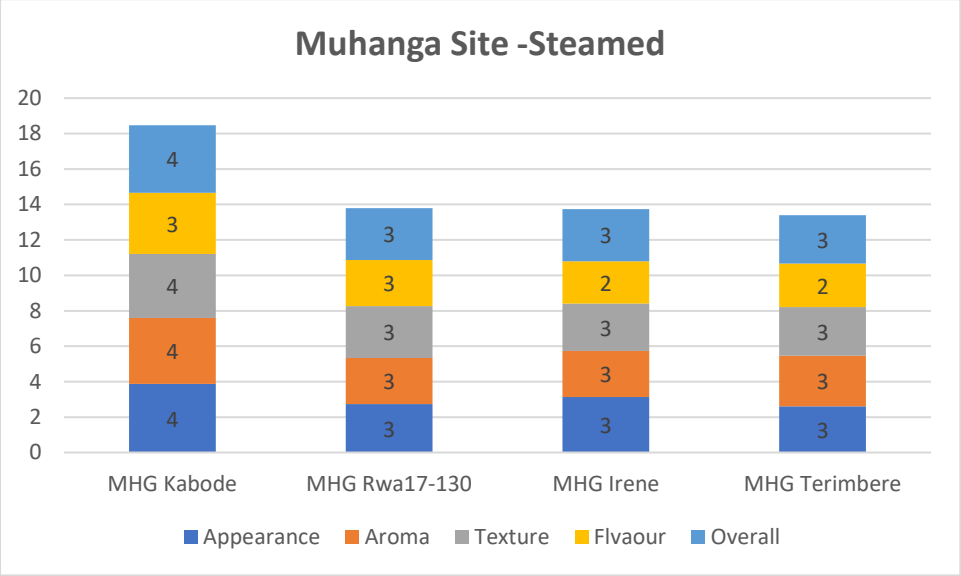

Figure 4: score for steamed roots from Muhanga site

As per the same figure, Kabode remained the most preferred by the assessors for all the 3 sites. This can be related to the high dry matter content it contains and its deep orange color. Steamed sweetpotato roots from Muhanga site scored the lowest average score.

Figure 5: Steaming OFSP Roots Figure 6: Steamed Roots During Sensory Evaluation

4.1.4. CHIPS (FRIES) PROCESSED USING *CUT-A-CHIP MACHINE*

Table 3 presents the mean score of each variety on 5 parameters analyzed during the sensory evaluation with local community members. The variety Kabode had the highest means score in all parameters with 4.28 for appearance, 4.04 for aroma, 4.08 for flavor 3.72 for crispness and 4.12 for overall liking. It was followed by the variety Terimbere, then the variety Urukundo (55). Variety RW-130 did not make good quality chips.

Table 3: Scores of Chips processed using *Cut-a-Chip machine*

Variety name		Appearance	Aroma	Flavour	Crispness	Overall
RW-130	Mean	2.96	2.76	2.84	2.32	2.92
	Std. Dev.	1.27	1.30	1.14	1.21	1.07
Kabode	Mean	4.28	4.04	4.08	3.72	4.12
	Std. Dev.	0.73	0.88	0.81	0.61	0.88
Urukundo (55)	Mean	3.88	3.60	3.60	2.88	3.64
	Std. Dev.	1.26	1.15	1.19	1.01	1.11
Irene	Mean	3.88	3.44	3.16	2.76	3.28
	Std. Dev.	1.09	0.96	0.98	1.01	0.89
Terimbere	Mean	3.96	3.68	4.00	3.60	3.92
	Std. Dev.	1.02	1.06	1.00	1.22	0.90

Variety RW-130 had the lowest scores in all parameters scoring below 3 on every parameter. This could be linked to its inconsistency in color and size.

There was a significant difference ($P< 0.005$) among the scores given to parameters for all five varieties as per Table 4.

The score for crispness was relatively low compared to the scores of other parameters. This can be related to the high water content of OFSP roots affecting rapid moisture removal expected during frying. Hence the need to blanch the root for approximately 15 minutes before frying.

Table 4: Difference Among the Scores of Analysed Parameters

		Df	Mean Square	F	Sig.
Appearance	Between Groups	4	6.088	5.065	0.001
	Within Groups	120	1.202		
	Total	124			
Aroma	Between Groups	4	5.532	4.704	0.001
	Within Groups	120	1.176		
	Total	124			
Flavour	Between Groups	4	7.132	6.657	0.000
	Within Groups	120	1.071		
	Total	124			
Crispness	Between Groups	4	8.732	8.080	0.000
	Within Groups	120	1.081		
	Total	124			
Overall	Between Groups	4	5.852	6.100	0.000
	Within Groups	120	0.959		
	Total	124			

Figure 7: Chips Used in Sensory Evaluation by Farmer Assessors

4.1.5. FACTORY PROCESSED CRISPS

Table 5 presents the mean score for each variety for the six parameters analyzed during the sensory evaluation. The variety Kabode had the higher scores for appearance, aroma, flavor, crispness, and overall liking than Terimbere, while the latter had higher score for oiliness over Kabode.

Table 5: Score by Trained Panelists For Factory Processed Crisps

Sweetpotato variety		Appearance Score	Aroma score	Flavour Score	Crispness score	Oiliness Score	Overall score
Kabode	Mean	8.4	7.7	8	8.2	6.8	8.3
	Std. Dev	0.699	1.16	0.816	1.033	1.549	0.483
Terimbere	Mean	5.9	6.7	7.4	8	7	6.7
	Std. Dev	1.101	1.337	1.35	0.667	1.7	0.823

There was considerable variation in scores given by assessors for a given parameter. For appearance, the lowest score was for Terimbere variety with 5 (disliked slightly) while the highest score was 9 (liked extremely). For oiliness, the lowest score was observed for Kabode variety with the score of 3 (disliked much).

Table 6: Variation In Score For Different Parameters For Factory Processed Crisps

		Df	Mean Square	F	Sig.
Appearance Score	Between Groups	1	31.250	36.765	0.000
	Within Groups	18	0.850		
	Total	19			
Aroma score	Between Groups	1	5.000	3.191	0.091
	Within Groups	18	1.567		
	Total	19			
Flavour Score	Between Groups	1	1.800	1.446	0.245
	Within Groups	18	1.244		
	Total	19			
Crispness score	Between Groups	1	0.200	0.265	0.613
	Within Groups	18	0.756		
	Total	19			
Oiliness Score	Between Groups	1	0.200	0.076	0.786
	Within Groups	18	2.644		
	Total	19			
Overall liking score	Between Groups	1	12.800	28.098	0.000
	Within Groups	18	0.456		
	Total	19			

The analysis of variance indicated that there was no significant difference (P >0.05) between the two varieties on the following parameters aroma, flavour, crispness, and oiliness (Table 6). However, there was a significant difference (P <0.05) between the two sweetpotato varieties on appearance and overall liking as per Table 6.

The clear golden yellow crips produced with Kabode were preferred by the panelists, in contrast to the darker, yellow crisps made with Terimbere. These differences are due to the initial colour of the respective variety roots, the frying time, dry matter contents of the varieties. The variety Kabode normally has a higher dry matter content and lower frying time (151 Seconds) compared to variety Terimbere, with a frying time of 171 seconds. Such differences are also seen with the e color and sensory qualities of potato chips, which are influenced by factors, such the potato variety, storage conditions before processing, thickness of the slices, duration of frying, and frying temperature (Islam et al., 2022).

Both varieties had relatively similar score on oiliness as varying between 6 (liked slightly) and 7 (liked moderately). Oiliness was readily evident by the visible residual oil observed on the surface of crisps for both varieties. The oil uptake of fried crips is has been reported to have a substantial and significant inverse correlation with the dry matter content (Kaur et al., 2008).

Figure 8: Sensory Evaluation With Trained Panelists at the University Of Rwanda

5. SECTION II: ROUND TWO OF SENSORY EVALUATION

5.1. Introduction

Roots grown during the second season (season B), from February through June, were analysed using trained panelists. In this second round, the sensory properties of sweetpotato boiled roots, fries, and crisps from the same five OFSP varieties and one yellow variety locally known as Kwezikumwe were evaluated. Combined with the results of Round 1, the results can guide the growing food processing industry in Rwanda on the varieties that best fit the crisps and fries processing as well as for home consumption.

5.2. Methodology

5.2.1. SAMPLE SOURCE

Roots of the five OFSP varieties (Kabode, Terimbere, Irene, Urukundo, and RW-130) were harvested, five months from planting, from a multilocation trial farm on a farmer's field in Musanze District, Northern Province that was managed by the International Potato Center (CIP). The local, yellow-fleshed variety Kwezikumwe was harvested from a different farm on the same site on the same day and had also lasted five months after being planted.

5.2.2. SAMPLE PREPARATION

5.2.2.1. Steamed roots preparation

The same quantity and approximately the same size of roots of each variety harvested a day before processing were washed with clean water, cut into approximately equal pieces of 5 cm long, and steamed on the stove until well-cooked (around 30 minutes).

5.2.2.2. Sweetpotato fries preparation

Roots of approximately the same size were selected, washed, steam blanched for 15 minutes and cut into equal-sized chips of approximately 7 cm long using a manual Cut-a-Chip machine. Chips were then put in pre-heated sunflower oil at 180^{o}C for five minutes. They were then removed from the oil, dried with a paper towel, and put in a clean container for cooling.

5.2.2.3. Sweetpotato crisps preparation

Crisps were processed by Hollanda Fairefoods Ltd, a local crisps processor. Sweetpotato roots of 20 kg of each variety, harvested a day before were manually washed, cut using an automatic cutter, and then fried in preheated oil at 171^{o}C for four minutes. They were then removed from the oil, allowed to cool for 30 minutes, and then packed with nitrogen into a multilayered polyethylene bag and sealed to preserve their quality.

5.2.3. PANEL TRAINING AND SELECTION

A refresher training session was held for the original sixteen (16) panelists who underwent training in April 2023. This refresher course centered on refining their evaluation skills for crisps, fries, and steamed products, while also revisiting the specific topics highlighted in the earlier section.

During this session, a focus group discussion facilitated the development of an updated lexicon encompassing attributes such as appearance, aroma, flavor, oiliness, and crispness. Data were collected during the training aimed to assess the panelists' consistency in utilizing these attributes to differentiate between various varieties.

Following an evaluation test, 13 panelists demonstrated proficiency and were selected to continue conducting sensory evaluations based on their successful performance during the test.

5.2.4. EVALUATION ROOM

The sensory analysis sessions took place at the University of Rwanda's School of Food Science and Technology, specifically within their dedicated sensory evaluation laboratory.

5.2.5. SAMPLE HANDLING AND SERVING SIZE

Samples were transported in a dry container and assigned a unique three-digit code generated through Excel. Panelists engaged in three daily sessions of product evaluation across three consecutive days, dedicating each session to the analysis of a specific product. For crisps and fries, a standardized serving size of 25g was provided, while each panelist received a single serving of steamed root from every variety cut into 4 equal parts, all neatly arranged on individual plates for assessment.

5.2.6. SAMPLE EVALUATION PROCEDURE

For crisps and fries, a method by Dery et al., (2021) was used to analyze 6 sensory parameters namely appearance, aroma, flavor, crispiness, oiliness, and overall liking of the sweetpotato crisps. A 9-hedonic scale was used where liked extremely =9, liked much =8, liked moderately =7, liked slightly =6, neither liked/ nor disliked =5, disliked slightly =4; disliked moderately =3, disliked much =2 and disliked extremely =1

The same method was applied for steamed roots however with five assessment parameters namely appearance, aroma, flavor, texture, and overall liking of the products.

Panelists evaluated all six samples (varieties) per session, and each sample was tasted three times on different days. Panelists were given potable water at room temperature to cleanse their palate before assessing the next sample.

5.2.7. DATA PROCESSING

Data were collected using a pre-designed form and they were subjected to a one-way analysis of variance (ANOVA). The Tukey test was performed at a significance level of 5% to discern differences in means for each sensory attribute.

5.3. Results and discussion

5.3.1. Gender of panelist

A group of 13 panelists, consisting of students from the University of Rwanda, participated in evaluating the products. Among them, 53.85% were female, while 46.15% were male. All of them were between 20 and 30 years old.

5.3.2. ATTRIBUTE SCORES FOR CRISPS

Kabode consistently exhibited the highest scores across all parameters, with Urukundo closely behind (Table 7). Kabode and Urukundo had the same mean scores for the aroma and oiliness attributes. Both varieties consistently outperformed the yellow-fleshed Kwezikumwe across all parameters. In contrast, Terimbere consistently scored the lowest across all attributes.

In terms of appearance, Kabode led with a mean score of 7.88 (±1.033), followed closely by Urukundo at 7.73 (±0.874). Aroma ratings were equal between Kabode and Urukundo, both achieving a score of 7.12, while Kabode also excelled in flavor, scoring 7.15, followed by Urukundo at 7.00 and RW-130 at 6.96 (±0.916).

Kabode demonstrated superior crispiness with a score of 7.73, followed by RW-130 and Irene, both at 7.54. Terimbere's low scores in crisp attributes correlated with its notably low dry matter content (21.0%) and high sugar content (20.37%) compared to Kabode's 24.0% dry matter and 15.6% sugar content. (Musembi et al., 2019)

Table 7: Mean Scores of Crisps Attributes

Variety		Appearance	Aroma	Flavor	Crispness	Oiliness	Overall
RW-130	**Mean score**	7.23	6.96	6.96	7.54	6.56	7.23
	Std. Dev	0.710	0.774	0.916	0.905	0.876	0.765
Urukundo	**Mean score**	7.73	7.12	7.00	7.42	7.44	7.54
	Std. Dev	0.874	0.909	1.131	0.857	0.918	0.905
Irene	**Mean score**	5.35	6.35	6.38	7.54	7.45	6.23
	Std. Dev	1.384	0.797	0.941	1.029	0.897	0.908
Kwezikumwe	**Mean score**	7.04	6.50	6.62	7.50	7.04	6.96
	Std. Dev	1.637	0.990	1.023	1.068	1.021	1.113
Terimbere	**Mean score**	4.69	5.54	5.62	7.08	6.55	5.35
	Std. Dev	1.289	1.174	1.061	1.093	0.992	1.164
Kabode	**Mean score**	7.88	7.12	7.15	7.73	7.44	7.73
	Std. Dev	1.033	0.711	0.967	0.827	0.743	0.827

5.3.3. ATTRIBUTE SCORES FOR CHIPS (FRIES)

Urukundo ranked highest in appearance for fries with a mean score of 7.85 (±0.555), followed by Kabode at 7.46 (±0.776), and Irene at 7.31 (±0.855) (Table 8). However, Kabode was superior to Urukundo in terms of crispiness and oiliness. RW-130 and Terimbere scored lower than the yellow-fleshed Kwezikumwe variety in appearance and overall likeability. Overall, Kwezikumwe had a mean score of 6.92 (±0.954), compared to 5.15 (±0.801) for Terimbere and 4.62 (±1.04) for RW-130.

It appears that panelists felt that the crispiness of sweetpotato fries across all varieties was not as high as they would like, with Kabode and Kwezikumwe obtaining the highest scores, and Terimbere and RW-130 receiving the lowest. Improved frying methods could be investigated to improve crispiness.

Urukundo was preferred the most for fries by panelists, followed by Kabode, Irene, Kwezikumwe, Terimbere, and RW-130.

Table 8: Mean Scores for Sweetpotato Chips (Fries) Attributes

Variety		Appearance	Aroma	Flavour	Crispiness	Oiliness	Overall
RW-130	**Mean score**	4.54	5.62	5.23	3.54	3.89	4.62
	Std. Dev	1.330	1.193	1.363	1.330	0.987	1.044
Urukundo	**Mean score**	7.85	6.77	6.92	5.54	4.54	7.31
	Std. Dev	0.555	0.599	0.954	1.613	0.765	1.032
Irene	**Mean score**	7.31	7.00	6.62	5.15	5.54	6.92
	Std. Dev	0.855	1.155	0.870	1.625	1.014	0.862
Kwezikumwe	**Mean score**	6.92	6.46	6.15	6.38	5.59	6.77
	Std. Dev	0.954	0.776	0.801	1.325	0.786	0.832
Terimbere	**Mean score**	6.23	5.38	5.38	3.77	3.45	5.15
	Std. Dev	1.166	0.768	1.044	1.423	1.143	0.801
Kabode	**Mean score**	7.46	7.00	6.92	6.46	6.10	7.00
	Std. Dev	0.776	0.816	0.862	1.198	0.965	1.291

5.3.4. ATTRIBUTE SCORES FOR STEAMED ROOTS

For steamed roots, Urukundo and Kabode received the highest scores for appearance, with Urukundo leading at 8.00 (±0.913) and Kabode following closely at 7.92 (±1.115) (Table 9). Terimbere scored lower at 7.77 (±1.363) for appearance and 6.38 (±1.121) for texture, attributed to its lower dry matter content compared to other varieties.

Urukundo was the most preferred variety for steamed roots, scoring 7.85 in overall preference, closely followed by Kabode at 7.77. For steamed roots, Irene and RW-130 had mean scores for all attributes above 7, indicating their acceptability to consumers.

Table 9: Means of Scores For Steamed Roots

Variety		Appearance	Aroma	Flavour	Texture	Overall
RW-130	**Mean score**	7.08	7.00	7.00	7.38	7.00
	Std. Dev	0.760	0.707	0.707	0.870	0.707
Urukundo	**Mean score**	8.00	7.31	7.31	7.62	7.85
	Std. Dev	0.913	0.855	1.182	0.650	0.689
Irene	**Mean score**	7.77	7.46	7.46	7.92	7.38
	Std. Dev	1.166	0.877	0.967	0.954	0.961
Kwezikumwe	**Mean score**	6.54	6.62	7.54	7.46	6.85
	Std. Dev	1.506	0.961	0.967	0.877	1.214
Terimbere	**Mean score**	7.77	7.31	7.62	6.38	7.08
	Std. Dev	1.363	1.032	1.044	1.121	1.320
Kabode	**Mean score**	7.92	7.08	7.23	7.92	7.77
	Std. Dev	1.115	0.760	1.166	0.760	0.927

Figure 9: Sweetpotato Roots and Fries Assessed In Round 2 Samples

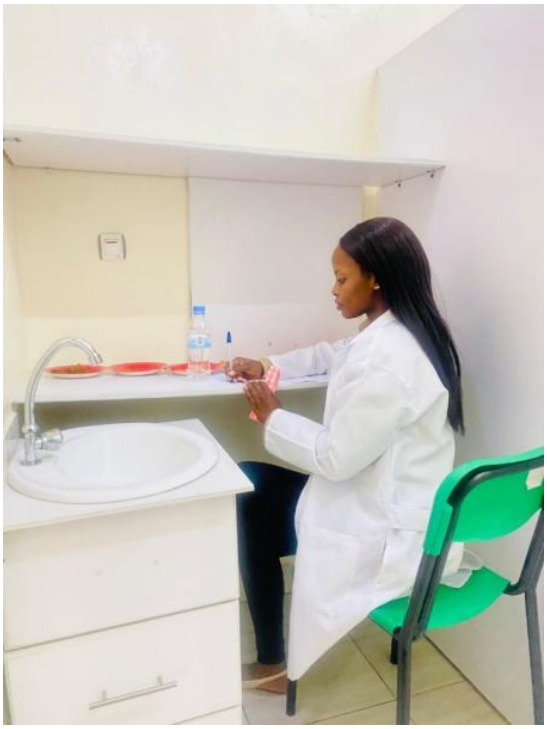

Figure 10: Assessors Tasting Samples

Figure 11: Fries Samples Analyzed During the Second Round

Figure 12: Panelists were awarded certificates for participating in training and conducting sensory evaluation

5.4. Recommendations

Based on the outcomes from both rounds of sensory evaluation, the following recommendations emerge:

- For Sweetpotato Crisps: Kabode and Urukundo OFSP varieties are highly recommended for sweetpotato crisps processing. They exhibited consistently high scores across all attributes studied, particularly excelling in crispiness and appearance.
- Further Studies for Sweetpotato Fries: Additional investigations are advised for the preparation of fries from sweetpotato. This study did not definitively recommend any

variety for fries, as all varieties obtained relatively lower scores, notably in critical attributes like crispiness and appearance.

- Variety for Puree Processing: Terimbere variety can be considered for puree processing due to its low dry matter content. This characteristic adversely affected its scores for crisps and fries attributes in this evaluation. Irene is also recommended for puree as it has been well accepted in other countries for this use.
- Need for More Studies on OFSP Products Using Puree: Further research is required to evaluate the sensory properties of OFSP products processed using puree. This additional investigation aims to better recommend suitable varieties for these specific products.

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