CHAPTER 4

The use of consumer tests and trained taste panels to assess sensory characteristics

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4.1 Background

Many of the sensory criteria of sweetpotato cultivars identified by consumers and traders (see Chapter 3) are complex. Many are subjective and, therefore, difficult or impossible to measure by analytical means. This makes assessment of new cultivars for consumer acceptability very difficult. Direct consumer testing of new varieties is possible but, in order to get a reliable result, it is necessary to use a large number of consumers (usually at least 100), which is expensive and time consuming, and becomes possible only at a late stage of cultivar screening.

The Tanzanian National Root and Tuber Crops Programme (TNRTCP) and NRI have been investigating an alternative strategy by using small trained taste panels of 10–20 people to produce sensory profiles of cultivars. To create a profile, the panel was asked to assess cooked sweetpotato samples for a range of pre-chosen characteristics as objectively as possible. The procedure depends upon the identification of a sensory profile that accurately represents the preferences of consumers, so that the profiles of new cultivars can be compared with this 'ideal profile'. One key question when determining whether this is feasible is how consistent consumer preferences are across a country and, therefore, whether one consistently preferred profile exists for each country. Initial results in Tanzania suggest that there is a degree of consistency (see section 4.3.3).

Thus the procedure would have the following stages.

1. Identification of 'ideal' sensory profile.
   - Use consumer tests to identify the most preferred cultivars for any region.
   - Use a trained taste panel to produce a sensory profile for the preferred cultivars.
2. Assessment of new cultivars.
   - Use a trained taste panel to produce a sensory profile for promising new cultivars and compare these with the 'ideal' profile.

This chapter describes a study carried out in the Lake Zone of Tanzania in 1998 to test these methods. Further information on the work presented here can be obtained from Tomlins (1998), Kapinga *et al.* (1998) and Rwiza *et al.* (2000). Further work was conducted in subsequent years but is not presented here. Information on this can be obtained by contacting D. Rees, K.I. Tomlins or T. Ndengello (see page vi). Effects of storage on sweetpotato sensory charactistics are described in van Oirschot *et al.* (2002).

4.2 Methods

4.2.1 Ranking consumer acceptability of locally available varieties

Consumer tests were conducted in three districts of the Lake Zone of Tanzania: Mwanza, Meatu and Misungwi. In each district, 5–6 locally available varieties were selected. Roots of these varieties were obtained and cooked using a standardized method, which as much as possible simulated the most common cooking method of the region. Consumers were then presented with samples of cooked roots (in random order) to examine and eat, ranking them in order of preference. Each sample was labelled with a three-digit random number so that the consumers did not know which varieties they were testing. In order to get an accurate picture of consumer preferences, tests were carried out using 100 consumers in each district. Additional socio-economic information was obtained on sweetpotato consumption using a questionnaire.

Further details of the testing method and analysis of results are given below.

Methods Used for Consumer Testing

Sweetpotato sample preparation

The objective was to prepare and cook samples by a standard method, which accurately reflected the preparation method usually used in the country. In this case, roots were peeled and cut into roughly equal sized portions (3–5 cm). They were placed in plastic bags in which holes had been made, and boiled until the texture, assessed by a fork, was considered right for eating.

Sample presentation to consumers

A full set of samples was presented to each consumer. The sample order was randomized and each sample coded with a random three-digit number. Figure 4.1 is an example of the random numbers and random order used, where the consumers were presented with five cultivars (e.g. as in Mwanza). **Note:** Where using random numbers in this way, it is important to keep careful and clear records relating the number to the actual sample.

Cultivar ranking and additional information from consumers

Each consumer interviewed was invited to assess the samples and rank them in order of preference. This was recorded on a report sheet as shown in Figure 4.2. (In this case six cultivars were assessed by 100 consumers.)

An interview was then carried out to gain an insight into the factors which affected their preference and purchasing decisions.

The information collected included the following:

- age category (10–19, 20–29, 30–39, 40–49, 50–60, over 60)
- gender category (male, female)
- which sample was the most preferred and why
- which sample was the most disliked and why
- how much would they be prepared to pay for the most preferred sample
- how often do they consume the product (never, once a year, once a month, once a week, every day)
- the ingredients usually included in the product that they eat
- where do they consume the product
- who purchases the ingredients
- who prepares it
- do they consume other sweetpotato products
- how much do they spend on food each month
- what is the monthly income.

Note: When carrying out such interviews, questions asked by the interviewer must be easy to understand with minimal possibility of misinterpretation. Questions must be clear and easily understood by the consumer. Open-ended questions should be avoided but the facility for recording spontaneous comments should be retained.

Equipment required for consumer testing

- Cookers and utensils for the preparation of sweetpotato samples.
- Cutlery.
- Table and cloth for sample preparation.
- Plates or bowls for presentation of samples. These preferably should be white in colour and plain in design.
- Score sheets.
- Temporary shelter (only required if a sheltered location for central location tests cannot be identified). Two temporary shelters might be required (consumer interview and product preparation).

Consumer	1st sample	Code	2nd sample	Code	3rd sample	Code	4th sample	Code	5th sample	Code
1	A	527	B	796	C	630	D	567	E	680
2	B	715	C	779	D	591	A	048	E	362
3	D	694	E	659	B	165	C	674	A	196
4	E	890	A	684	D	856	C	765	B	072
5	C	228	E	458	D	097	B	301	A	385
6	A	003	D	094	C	701	E	294	B	827
7	B	786	C	050	D	473	A	638	E	243
8	B	699	C	777	E	926	D	138	A	543
9	D	089	C	278	A	639	B	052	E	925
10	C	536	D	255	A	098	B	673	E	150

Where: A, B, C, D and E are sweetpotato cultivars.

Figure 4.1 Sample randomization and codes used for sample labelling for 10 consumers and five sweetpotato cultivars

Consumer testing score sheet Date_____

Name	Rank						
	No.	Cultivar A	Cultivar B	Cultivar C	Cultivar D	Cultivar E	Cultivar F
	1	1	2	6	3	4	5
	2	6	1	2	4	5	3
	3	4	1	2	6	5	3
	4	6	1	2	3	4	5
	5	1	2	6	4	5	3
	⋮						
	99	5	2	1	3	6	4
	100	5	1	3	4	2	6

Figure 4.2 Example score sheet for consumer ranking of six sweetpotato samples

Analysis Using The Ranking Method

The ranking method for analysing data is described below but further details are given in Bainbridge *et al.* (1996).

Ranking is a test in which a series of three or more samples are presented to an assessor or consumer at the same time to be arranged in order of intensity, degree or preference. The simplicity of the method makes it valuable in consumer testing.

Calculation of the rank sums

The samples are decoded and the rank orders given by each assessor for each sample tabulated. (**Note:** 1 indicates favourite cultivar, 2 second favourite, etc.). Where there are tied rankings, the mean rank is recorded. The rank sum for each variety is then calculated by summing the ranks for all the assessors. This gives the overall ranking of the varieties. The calculation is demonstrated in Figure 4.3.

In the case shown, E is the favourite followed by F, D and A and C tie in 4th place and B is the least favourite.

By comparing the rank sums for the samples, it is possible to carry out a statistical analysis called the Friedman test for an evaluation of the significance of the differences between the samples. Details of this method are given in Bainbridge *et al.* (1996).

Note: Graphical techniques, such as frequency histograms, are useful for summarizing the results and picking out trends to understand how preferences might differ for different sectors of the population.

	Rank for each sample					
Consumer	Cultivar A	Cultivar B	Cultivar C	Cultivar D	Cultivar E	Cultivar F
1	5	6	4	3	1	2
2	6	5	3	4	2	1
3	4	5	6	3	1	2
4	5	4	6	1	3	2
5	5	4	6	3	2	1
6	4	5	6	3	1	2
7	5	6	4	3	1	2
8	4	5	6	3	1	2
9	4	5	6	1	3	2
10	6	4	5	1	2	3
Sum	48	49	48	25	17	19

Figure 4.3 Example calculation of rank sum

4.2.2 Training of on-station taste panels and obtaining sensory profiles of local cultivars

A taste panel was selected, trained and used on-station at the Lake Zone Agricultural Research and Development Institute (LZARDI), Ukiriguru to obtain sensory profiles of local varieties assessed by consumers. The process of setting up and training the panel included several stages.

Panel selection

It is important to be as consistent as possible and, therefore, to use the same people throughout a study. For that reason it was considered easiest to choose people from among local staff, preferably those that did not travel much as part of their work. Ten people were selected on this basis.

Selection of sensory attributes to be used

The panel members were presented with cooked samples of the roots of a few key cultivars, and group discussions were held to decide which were the most important sensory attributes in terms of appearance, odour, texture and taste. As a word may not have precisely the same meaning for all people, it was important to discuss sufficiently to ensure that there

were no misunderstandings and that the panel members reach a consensus. As much as possible, the terms chosen were objective, but in some cases this was difficult, so that some of the terms depended on the panellists' preferences and thus included a level of subjectivity.

Checking the effectiveness of a panel in distinguishing between cultivars

To check the consistency and sensitivity of the panel, a set of contrasting cultivars was chosen, and the panel used to create sensory profiles. Each panellist assessed each sample for all the sensory attributes previously chosen. The panellist recorded the intensity of that attribute by placing a mark on a line indicating the continuum between the extremes of the attribute (see Figure 4.4). The data obtained were analysed statistically to determine whether the panel was able to distinguish significantly between the cultivars.

Obtaining sensory profiles of the cultivars assessed by consumers

Once the panel had been trained and had been shown to be sufficiently sensitive, it was used to obtain sensory profiles of roots of the varieties assessed by consumers in each of the three districts. This involved several tasting sessions in which each panellist was presented with between 4 and 6 samples at random. Sessions were repeated until each cultivar was assessed twice by each panellist.

Methods Used to Train and Use On-station Taste Panels

Preparation of sweetpotato samples

The sensory character of the cooked material will depend on the method of preparation, so it is important that the method used is carefully standardized and reflects the usual local methods used. The following method was used.

The sweetpotatoes were peeled and approximately 10% of the root removed at each end since the texture at the ends significantly differs from the bulk of the storage root. The roots were peeled and cut into roughly equal sized portions (3–5 cm). The portions were placed in perforated plastic bags, and boiled until the texture, assessed by a fork, was considered right for eating. The cooking time varied between 15 min and 27 min.

Selection of sensory attributes to be used

The panel members were presented with cooked samples of the roots, and group discussions were used to decide the most important sensory attributes in terms of appearance, odour, texture and taste. The following terms were selected by the panel. Those marked with a * are subjective, in this case 50% of the chosen attributes.

- Appearance*
- External colour*
- Internal colour*
- Odour*
- Softness (using fingers)
- Taste*
- Chewiness
- Sweetness
- Mealiness
- Stickiness
- Fibre
- Overall acceptability*

Scoring samples for sensory attributes

Figure 4.4 shows a score sheet used for recording one panellist's assessment of one sweetpotato sample. Each attribute is scored using a mark on a line to record intensity.

During each panel session up to four test samples are randomly presented to each assessor, each labelled with a random number. Thus to assess more than four cultivars, several panel sessions may be needed, and in each session not all panellists will taste the same samples.

Name:_____ Date:_____

Sample number:_____

Score the sample in front of you for each of the qualities that it possesses in the list below by making a mark on the line at the position corresponding to the score that you perceive.

Appearance	bad	good
Colour (external)	bad	good
Colour (internal)	bad	good
Odour	bad	good
Softness (to touch)	hard	soft
Taste	bad	good
Chewiness	very chewy	soft
Sweetness	not sweet	very sweet
Mealiness	not mealy	very mealy
Stickiness	not sticky	very sticky
Fibre content	no fibre	very fibrous
Overall acceptability	very acceptable	not acceptable

Figure 4.4 Score sheet for sensory evaluation of sweetpotato

4.2.3 Obtaining profiles of elite cultivars within the breeding programme

Using the same methods as described above, the trained taste panel was used to assess the sensory characteristics of 12 elite cultivars that were being assessed for production characteristics by the TNRTCP at LZARDI, Ukiriguru.

4.3 Results and discussion

4.3.1 Consumer tests on local varieties in Mwanza, Meatu and Misungwi

Although the varieties, Polista, SPN/0 and Sinia B, were found at all three sites, the other varieties available at the sites were not the same. Table 4.1 lists the varieties and their ranking by consumers. In all cases, the ranking when analysed by rank sum was statistically significant.

Table 4.1 Ranking of local varieties at three locations in the Lake Zone of Tanzania

Ranking	Location of consumer study		
	Mwanza	Meatu	Misungwi
Most preferred	Polista	SPN/0	Ngikuru
	Sinia B	Ngosha	SPN/0
	SPN/0	Polista	Polista
	Mzondwa	Serena	Toniki
		Sinia B	Sinia B
Least preferred	Bilagala	Ipembe	Nguruka

4.3.2 Testing the consistency and sensitivity of the trained taste panel

The overall results of the sensory profiles created by the taste panel for three test varieties are represented graphically in the form of a 'spider diagram' (Figure 4.5). One way analysis of variance (ANOVA) indicated that the panel could significantly ($P = 0.05$) distinguish the three cultivars for 7 of the 12 sensory attributes. This was the first time that the panel had been used, and it was found that with experience precision increased.

4.3.3 Obtaining sensory profiles of the varieties from Mwanza, Meatu and Misungwi

The panel was then used as part of a study to determine consumer preferences for three sites in the Lake Zone. A sensory profile was created for each of the varieties ranked by the consumers. Figure 4.6a–c shows the profiles for the most and least preferred varieties at each site, while Figure 4.6d compares the profiles for the three most preferred varieties. An interesting and encouraging finding was that although the most preferred varieties were not the same, they had similar profiles. Although a more extensive study is needed, this may mean that in terms of sensory characteristics, varieties will not need to be bred for specific regions.

4.3.4 Profiles of elite cultivars within the breeding programme

Once the sensory profile relating to the sensory characteristics preferred by consumers had been established, it was possible to assess cultivars within the breeding programme to determine those close to this profile. A great range in profiles was obtained for the 12 elite cultivars assessed from the breeding programme at LZARDI, Ukiriguru, as illustrated by the 'spider diagrams' in Figure 4.7. Analysis of variance indicates that the panel was able to distinguish between the varieties for all attributes except *Fibre* (Table 4.2). This indicates a consistency between panel members, even for very subjective criteria. The inability to distinguish between varieties for *Fibre* may be because all varieties tested were considered low in *Fibre* by the panel and, therefore, the range was not sufficiently large.

The composition of the storage roots of the varieties profiled was analysed in terms of dry matter content and sugar content. The attribute described by *Starch*, refers to the texture of the root, and is sometimes described as *Mealiness* or *Flouriness.* Although a complex attribute, it is thought to be related to the dry matter of the roots. Figure 4.8 shows the *Starch* score obtained by the panel for each variety plotted against

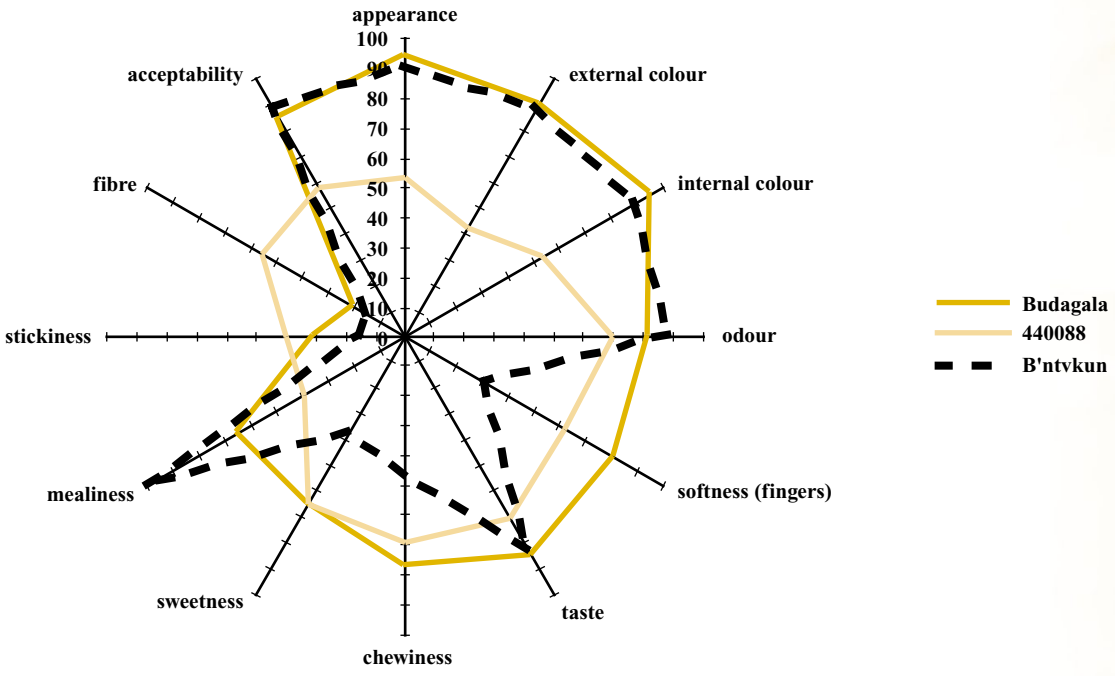


Figure 4.5 Spider chart of mean sensory scores for three sweetpotato cultivars

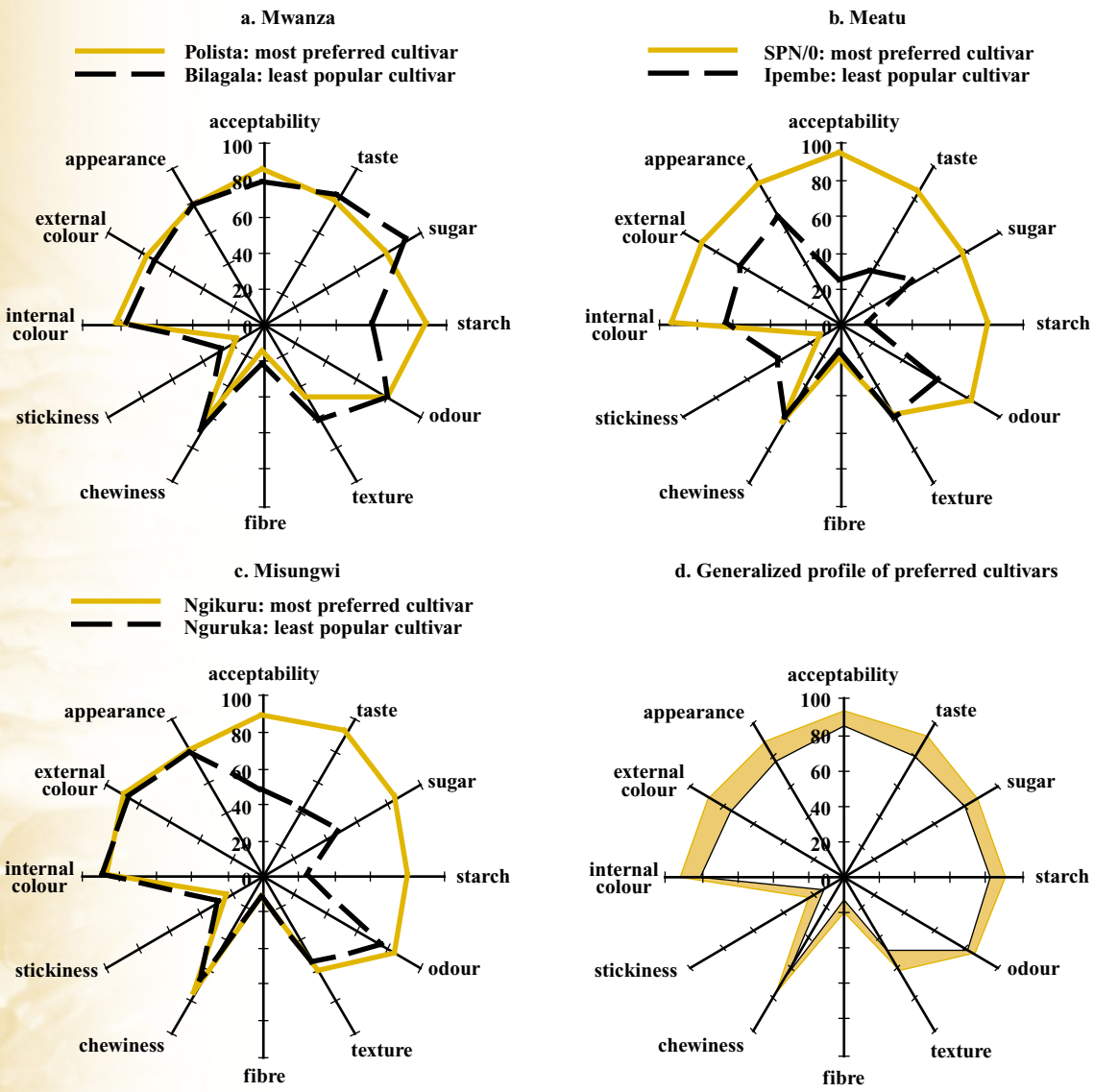


Figure 4.6 Sensory profiles of the most preferred and least preferred variety for each location, and the generalized profile of preferred varieties

Table 4.2 Attributes used by the trained panel to assess varieties, and the level of significance for discrimination between the 12 cultivars

Sensory attribute	Significance of discrimination between 12 cultivars as determined by the trained panel
Acceptability	***
Appearance	***
External colour	***
Internal colour	**
Taste	***
Sugar	***
Starch	***
Texture	***
Stickiness	**
Chewiness	***
Fibre	n.s.
Odour	***

n.s. = not significant.

** , *** significant to less than 1%, and less than 0.1%, respectively.

the measured dry matter content. Apart from one variety, Kagole, which has an exceptionally low *Starch* score, there is a significant relationship ($P<0.01$) between the two parameters.

Sugar, or sweetness, of the roots is considered an important taste attribute. It can also be a complex characteristic, not necessarily related directly to sugar content. The sugar content of roots increases during cooking, as the process promotes the breakdown of starch. Figure 4.9 shows the *Sugar* score obtained by the panel plotted against the actual sugar content of cooked roots as analysed by high performance liquid chromatography (HPLC) analysis. There is a significant ($P<0.05$) correlation between the two parameters.

The consistency of the panel's scores with the compositional analysis gives us further confidence in the validity of the assessments.

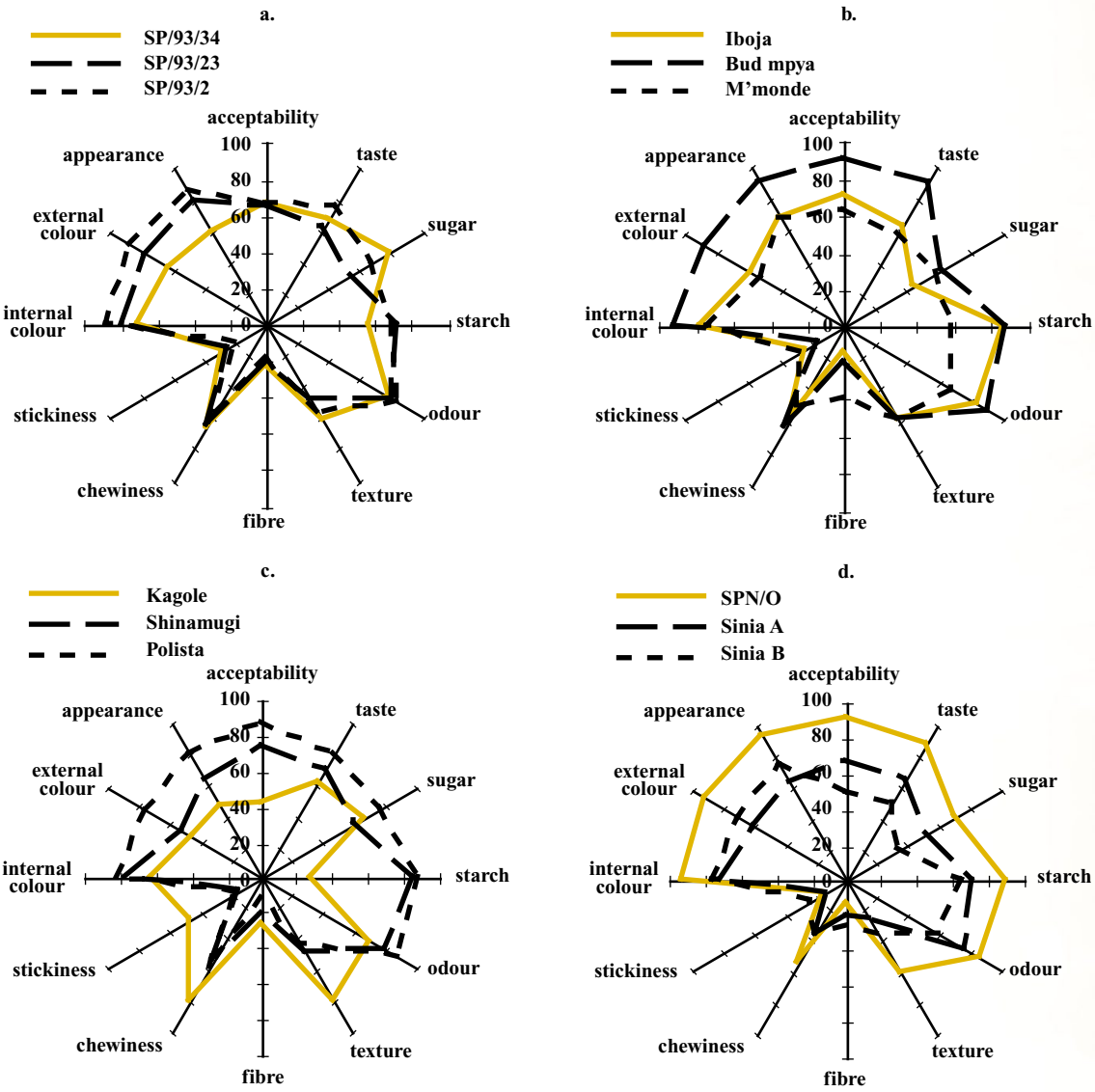
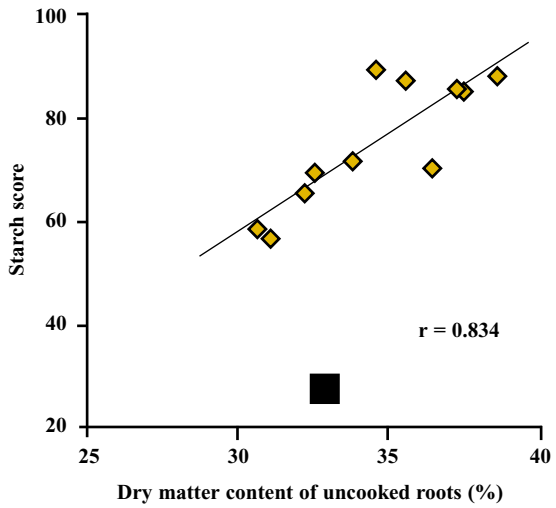


Figure 4.7 Sensory profiles created by the trained taste panel for 12 sweetpotato varieties (Bud mpya = Budagala mpya, Mmonde = Mwanamonde)



The square symbol indicates the data for Kagole.

Figure 4.8 The relationship between *Starch* score given by the panel and dry matter content of roots of a range of sweetpotato varieties

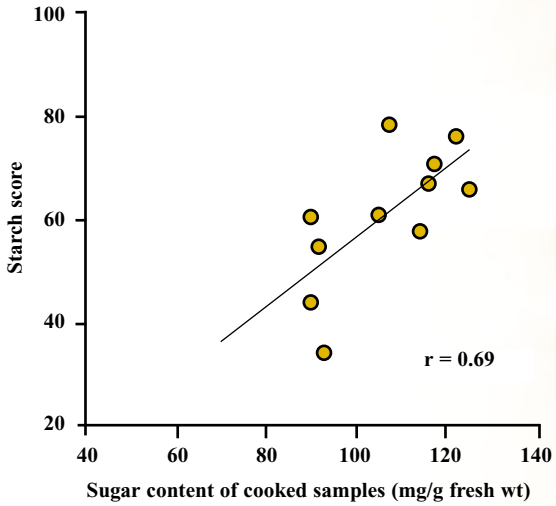


Figure 4.9 The relationship between *Sugar* score given by the panel and sugar content of cooked roots of a range of sweetpotato varieties

Comparison of the profiles with that of the preferred varieties (Figure 4.6) indicates that SPN/0, Polista and Budagala mpya should all be very acceptable. These varieties are all in fact already used by local growers. SP/93/2, SP/93/23 and SP/93/34 are new cultivars bred by the TNRTCP, and chosen for their good production characteristics. Their sensory profiles are reasonable but still less acceptable than the best available cultivars, particularly in terms of taste.

4.3.5 Advanced techniques for assessing cultivar acceptability over seasons

Recent analysis has explored the consistency of cultivar acceptability over seasons. This is important, as both the consumer preferences, and the cultivar characteristics could change between years.

In 2000, consumers were interviewed again and asked to assess sweetpotato samples using the same methods and in the same locations as for the study described above. Table 4.3 shows the cultivars in order of preference for the three regions over the two seasons. Although there was some difference in the cultivars found in the regions, many were common, and over both years (1998 and 2000), the cultivars, Polista and SPN/0, were consistently within the three most preferred cultivars. Other cultivars, such at Sinia B, were not liked in 1998 but were liked in 2000, while Mzondwa, Bilagala and Serena were consistently disliked.

All the cultivars were assessed for their sensory attributes in 2000 using the same taste panellists as used in 1998. With 11 attributes being assessed for each cultivar (overall acceptability was left out in 2000), the data can become very complex to interpret. For that reason, a mathematical technique called principal component analysis (PCA) was used to express the data. A full explanation of this technique is outside the scope of this publication, but some idea of the power of the method can be obtained by looking at Figures 4.10a and b. The data are mathematically *transformed* so that the 11 attributes can be expressed by *vectors* (lines) pointing in different directions on a two-dimensional graph (Figure 4.10a) that accounts for 78% of the variability. The greater the variability accounted for, the more reliable the fit. Attributes which are closely related have vectors which are almost parallel (e.g. *Starch*, *Taste* and *Sweetness*), while those which are not related tend to be perpendicular (e.g. *Sweetness* and *Stickiness*). Cultivars can be described by a point on the same graph, depending on their sensory characteristics (Figure 4.10b). Thus Serena (Meatu 2000) is very fibrous, whereas Sinia (Mwanza 2000) is not fibrous, but is sweet. Similar cultivars will be clustered together.

Hierarchical cluster analysis (Wards method; Figure 4.10b), shows that the most popular cultivars are all located in a cluster in the same area (lower right-hand quadrant) of the graph, indicating that the sensory panel found that all these cultivars had similar sensory profiles. The other thing that the graph shows is that SPN/0 and Polista had stable sensory characteristics, whereas Sinia was different in 1998 and 2000 (i.e. the position on the graph is different). This fits with the finding that the consumers tended to like Sinia more in 2000 than in 1998.

The PCA plot (Figure 4.10a) suggests that many sensory attributes are highly correlated and so the approach can be simplified. Analysis of variance (ANOVA) can be used to determine the significance of cultivar differences and, therefore, to give an indication of how useful a sensory attribute is for discriminating between cultivars. By selecting only those sensory attributes with the most significant cultivar differences and only those that are not correlated, the approach can be simplified to only two sensory attributes; *Starch* and *Stickiness*. That is, *Starch* and *Stickiness* have good discriminating power (highly significant cultivar differences) and are not significantly correlated with each other. This is illustrated in Figure 4.11 where the most preferred cultivars are in the upper left-hand quadrant of the *x-y* plot. The most preferred cultivars are starchy but not sticky and the least preferred are not starchy and not sticky.

More information on this study and on the PCA technique can be obtained from K.Tomlins. Examples

Table 4.3 Consumer acceptability – ranking sweetpotato cultivars by 100 consumers at Mwanza, Meatu and Misungwi over two seasons

Liking	Mwanza		Meatu		Misungwi	
	1998	2000	1998	2000	1998	2000
1 (most)	Polista	SPN/0	SPN/0	Polista	Ngikuru	SPN/0
2	Sinia B	Sinia B	Ngosha	Sinia B	SPN/0	Sinia B
3	SPN/0	Polista	Polista	SPN/0	Polista	Polista
4	Bilagala	Mzondwa	Serena	Serena	Toniki	Bukolu
5	Mzondwa	Bilagala	Sinia B		Sinia B	Hudi Shinyanga
6 (least)			Ipembe		Nguruka	Ngikuru

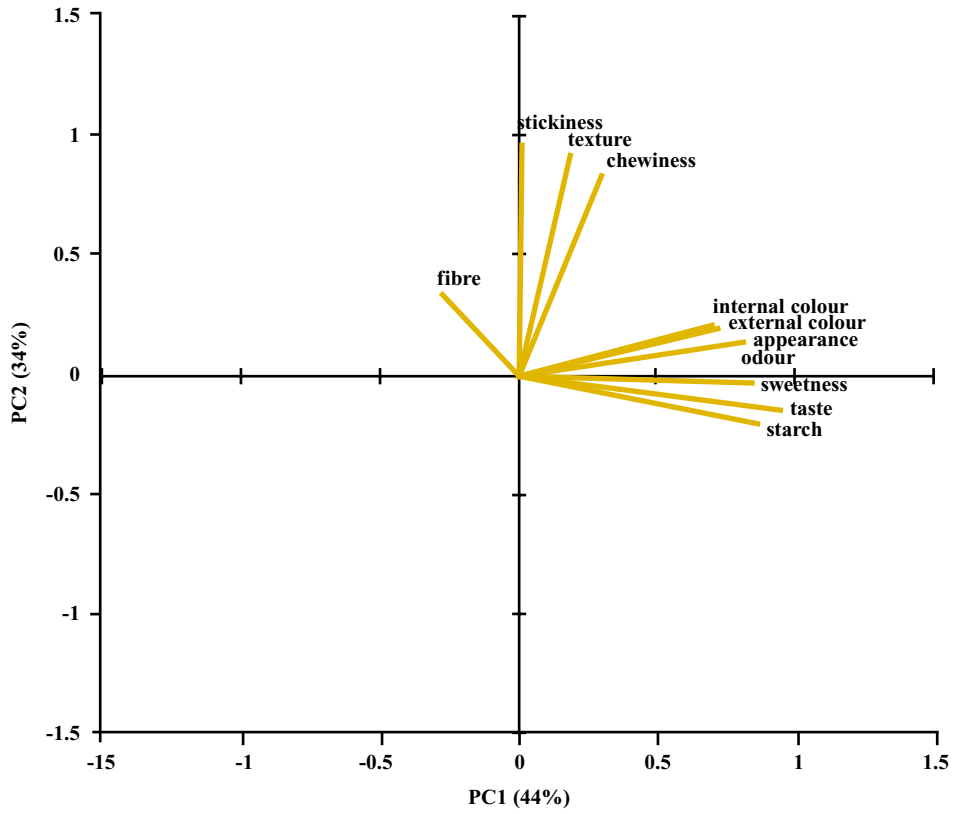
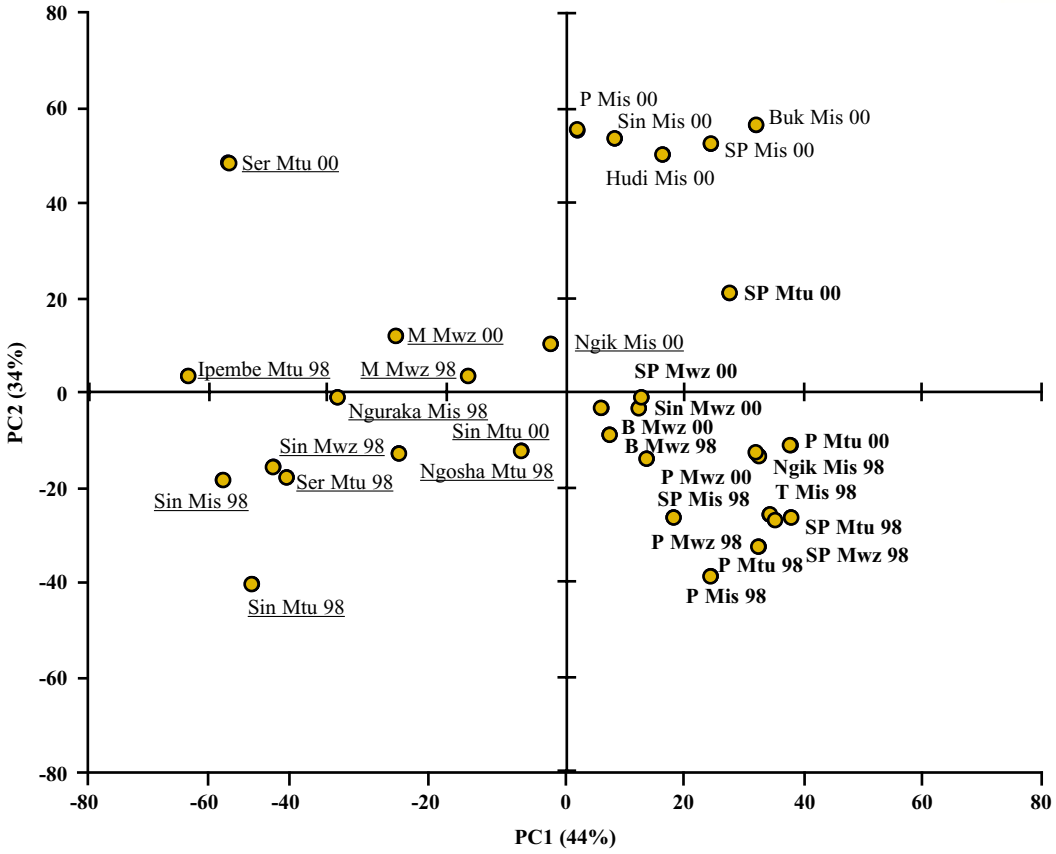
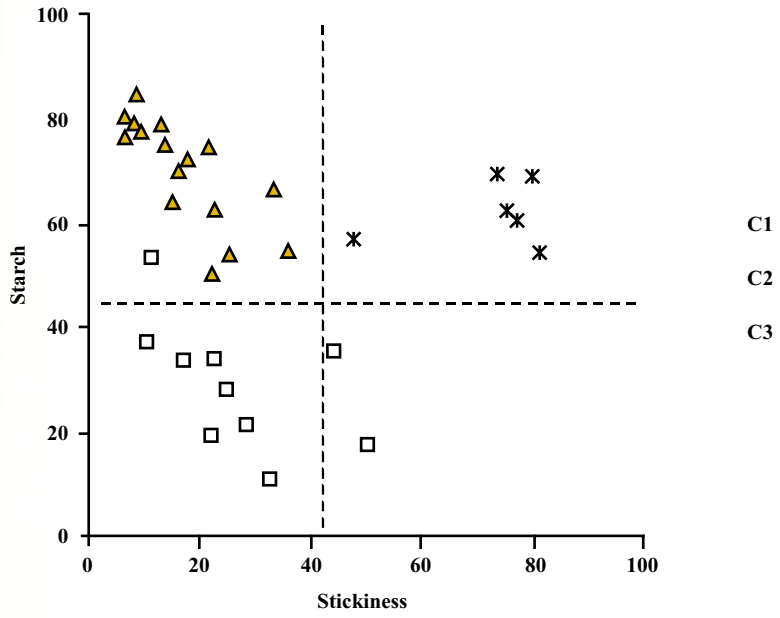


Figure 4.10a **Principal component plot showing relationship with respect to the sensory attributes**



Bold = most preferred cultivars, underlined = least preferred cultivars; normal text = Misungwi 2000 cultivars

Figure 4.10b **Principal component plot showing spacing of sweetpotato cultivars with respect to the sensory attributes**



Horizontal and vertical dotted lines are cut-off limits for selection criteria.

▲ most preferred cultivars

□ least preferred

✱ Misungwi 2000 cultivars

Figure 4.11 Discrimination of sweetpotato cultivars with respect to *Starch* and *Stickiness*

of the way in which sensory evaluation can be used in practice are given in Baker *et al.* (1994), Tomlins (2000a, b), Tomlins and Gay (1994) and Tomlins *et al.* (in press).

4.4 Conclusions and implications

This study has shown that a trained panel can be used to assess sensory attributes of sweetpotato varieties and can be a useful selection tool in cultivar selection. The finding that the most popular varieties in three locations and from year to year have similar sensory profiles is very encouraging. The results presented in section 4.3.5 indicate that consumer preferences are relatively stable, but there are some cultivars (notably Sinia) for which sensory attributes can change markedly between years while others (Polista, SPN/O, Mzondwa and Serena) are very consistent. While it is important to screen using the entire spectrum of sensory attributes, the most important sensory attributes in selecting for consumer acceptability are *Starch* and *Stickiness*. The most preferred cultivars were starchy but not sticky while the least preferred were not starchy and not sticky. Non-sensory tests indicated that preferred cultivars (high starch) also had high dry matter and suggests measurement of dry matter content can assist screening studies.

The study was based in three locations which were all in one zone of Tanzania. It will now be important to determine whether the preferences of consumers remain consistent over the whole country.

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