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Application of consumer preference and sensory evaluation to sweetpotato research in East Africa

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Abstract. Sweetpotato is a major staple food and income source in several regions of Tanzania and other countries of sub-Saharan Africa. Research, funded by DFID Crop Post Harvest Programme, has sought to expand the potential for introducing improved cultivars, extend the storability of sweetpotato at the farm and prolong the shelf-life during marketing. Consumer preference and sensory evaluation can play an important role in these research projects and has been applied at the rural village level. This paper explores the sensory and consumer approaches developed and applied and outlines some of the statistical tools used to analyse and interpret the results. For example, in cultivar selection, sensory panels and consumer preference studies have been used to investigate regional and seasonal variations in the preference and sensory characteristics of sweetpotato cultivars. Models were developed to relate sensory attributes used by a trained panel to consumer preference. In other studies, simple techniques were developed for use by farmers so that sweetpotato could be evaluated under field conditions. Implications and approaches for future research are discussed.

Introduction

Sweetpotato is an important food crop in much of sub-Saharan Africa where annual production is estimated to be 9.9 million tonnes. The crop is often considered to be a 'poor person's food' which can lead to the sensory and preference criteria of sweetpotato to be under represented and neglected. This paper discusses consumer preference and sensory evaluation approaches developed and applied in East Africa within collaborative projects involving Natural Resources Institute, University of Greenwich at Medway, UK and the Lake Zone Agricultural Research and Development Institute, Tanzania with inputs from the Kenyan Agricultural Research Institute, Kenya.

Discussion

This discussion indicates how consumer acceptability and sensory evaluation has been applied to sweetpotato in East Africa. Consumer testing has involved the evaluation of suitable methods for rapidly assessing preference in rural and urban locations. Detailed understanding of the sweetpotato cultivars was provided by a sensory panel that enabled models to be developed that can be used by those selecting local sweetpotato cultivars for quality (Rwiza *et al.,* 2000; Tomlins *et al.,* 2003ab). Sensory evaluation has also been applied to understanding sensory changes during shelf-life studies (Anon 2002; Oirschot *et al*., 2003). Simpler sensory evaluation approaches have been used by rural farmers in Tanzania to compare simple methods for storing fresh sweetpotato

roots under tropical conditions (Anon 2002; Tomlins *et al* 2003c).

Case Study 1. Linking trained sensory panels to consumer preference to simplify cultivar selection.

Little has been reported on the use of trained sensory panels in the selection of sweetpotato cultivars in East Africa. Consumer testing requires interviewing at least 100 consumers which makes it time consuming and expensive. In East Africa, consumers in rural locations may be remote and vary in literacy and education. Simplified methods for rapidly measuring consumer acceptability in both rural and urban locations in Tanzania have been assessed (Rwiza *et al.*, 2000; Tomlins *et al.*, 2003ab). One investigated by NRI was the ranking method (ISO reference) and a simpler approach based on asking the consumer to say which of the sweetpotato cultivars they prefer the most.

Use of ranking methods in consumer preference and linking preference with socio-economic profiles of consumers. Rankings (ISO 1988) can be used to assess the consumer acceptability of several samples at the same time. In 1998, a total of 300 consumers equally divided between three locations Mwanza, Meatu, and Misungwi in the Lake Zone, Tanzania ranked the acceptability of locally available sweet potato cultivars. The cultivars were locally grown and those available in the markets at the time of sampling. This meant that the varieties available differed from year to year although certain 'core' varieties (Polista, Sinia B and SPN/0) were consistently available. The Friedman's test indicated that the acceptability of the cultivars significantly differed at each location (Table 1).

At the three locations where a total of 300 consumers were interviewed, the cultivars with consistently high ranks for acceptability were Polista and SPN/O. Ngosha, Toniki and Ngikuru were also highly ranked but were only assessed once because they were local to these locations. The cultivar Sinia B was highly ranked by consumers at Mwanza but locally available versions at Meatu and Misungwi were ranked low as were Serena, Ipembe and Nguruka. The ranks for each consumer can be compared with socio-economic data collected at interview. The Kruskall-Wallis test showed that at Meatu female consumers significant ranked SPN/O (P=0.044) and Ipembe (P=0.044) cultivars as more preferred while men ranked these as least preferred. At Misungwi Sinia B (P=0.013) was significantly more preferred by women. Consumers who ate sweetpotato least often most preferred SPN/O at Meatu (P=0.023) and Misungwi (P=0.057).

Rapid and simple method for measuring consumer preference. A simpler and more

Table 1: Rank sums of preference of sweet potato cultivars by consumers at Mwanza.

Rank order	Mwanza (100 consumers)	Meatu (100 consumers)	Misungwi (100 consumers)
1	Polista (350)a	SPN/0 (500)[a]	Ngikuru (457)a
2	Sinia B (337)a	Ngosha (420)[b]	SPN/0 (388)b
3	SPN/0 (315)a	Polista (410)[b]	Polista (351)b
4	Mzondwa (256)b	Serena (299)[c]	Toniki (350)b
5	Bilagala (242)b	Sinia B (255)[c]	Sinia B (283)c
6		Ipembe (187)[d]	Nguruka (249)c
F value	37.6	221.4	79.4
LSD (P=0.05)	43.8	51.3	51.6

Where: number in brackets is the rank sum, a, b or c donates grouping with respect to the least significant difference using the Friedman's test.

rapid method than ranking was evaluated (Tomlins *et al*., 2003a). Using the data from the consumer in 1998, the rank sum for a cultivar and the percent of consumers who gave it the highest rank (assumed to indicate it was the consumer's most preferred cultivar) were compared. The relationship is illustrated in figure 1 using cultivars tested at Meatu. The correlation coefficients of 0.872, 0.954 and 0.953 obtained for comparisons at Mwanza, Meatu and Misungwi respectively indicated that the simpler method was comparable to the ranking method and suitable for use with consumers in Tanzania. The first choice preference approach to consumer testing was used to evaluate sweetpotato cultivars tested in 1998 and 2000 seasons at Mwanza, Meatu and Misungwi. The cultivars were locally grown and those available in the markets at the time of sampling. This meant that the varieties available differed from year to year although certain 'core' varieties (Polista, Sinia B and SPN/0) were consistently available. The percentages of consumers for whom each cultivar was the first preference are given in Table 2. While not all cultivar were available locally at each location, the two cultivars that were consistently the first choice were Polista and SPN/O.

Linking consumer preference and sensory evaluation in developing models for cultivar selection. A sensory panel scored the sweetpotato cultivars assessed by consumers in 1998 and 2000 in Mwanza, Meatu and Misungwi. This enabled the comparison of locational and seasonal effects in addition to giving a more detailed sensory assessment of the samples.

A sensory panel using Quantitative Descriptive Analysis (Meilgaard *et al*., 1987; Bainbridge *et al*., 1996, Tomlins 1998) used 11 sensory attributes to describe the appearance, taste and texture. Cluster analysis (Hierarchical Cluster Analysis, Wards Method, Euclidean distance) of the sensory attributes for the combined years identified three groups of cultivars according to similarity of sensory properties (Figure 2). Cluster 1 was comprised mainly of cultivars that were named as the most preferred by a relatively small percentage of consumers (on average only 19% preferred these the most). The cultivars within this cluster were predominantly Mzondwa (98 and 00), Serena (98 and 00) and Sinia (98). Cluster 2 was comprised entirely of the cultivars from Misungwi (00) and suggests a locational effect for that year (on average 36% preferred these

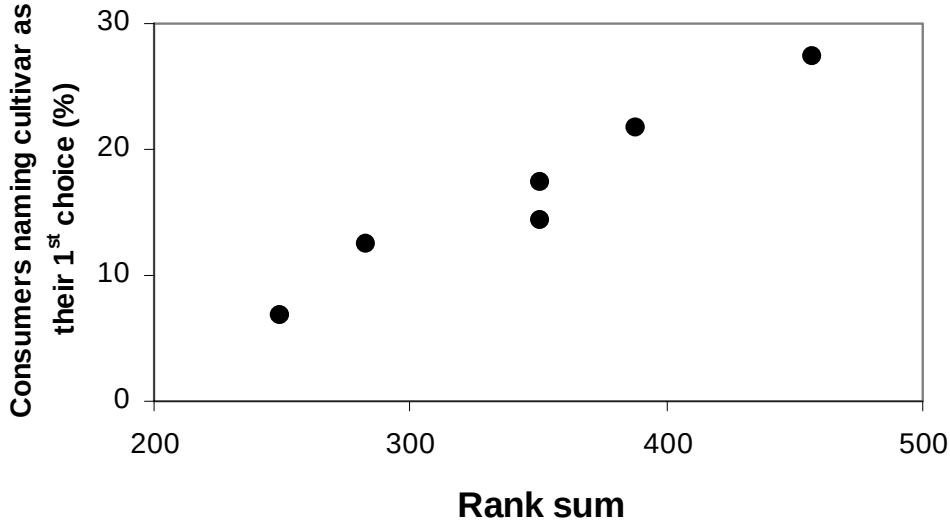

Figure 1: Relationship between first preference choice (%) and rank sum for cultivars evaluated by consumers at Meatu.

the most). Cluster 3 was comprised of cultivars that were most preferred by the largest percentages of consumers (on average 47% consumers preferred these the most), and consisted of Polista and SPN/0 from both years and Sinia B for year 2000.

Considering cultivar and seasonal differences, all Polista and SPN/0 cultivars, were in cluster 3 and all Mzondwa and Serena cultivars, were in cluster 1. Therefore, these cultivars had similar sensory characteristics even though they were grown at different locations and seasons. However, certain cultivars appear to differ in sensory characteristics from year to year and with location, for example Sinia B was in cluster 3 in 1998 but generally in cluster 1 in 2000. Similarly, the same was noted for Ngikuru A. For some cultivars (Ipembe, Ngosha, Bukoli, and Hudi Shinyanga), it was not possible to draw conclusions because they were only tested once.

Table 2: Consumer preference (based on first choice preference) of sweetpotato cultivars evaluated at Mwanza, Meatu and Misungwi Values in brackets refer to the percent of consumers for whom the cultivar was their first preference.

	Mwanza		Meatu		Misungwi	
Liking	1998	2000	1998	2000	1998	2000
1 (most)	Polista (54)	SPN/0 (56)	SPN/0 (77)	Polista (79)	Ngikuru (57)	SPN/0 (57)
2	Sinia B (52)	Sinia B (47)	Ngosha (51)	Sinia B (67)	SPN/0 (45)	Sinia B (52)
3	SPN/0 (42)	Polista (39)	Polista (42)	SPN/0 (47)	Polista (36)	Polista (50)
4	Mzondwa (28)	Mzondwa (8)	Serena (19)	Serena (5)	Toniki (30)	Bukolu (14)
5	Bilagala (18)	Bilagala (6)	Sinia B (6)	Sinia B (26)		Hudi Shinyanga (6)
6 (least)			Ipembe (3)		Nguruka (14)	Ngikuru (3)

Figure 2: Dendrogram illustrating hierarchy of clusters of sweetpotato cultivars with respect to their sensory attributes.

Where:
M = Mzondwa, SP = SPN/0, Sin = Sinia B, Ser = Serena, B = Bilagala, P = Polista, Ngik = Ngikuru, Mwz = Mwanza, Mis = Misungwi, Mtu = Meatu.

Principle component analysis (PCA) was used to evaluate the relationship between the cultivars tested in each season and region (figures 3 and 4). PC1 and PC2 accounted for 44% and 34% of the variability respectively. The clusters are clearly divided into three groups with cluster 2 being the most distinct (figure 3). Boundaries drawn to each outer point in each cluster are included to assist in the interpretation. Cluster 1 is predominantly in the left-hand quadrant, cluster 2 in the upper right-hand quadrant and cluster 3 in the lower left-hand quadrant. Comparison with Figure 4 confirms the findings described above. Thus, cluster 1 is mostly associated with cultivars that score low for the majority of the sensory attributes. Cluster 2 is associated with sweetpotatoes that score

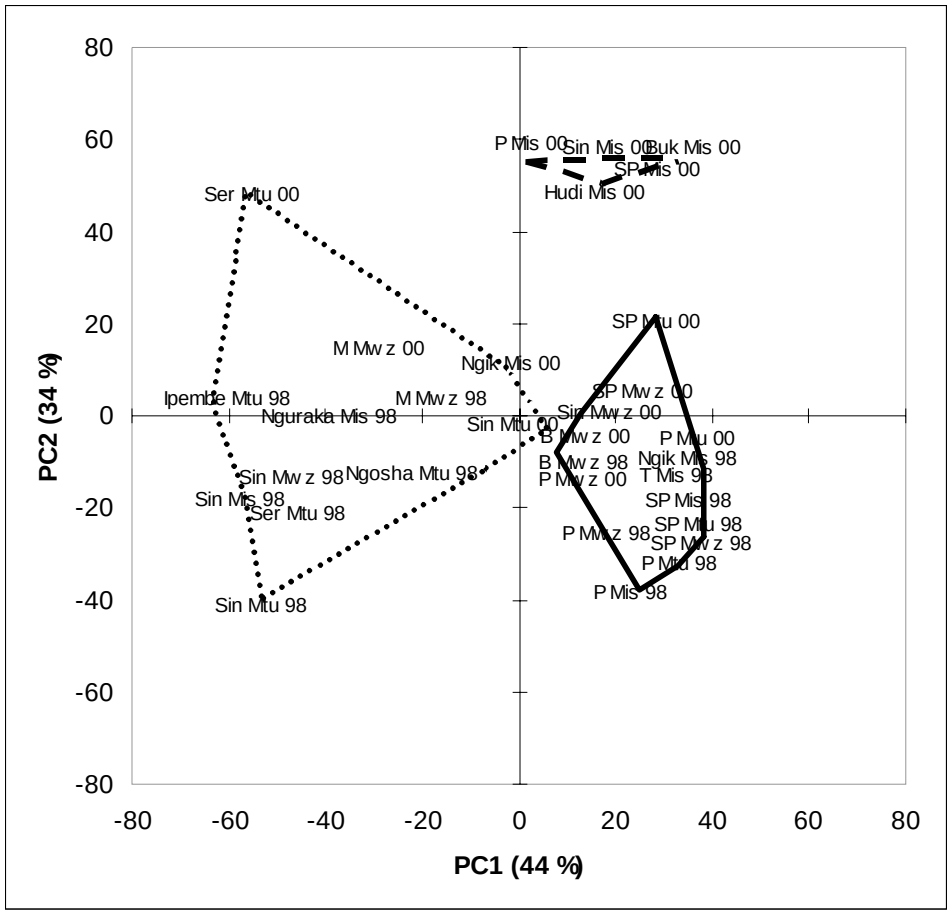

Figure 3: Principal component plot showing spacing of sweetpotato cultivars.

Where:
M = Mzondwa, SP = SPN/0, Sin = Sinia B, Ser = Serena, B = Bilagala, P = Polista, Ngik = Ngikuru, Mwz = Mwanza, Mis = Misungwi, Mtu = Meatu.
Cluster 1 = cultivars within the dotted line;
Cluster 2 = cultivars within the broken line;
Cluster 3 = cultivars within the continuous line.
Points are not included but would be located at the centre of each cultivar name in the plot
Boundaries illustrate the extent of each cluster.

higher for stickiness, texture, chewiness, internal colour, external colour, appearance and odour. Cluster 3 is related to sweetpotato that scores highly for internal and external colour, appearance, odour, sweetness, taste and starch.

Samples of the same cultivar tended to be clustered together. SPN/0 and Polista were in the right hand quadrants in both years while Mzondwa and Serena were consistently in the left-hand quadrants. This implies that for these cultivars, the sensory characteristics are broadly similar from year to year and not influenced by location where they were grown. Sinia B, however, was in the lower left-hand quadrant in 1998 but in the right hand quadrant in 2000. The cultivars from Misungwi in 2000 were generally more sticky, chewy and scored higher for texture. It is not clear why these cultivars differed, although climatic differences and differences in storage by the traders are likely to have contributed.

Developing a model for selecting optimum sensory characteristics for selection for sweetpotato. Screening programmes often

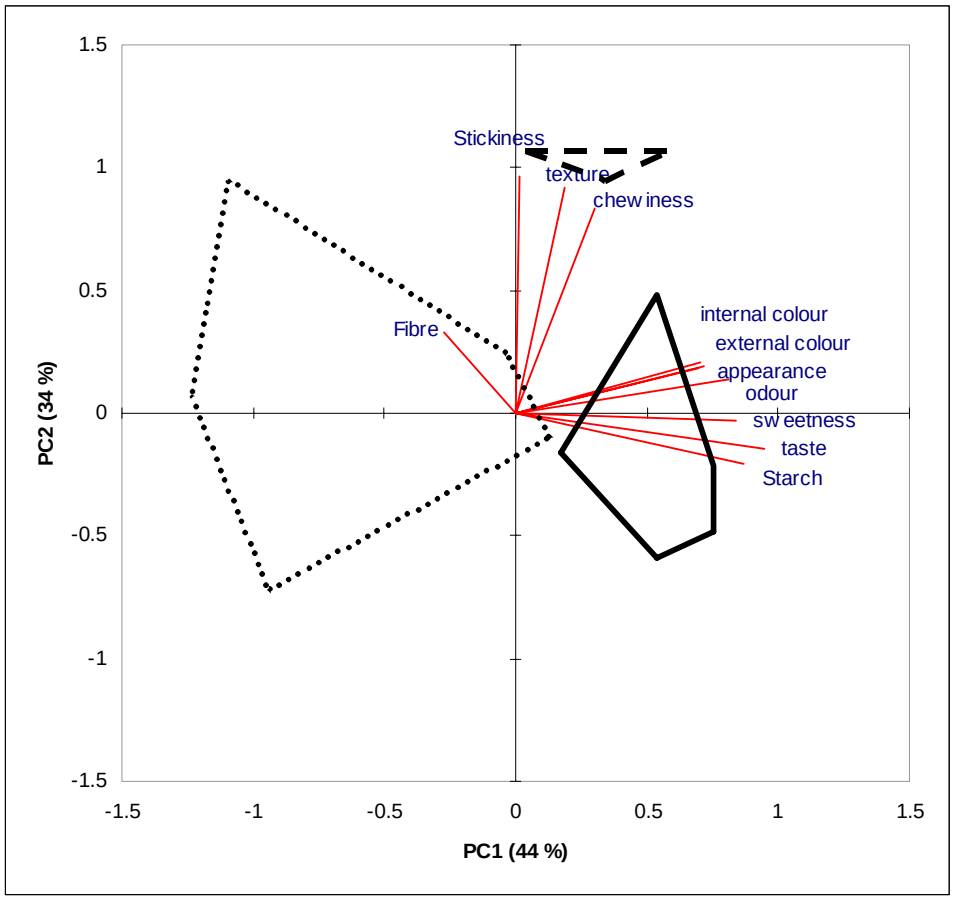

Figure 4: Principal component plot showing relationship of clusters with respect to the sensory attributes.

Where: Cluster 1 = dotted line; Cluster 2 = broken line; Cluster 3 = continuous line.

consider a large number of cultivars, so that any method that simplifies the assessment would be advantageous. We therefore wished to determine what was the minimum number of sensory characteristics that we could consider while still being able to distinguish between the clusters of cultivars.

Stepwise discriminant analysis (functions 1 and 2 account for 76% and 24% variance respectively) indicated that starch and stickiness were the optimum sensory attributes for distinguishing between the clusters. The discriminant model correctly classified 16 out of 20 cultivars.

Since only two sensory attributes were used in the model and sensory testing is fairly subjective, a simple scatter plot of these attributes (figure 5) was used to simplify cultivar selection. Cluster 3 is in the top left-hand quadrant, cluster 1 is in the bottom left-hand quadrant and cluster 2 is in the top-right quadrant. The dotted lines (arbitrarily drawn by the authors) represent the lower and maximum limits for starch and stickiness respectively. Hence, cultivars might be considered to be the most preferred if the score for starch is 48 or greater and the score for stickiness is 42 or less.

Case study 2: Changes in sensory characteristics during shelf-life studies. NRI and partners have used sensory panels to investigate changes in the sensory characteristics of five sweetpotato cultivars (Kemb10, SPK004, KSP20, Yan Shu 1 and Zapallo) during storage under tropical conditions (van Oirschot et al., 2003). A QDA (Meilgaard et al., 1987; Bainbridge et al., 1996,

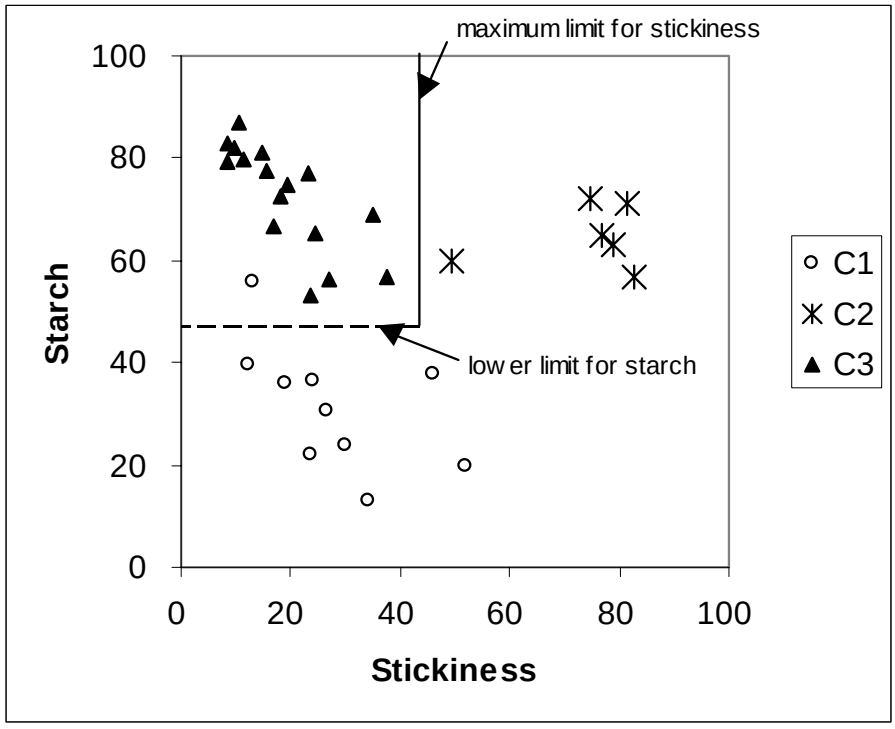

Figure 5: Scatter plot of starch and stickiness to illustrate limits for starch and stickiness when selecting sweetpotato cultivars that are preferred by consumers.
Where C1 = cluster 1, C2 = cluster 2 and C3 = cluster 3, dotted lines illustrate boundaries for cluster 3 (most preferred cultivars).

Tomlins 1998) panel used nine descriptors for sweetpotato which were floury, smooth, soft, chestnutty, sweet , fibrous, grainy , moist and discoloration . There were significant differences observed among the cultivars profiles. PCA (figure 6) revealed two principal components that explained 90% of the variation. PC1 explained 72% and correlated with textural properties, and PC2 explained 18% of the variation and correlated with flavour components. The results suggest that differences between sweet potato cultivars are mainly determined by textural components while storage had the most effect on the sweet and chestnutty characteristics. Of these differences, cultivar differences were greater than those occurring during storage.

Farmer testing of sweetpotato. Sensory panels are normally only recommended for use by trained panellists who assess the product in an environment where sample preparation, lighting and temperature are controlled. However, in adaptive research in rural areas, farmers views need to be taken into account (Van Oirschot and Tomlins 2000). Therefore, panels suitable for use by farmers in rural locations were devised (Anon 2002; Tomlins *et al* 2003c). The simple approach was part sensory and part hedonic. Sweetpotato from either pit or clamp stores were tested in this study. The roots were cooked in boiling water at the farm until soft. A total of 56 farmers scored the roots from the stores from their farm using the score sheet in Table 3.

Cluster analysis indicated three groups with respect to the sensory attributes with either, high, intermediate or low scores. The PCA, accounting for 84% of the variation, is shown in figure 7. The three clusters line in the same plane at PC1 which accounted for 71% of the variation. Cluster 2 is most

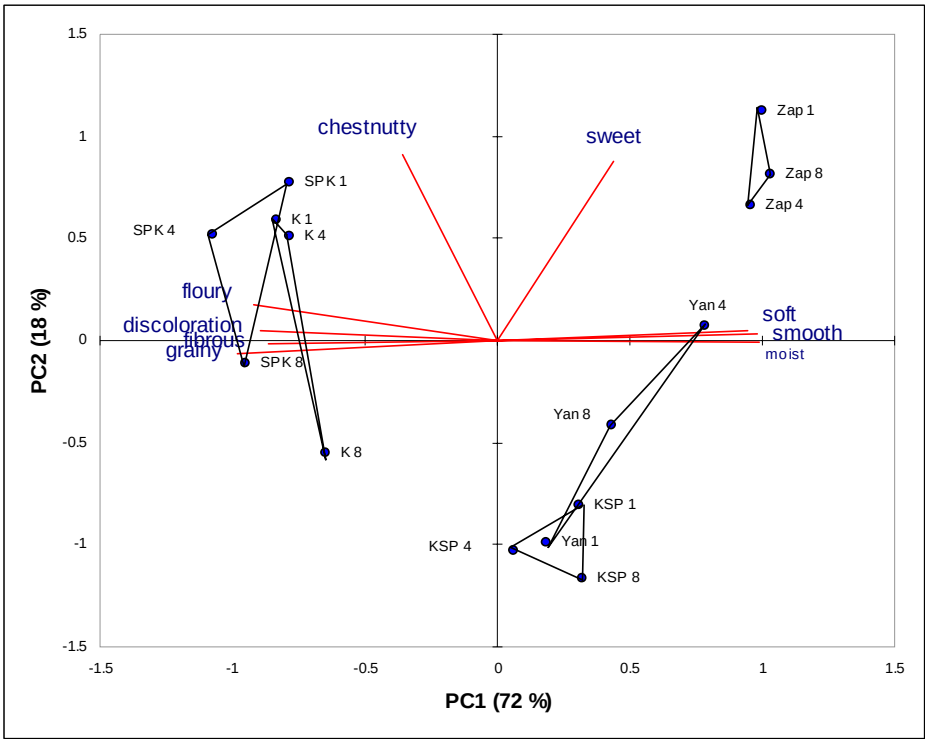

Figure 6: Sample scores of five cooked sweet potato cultivars on the first and second principal component after PCA analysis of the sensory profiles. Cultivars presented are Zap = Zapallo, Van = Van Shu 1, KSP = KSP 20, K10 = Kemb 10, SPK = SPK 004, and the numbers refer to the storage times of 1,4 or 8 weeks after harvest.

Table 3: Used a simplified panel. Farmers prepare the samples and access using the simplified score sheet.

	Very bad	Bad	Medium	Good
Very good				
Appearance				
Sweetness				
Flouriness				
Acceptability				

positively associated with the sensory attributes and cluster 3 the least. The variability within each cluster was in the same direction of PC2 which accounted for 13% of the variation.

Although the cluster did not significantly differ with respect to the type of store (pit or clamp), they did differ (P = 0.001) in the proportion of rotten roots in the stores. The proportion of rotten roots was associated with stores that were exposed to direct sunlight or that had been flooded with rain water. Therefore, the sensory attributes could be influenced by how the stores were managed and situated.

Conclusions

The majority of consumer preference studies is undertaken in developed nations and is directed towards high income consumers. This paper has shown that appropriate consumer preference and sensory evaluation approaches can have an important role to play in sweetpotato research, production and marketing for low-income consumers in developing countries. This can lead to increased uptake by these groups.

In consumer preference, by interviewing sufficient consumers (100 or greater) it is possible to evaluate the views of the low income consumers and how they make a choice. The use of simplified consumer testing methods (only to chose the most preferred cultivars out of those offered) can facilitate consumer preference studies where people have minimal education such as in rural areas and the urban poor. The application of appropriate statistical tools (principal component analysis, discriminant analysis) can enable models to be developed that enable consumer preference to be combined with sensory panels so that sensory results can be used as a low cost approach for predicting consumer preference of sweetpotato culitvars. The study showed that consumer preference of some sweetpotato culitvars varied from season to season implying that new cultivars should be evaluated over more than one season.

Sensory evaluation can used to assess the effect of changes during shelf-life of sweetpotato cultivars using Quantitative Descriptive Analysis, while simpler, less controlled methods could be used by farmers in rural areas of East Africa so that their views could be taken into account.

Consumer preference and sensory testing has an important part to play in sweetpotato research and marketing. The application of consumer preference to low-income groups is necessary to increase the success of research and marketing strategies. In particular, the new orange fleshed sweetpotato varieties that are being introduced for reducing vitamin A deficiency in Africa require extensive consumer preference testing.

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