Sensory evaluation and consumer acceptability of white and orange fleshed sweetpotato in Tanzania

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Abstract

The consumer acceptability of orange and white fleshed sweetpotato cultivars was compared for 100 school children (5 to 18 years) and 60 mothers with pre-school children. All were acceptable but there were variations. The orange-fleshed Resisto received the highest scores for acceptability followed by the orange fleshed Karote, then the white fleshed Polista and lastly the white fleshed Sinia B. This trend for acceptability was similar for all of the groups interviewed. The most acceptable cultivars (orange fleshed) were associated with the sensory descriptors watery, pumpkin flavour and orange colour.

There were three variations in acceptability for sweetpotato within the population of school children and mothers. The largest group gave high scores to both orange and white fleshed cultivars suggesting that this group like all forms of sweetpotato. The next largest was more discriminating and gave higher scores for the orange fleshed cultivars compared to white fleshed ones. The third group gave lower scores to the orange fleshed cultivar Karote.

Interviews with the school children suggested a strategy for promoting orange fleshed sweetpotato. Half of the school children were already eating orange fleshed sweetpotato and said they had received information before. This implies that previous promotions were having a positive impact on eating behaviour. However, less than a third of the children mentioned that sweetpotato was their favourite meal, the competing meals were ugali (stiff maize porridge) and rice. Considering pathways for promoting the benefits of growing and eating orange fleshed sweetpotato. The pathways that they wished to receive information in the future differed from how they have previously received it While parents were still rated as important sources of information, extension workers, radio and school teachers were considered more important and ought to be considered as promotion pathways.

Introduction

Sweetpotato (*Ipomoea batatas* (L) Lam) is among the most under-exploited of the developing world's major crops[2, 16]. Traditionally, sweetpotato cultivars consumed in East Africa had a white or cream coloured flesh but new orange coloured flesh cultivars have been introduced that are high in beta-carotene that the body uses to produce vitamin A. Vitamin A deficiency is a leading cause of early childhood death and a major risk factor for pregnant and lactating women. A. A recent ex ante impact case study conducted by economists at the International Potato Center and Michigan State University strongly suggests that 15 million African women and children could benefit from the new orange-fleshed cultivars (insert reference). A complementary field study conducted by the International Center for Women (ICRW) noted that in western Kenya: orange-fleshed sweet potatoes and sweet potato-based food products were acceptable to both producers and consumers in terms of appearance, taste, and texture (Hagenimana et al., 1999). Additionally, the new orange fleshed sweet potato cultivars grown in on-farm trials performed well with respect to yield and pest resistance. One of the principal findings from the study was that African mothers will readily accept the new cultivars, dispelling the popular myth that African taste preferences precluded the use of orange-fleshed cultivars. The study also demonstrated that the daily addition of less than 100 grams of orange-fleshed sweet potato to the diet could prevent vitamin A deficiencies in children, pregnant women, and lactating mothers.

The success of any newly introduced cultivar will depend not only on production characteristics, but also on its acceptability to consumers in terms of both sensory and utilisation characteristics (Kapinga/Rees). Consumer acceptability and sensory evaluation in East Africa has been investigated for the white fleshed cultivar of sweetpotato (Tomlins report, Oirchot, Tomlins et al., 2004) and for orange fleshed sweetpotato (references).

This study will compare the consumer preference of the nutritionally improved orange fleshed sweet potato with those currently available in the market (white fleshed sweet potato). Results of this activity

will enable a more cost effective and focused marketing strategy through identifying the proportion of consumers that prefer the OFSP and how important the nutritional advantages are to purchasing behaviour.

Materials and Methods

Sweetpotato samples
Two white fleshed (Polista, Sinia B) and two orange fleshed (Karote DSM and Resisto) cultivars of sweetpotato were harvested from farms at Mwansonge, Lake Zone.

Cooking of sweetpotato
Roots were sorted to remove diseased and insect damaged ones followed by peeled and cooking in boiling water until soft.

Sensory evaluation
The sensory panel consisted of 12 assessors at the Lake Zone Agricultural Research and Development Institute (LZARDI), Ukiriguru Tanzania. The panel generated descriptive terms for the cooked product using a range of white and orange fleshed sweetpotato cultivars. The descriptive terms were orange colour, creamy colour, pumpkin flavour, watery texture, starchiness, hard texture, coarse texture, yellow colour, fibrous texture and sweet taste.

At each sensory panel session, three cooked sweetpotato samples were coded with three figure random numbers and served in random order. Intensity ratings were scored on a 100 mm unstructured scale, anchored with the terms 'not very' at the low end and 'very' at the high end. Panel sessions were repeated until all samples were scored in duplicate (Tomlins et al 2004). Cooked samples were prepared using the same method as for the consumer testing.

Consumer acceptability
One hundred school children (aged between 5 and 17 years) and 60 mothers with preschool aged children were interviewed in a rural village (Mwasongwe) in the Lake Zone of Tanzania, using the method of central location testing[10 & Tomlins] et al 2004. Consumers were selected on the basis of quota sampling according to age, gender and income status. Every consumer tasted a portion (30 g) of each cooked sweetpotato cultivar (presented in random order and coded with three figure random numbers).

During testing, fresh samples were prepared hourly. Roots were peeled and cut into roughly equal sized portions (5 to 10 cm) and boiled until the texture, assessed by a fork, was considered correct for eating.

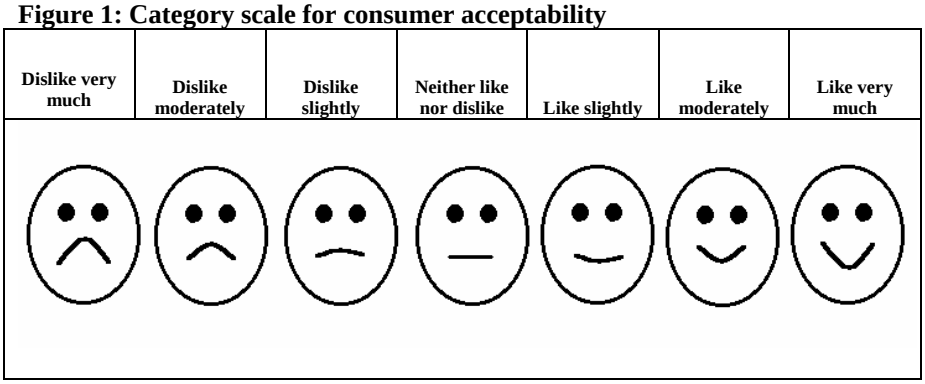
Interviews, lasting approximately 30 minutes, were conducted using a simple questionnaire. This elicited information on the following issues:

- School age children – Gender, Age, consumption of sweetpotato, knowledge of benefits of eating sweetpotato, awareness of orange-fleshed sweetpotato and how they would like to receive more information promoting orange fleshed sweetpotato.
- Mothers with preschool age children – Age, employment, income status, number of children, achieved level of education, consumption of sweetpotato with respect to self and for children, purchasing patterns for sweetpotato, knowledge of benefits of eating sweetpotato, awareness of orange-fleshed sweetpotato and how they would like to receive more information promoting orange fleshed sweetpotato.

Permission from the school and the children's parents was sought for all children being interviewed. Parents could be present during the interview of their child if they wished and were informed that several adults would be supervising. At interview, the interviewer explained to the children that their participation was entirely voluntary, that they could stop the interview at any point and that the responses would be anonymous. Similarly, the interviewer explained to the mothers that their participation was entirely voluntary, that they could stop the interview at any point and that the responses would be anonymous. The mothers were with their children at all times.

Children and mothers scored the acceptability of the cooked sweetpotato using the category scale in figure 1.

Figure 1: Category scale for consumer acceptability



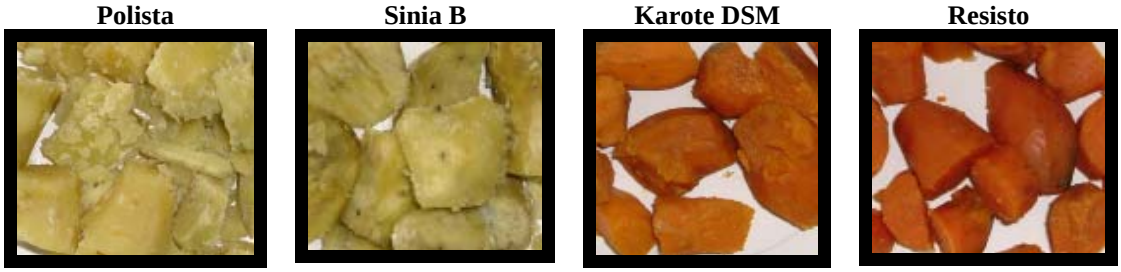
Statistical Analysis
Analysis of variance, Kruskal-Wallis test, Wilcoxon signed ranks, cluster analysis (agglomerative hierarchical cluster, Euclidean distance, Wards method), principal component analysis (covariance matrix) and discriminant analysis were carried out using SPSS (V 10.0.5) or XLSTAT (V 5.2, Addinsoft).

Results and Discussion

The appearance of the cooked roots from each cultivar (Polista, Sinia B, Karote DSM and Resisto) differed as illustrated in figure 2 with the orange fleshed cultivars having the higher pro-vitamin A content. These cooked roots were evaluated by the following:

a) Sensory panel to determine the sensory properties of the cooked roots under controlled conditions using descriptors determined by the panel comprising 12 trained experts;
b) Consumer acceptability by 100 school children in rural areas aged between 5 and 19 years to determine acceptability of the roots, social factors associated with acceptability and ways of promoting orange fleshed sweetpotato;
c) Consumer acceptability by 60 mothers and pre-school children in rural areas to determine acceptability of the roots, social factors associated with acceptability and ways of promoting orange fleshed sweetpotato;

Figure 2: Visual appearance of white and orange fleshed cultivars of cooked sweetpotato



Sensory evaluation
Focus groups (figure 3) comprising the panellists were used to generate the sensory descriptor used by the sensory panel. The sensory descriptors derived were orange colour, creamy colour, pumpkin flavour, watery texture, starchiness, hard texture, coarse texture, yellow colour, fibrous texture and sweet taste. Cooked sweetpotato samples were scored by the panellists (figure 4) using the descriptive terms.

Figure 3: Sensory panel collectively agreeing the sensory descriptors

Figure 3: Sensory panellist scoring the sweetpotato samples

ANOVA indicated that the panel could discriminate ($P<0.05$) between the cultivars with respect to orange colour, creamy colour, pumpkin flavour, watery texture, starchiness and hard texture (table 1). The panel could not discriminate with respect to course texture, yellow colour, fibrous texture and sweet and these were not included is subsequent analysis.

Table 1: F values and probabilities for each sensory descriptor

Sensory descriptor	F	Sig.
Orange colour	96.026	.000
Creamy colour	48.117	.000
Pumpkin flavour	47.210	.000
Watery texture	23.781	.000
Starchiness	23.189	.000
Hard texture	4.172	.012
Coarse texture	.893	.454
Yellow colour	.747	.531
Fibrous texture	.752	.528
Sweet taste	.539	.659

The means table (table 2) along with the least significance difference test (lsd) suggests that the characteristics of each cultivar were:

- Resisto – most orange, pumpkin and watery and least starchy, hard and creamy.
- Karote – most orange, intermediate pumpkin, watery, starchy and hard and least creamy.
- Polista and Sinia B – most starchy, creamy and hard and least orange, watery and pumpkin.

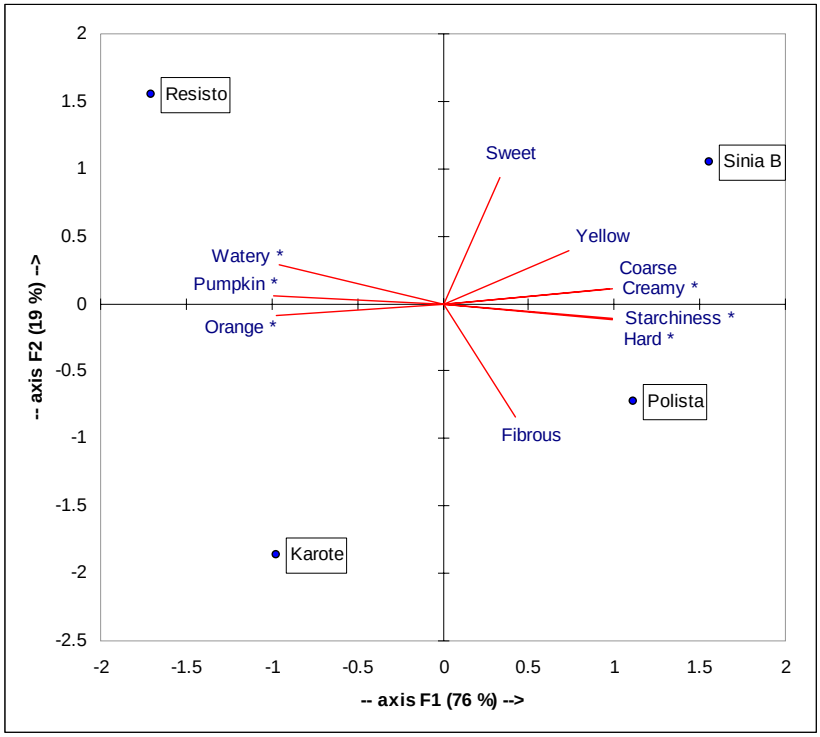
Table 2: Mean values for each sensory descriptor and sweetpotato cultivar

Sweetpotato cultivar	**Creamy****	**Orange****	**Watery****	**Pumpkin****	**Starchiness****	**Hard***	**Yellow**	**Sweet**	**Coarse**	**Fibrous**
Resisto	2.8a	94.9a	80.0a	91.8a	20.3a	9.7a	27.9	67.4	26.0	34.3
Karote	2.1a	93.6a	43.6b	70.3b	40.7b	23.6b	29.8	72.2	41.4	29.1
Polista	73.1b	5.4b	9.0c	1.6c	83.6c	47.3c	27.0	76.9	24.1	16.9
Sinia B	69.8b	9.4b	9.2c	1.8c	85.1c	50.3c	49.8	80.0	44.8	28.4

Where ** = significantly different at $P<0.01$, * = significantly different at $P<0.05$

The relationship between the sensory descriptors and the sweetpotato cultivars is illustrated in the principal component plot in figure 5. This shows that the sensory attributes creamy, starchiness and hard are highly correlated and inversely correlated to watery, pumpkin flavour and orange and yellow colour. Sweet and fibrous were not highly correlated. The sweetpotato cultivars were in each quadrant of the graph. Sinia B was in the right-hand top quadrant and associated most strongly with creamy, coarse, yellow and sweet. Polista, in the right-hand bottom quadrant was associated with starchiness, hard and fibrous. Karote (bottom left-hand quadrant) was associated with orange and inversely associated with sweet and to a lesser degree yellow colour. Resisto (top left-hand quadrant) was associated with watery, pumpkin, orange and inversely with fibrous.

Figure 5: Principal components plot illustrating relationship between sensory descriptors and sweetpotato cultivars



*Where * = significantly different at P<0.05*

Consumer acceptability of white and orange fleshed sweetpotato

The cooked sweetpotato cultivars were evaluated by 100 school children (figure 6) and 60 mothers with preschool age children (figure 7).

Figure 6: School children participating in consumer acceptability study

Figure 7: Mothers with preschool children participating in consumer acceptability study

School children

The school children were individually interviewed to determine their attitude to sweet potato and ask how they would like to receive more information promoting orange fleshed sweet potato. The results are summarised in table 3.

Ninety four children were interviewed of which half were female and most were aged between 10 to 15 with a mean age of 12 and a minimum of 5 and maximum of 18. The number eating white fleshed and orange fleshed sweetpotato was of equal proportions and most consumed sweetpotato every week (70%) and to a lesser extent every day (30%). The majority (82%) ate sweetpotato in the boiled form and others roasted (17%). While all said that they liked eating sweetpotato, the most favourite meal mentioned was ugali (stiff maize porridge; 38%), followed by rice (34%) and then sweetpotato (28%). The fact that sweetpotato was their third choice suggests that if children are to increase their intake of

vitamin A through consumption of orange fleshed sweetpotato that their parents need to control their eating patterns to ensure they eat sufficient to have an impact on their health.

Half of the children said they were not aware of the benefits of eating sweetpotato although 70% said that they had received information. Nonetheless, the response was high suggesting that previous promotion campaigns had made an impact. The majority of children said they received information about the benefits of sweetpotato through their parent (62%), followed by extension workers (14%), radio (11%), relatives (6%), school teachers (5%) and friends (3%). The majority of children said they would like to receive more information about sweetpotato. The pathways that they wished to receive information, however, differed from how they have previously received information. While parents are still rated as important sources of information, extension workers, radio and school teachers were considered important and ought to be considered as promotion pathways.

Table 3: Responses of children to interviews on attitudes to sweet potato and promotion

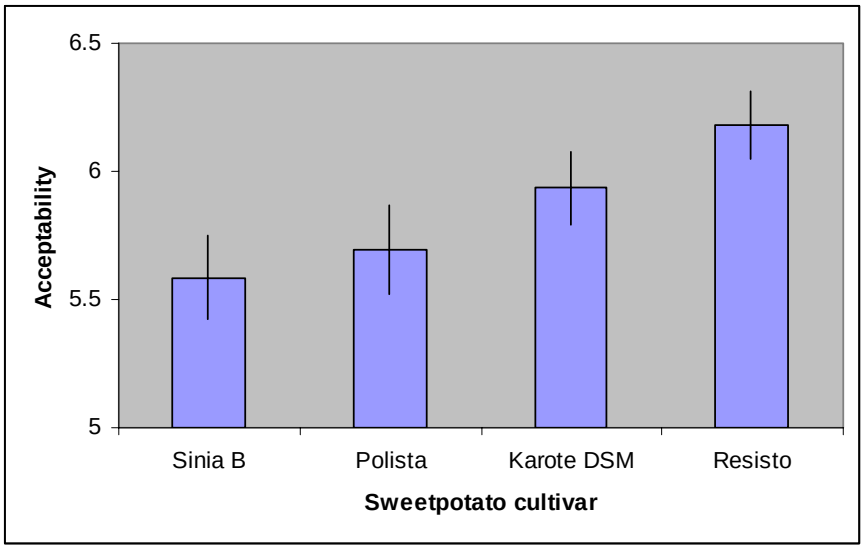
Question / observation	**Consumer response (%)**				
Gender	Male	Female			
	51	49			
Age	<10	10 to 15	>15		
	24	65	11		
What type of sweetpotato do you eat? (tick all that apply)	White	Orange			
	50	50			
How often do you eat sweetpotato?	Every day	Every week	Every month	Rarely	Never
	28	70	0	3	0
In what form do you eat sweetpotato? (tick all that apply)	Boiled	Roasted	Raw	Mashed	Other
	82	17	0	0	1
What is your favorite meal?	Ugali	Rice	Sweet potato		
	38	34	28		
Do you like eating sweetpotato?	Yes	No			
	100	0			
Are you aware of the benefits of eating orange fleshed sweetpotato?	Yes	No			
	48	52			
Have you received information promoting orange fleshed sweetpotato before?	Yes	No			

	70	30							
If yes, how (tick all that apply)?	Parents	School teachers	Relatives	Friends	Extension workers	Spiritual leaders	Radio	Public meetings	Other
	62	5	6	3	14	0	11	0	0
Would you like to know more about sweetpotato?	Yes	No							
	89	4							
If you were to receive more information about sweetpotato, which would be best for you?	Parents	School teachers	Relatives	Friends	Extension workers	Spiritual leaders	Radio	Public meetings	Other
	36	16	0	1	28	0	15	4	0

School children - Determining if the acceptability of the sweetpotato cultivars differed
Acceptability was scored under the supervision of the trained interviewer (figure 8). Considering the school children, the acceptability of the sweetpotato cultivars was significantly different (Kruskal-Wallist; P = 0.02). The means are illustrated in figure 9. While all cultivars were considered acceptable by the children, the white fleshed ones (Sinia B and Polista) had the lowest scores for acceptability while the orange-fleshed, in particular Resisto, had the higher scores.

Figure 8: Trained interviewer supervising child scoring sweetpotato for acceptability

Figure 9. Mean acceptability scores for children tasting cooked sweetpotato.

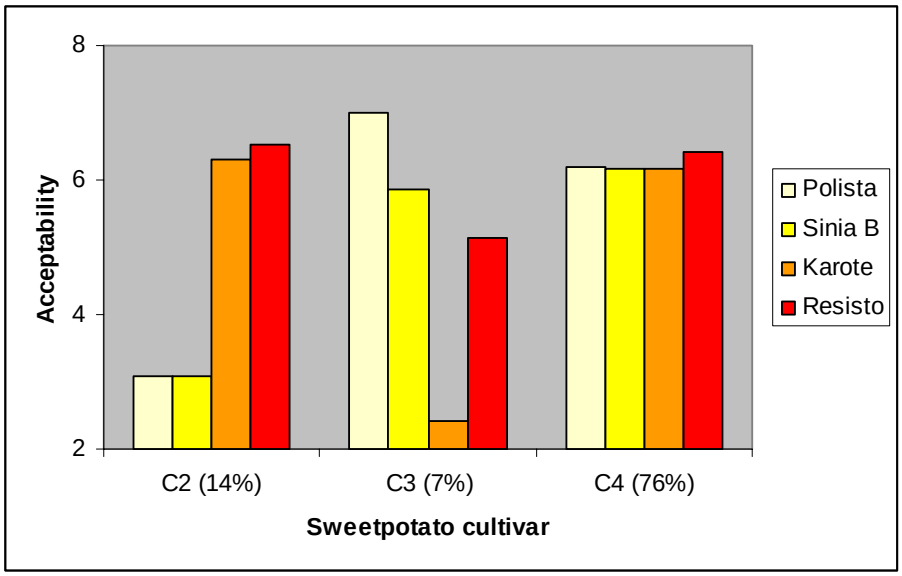


The clear liking for the orange fleshed varieties along with the fact that orange flesh sweet potato had recently been promoted raised the question as to whether the school children had become biased. To test this, the results were divided into two groups based on responded to the questions asked at interview being 'Are you aware of the benefits of eating orange fleshed sweetpotato?' and 'Have you received information promoting orange fleshed sweetpotato before?' Of the 80 children who responded to these questions, 56 answered yes and 24 answered no. Considering these different groups, the Kruskal-Wallis test showed that the acceptability scores for the sweetpotato cultivars tested did not differ. Therefore, although some children had received knowledge through promotion, the acceptability had not become biased.

Determining if the school children score the sweetpotato cultivars in the same way
Hierarchical cluster analysis (Wards method) indicated three clusters or groups of consumers with similar acceptability patterns for the sweetpotato cultivars (a forth cluster was discounted because their acceptability was very different from the rest indicating incorrectly filled in score sheets). The mean acceptability of the three other clusters is illustrated in figure 10. Children in the largest cluster (C4; 76% of children) gave high acceptability scores for both white and orange fleshed sweetpotato cultivars. The next largest cluster (C2; 14% of children) scored the orange fleshed sweetpotato highly but found the white fleshed cultivars less acceptable. The smallest group (C3; 7% of children) gave higher scores for all the cultivars apart from Karote. The children in cluster 3 tended to consume sweetpotato the least often and were the least aware of the advantages of eating sweetpotato compared to the school children belonging to the other clusters. This might explain why they gave lower scores for the orange fleshed cultivar Karote. However, the number of school children in this cluster was only 7% and small compared to the other clusters.

Considering the orange-fleshed cultivars, the cluster analysis results are very encouraging. In particular Resisto was given high acceptability scores by children in all clusters. Karote also received high scores apart from 7% of children in cluster 3. This suggests that the orange-fleshed sweetpotato cultivars, in particular Resisto, will be readily accepted by these children.

Figure 10: Children: Mean acceptability scores for sweetpotato cultivars with respect to three clusters of similar acceptability.



Analysis of mother-child pairs for acceptability of white and orange fleshed sweetpotato

Mothers with preschool age children were individually interviewed to determine their attitude to sweet potato and ask how they would like to receive more information promoting orange fleshed sweet potato (figure 11).

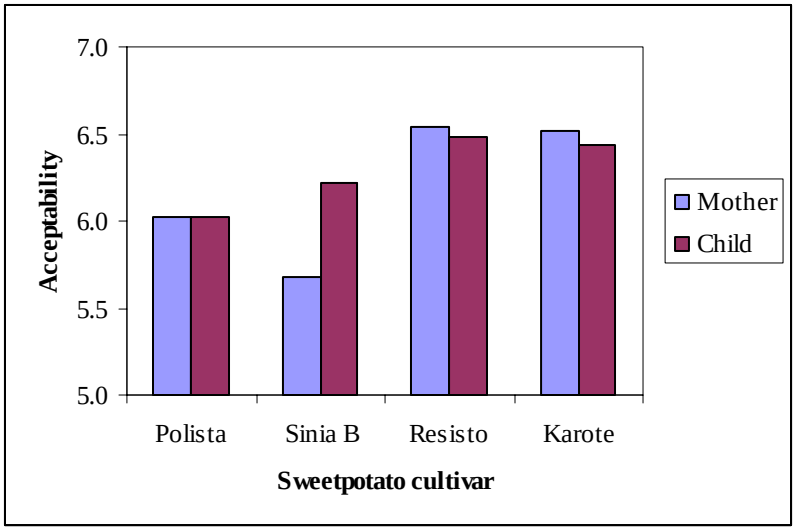
Figure 11: Mother with preschool age children being interviewed by a trained member of the project team

Determining if the acceptability of the sweetpotato cultivars differed with respect to mothers and their children

The mothers scored the acceptability of the sweetpotato cultivars and also indicated how acceptable each cultivar would be to their children (figure 12). The mean acceptability of the sweetpotato cultivars scored for their own personal consumption differed from how they scored for their children (Kruskal-Wallis; $P<0.01$ and $P=0.028$). The means are illustrated in figure 13. For both the mothers and children, the most acceptable cultivars were the orange fleshed ones (Karote and Resisto) which were similar in acceptability. The acceptability of the mother and children differed for the white fleshed cultivars; for the children Sinia B was the least acceptable while for the mothers it was Polista.

Figure 12: Mother with child scoring the acceptability of the sweetpotato cultivars

Figure 13: Mean acceptability scores for sweetpotato for mothers and for their children



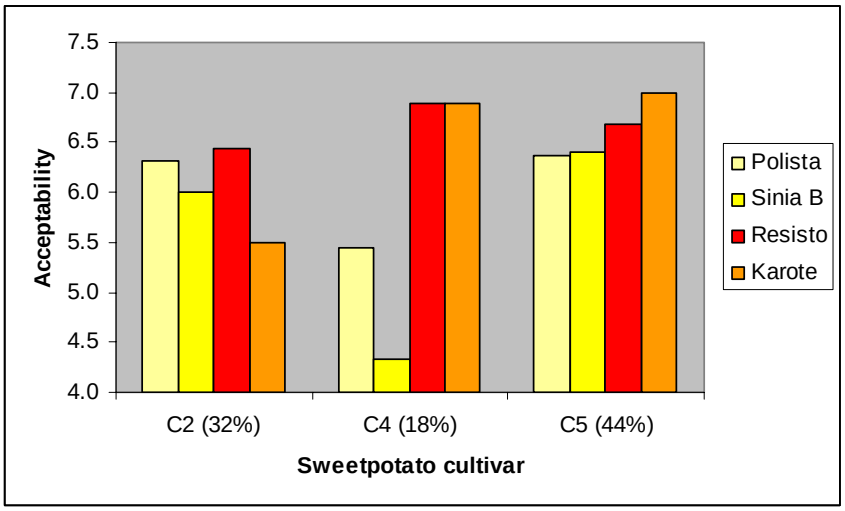
Since the mother and their children scored the acceptability of the cooked sweetpotato together, the Wilcoxon signed ranks test was used to determine if the pairing for each cultivar differed. The test showed that only the scores for Sinia significantly differed (P=0.017) and this supports that found by the Kruskal-Wallis test.

Do all the mothers and their children score the sweetpotato cultivars in the same way?
Hierarchical cluster analysis (Wards method) was used to separate the consumers into different groups of acceptability for sweetpotato.

Mothers
The mothers belonged to three clusters (two additional clusters accounting for 3% of respondents were rejected because the trends were very different from the remained suggesting improperly completed forms). The means for the three main clusters that accounted for 32%, 18% and 44% of respondent respectively is given in figure 14. Cluster 5 was the largest accounting for 44% of respondents followed by C2 (32%) and C4 (18%). Resisto scored high for acceptability for all clusters but the clusters differed with respect to acceptability of the other three cultivars. Cluster 5 was comprised of respondents who gave all cultivars high scores for acceptability. Respondents in cluster 2 gave higher scores for Polista, Sinia B and Resisto but lower scores for Karote. Respondents in cluster 4 gave higher scores for the orange fleshed and lower for the white fleshed, in particular Sinia B.

This implies that the new orange fleshed cultivars, in particular the Resisto are acceptable to all clusters of the mothers but the orange fleshed Karote, although acceptable, did not score as well as the other cultivars (white and orange fleshed) for 32% of respondents.

Figure 14: Mothers: Mean acceptability scores for sweetpotato cultivars with respect to three clusters of similar acceptability



Differences in acceptability between the mothers and school children

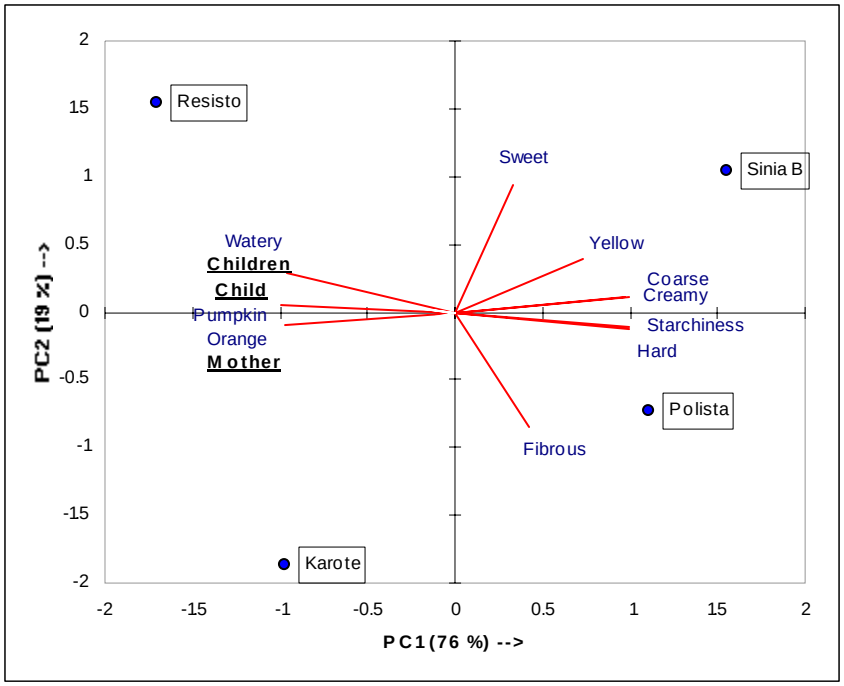
The acceptability scores for the mothers and children differed (ANOVA; $P<0.001$). The mothers giving the sweetpotato cultivars higher scores than the children. The absence of a significant interaction (ANOVA; $P=0.510$) shows that the order of preference, however, was the same.

Relating consumer acceptability of school children and mothers and pre-school children with the sensory panel scores

Internal preference mapping (Tomlins rice paper and others) was used to indicate how consumer acceptability related to the mean scores for the sensory descriptors used by the sensory panel. The means for the consumer acceptability were not included in the calculations but were included as supplementary or passive observations so that they could be included in the plots with the active consumer variables.

The internal preference PCA plot, accounted for 95% of the variability (figure 15) and was based on the mean sensory descriptors. Most sensory descriptors were in the direction of PC1 (76% of variability) and this is also the direction along which the white fleshed and orange fleshed cultivars were separated. The means of the consumer acceptability for the school children, mothers and their children are associated with the sensory descriptors water, pumpkin and orange and the orange fleshed sweetpotato cultivars Resisto and Karote. Consumer acceptability was negatively associated with the sensory descriptors hard, starchiness, coarse, creamy and yellow and the white fleshed sweetpotato cultivars Sinia B and Polista.

Figure 15: Internal preference map illustrating relationship between sensory descriptors and mean consumer acceptability for school children and mothers with pre-school age children.



Conclusions

The orange and white fleshed sweetpotato cultivars were acceptable to 100 school children (5 to 18 years) and 60 mothers with pre-school children. Of the cultivars, the orange-fleshed Resisto received the highest scores for acceptability followed by the orange fleshed Karote, then the white fleshed Polista and lastly the white fleshed Sinia B. This trend for acceptability was similar for all of the groups interviewed. The most acceptable sweetpotato cultivars were associated with the sensory descriptors watery, pumpkin flavour and orange colour and these are associated with orange fleshed sweetpotato.

There were three variations in acceptability for sweetpotato within the population of school children and mothers. The largest group (76% school children and 54% mothers) gave high scores to both orange and white fleshed cultivars suggesting that this group like all forms of sweetpotato. The next largest group (14% school children and 18% mothers) were more discriminating and gave higher scores for the orange fleshed cultivars compared to white fleshed ones. The third group (7% school children and 32% mothers) did not give high scores to the orange fleshed cultivar Karote.

Interviews with the school children suggested a strategy for promoting orange fleshed sweetpotato. Half of the school children were already eating orange fleshed sweetpotato and said they had received information before about sweetpotato. This implies that previous promotions were having a positive impact on eating behaviour. However, less than a third of the children mentioned that sweetpotato was their favourite meal, the competing meals were ugali (stiff maize porridge) and rice. Considering pathways for promoting the benefits of growing and eating orange fleshed sweetpotato. The pathways that they wished to receive information in the future differed from how they have previously received it While parents were still rated as important sources of information, extension workers, radio and school teachers were considered more important and ought to be considered as promotion pathways.

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