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Consumer acceptability and sensory evaluation of a fermented cassava product (Nigerian fufu)

Keith Tomlins,[1]* Lateef Sanni,[2] Olusola Oyewole,[2] Adewale Dipeolu,[2] Idris Ayinde,[2] Kolawole Adebayo[2] and Andrew Westby[1]

[1]*Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK*
[2]*University of Agriculture, PMB 2240, Abeokuta, Ogun State, Nigeria*

Abstract: The purpose of the study was to evaluate the sensory profile and acceptability of six types of fufu (a fermented cassava product) produced by different processes using sensory evaluation and consumer acceptability testing. Fufu samples were selected to evaluate the acceptability of dried fufu flours, which are increasingly being consumed, and compare with a traditional paste and a newly developed paste that produces less environmental waste. Descriptive sensory profiles of the selected samples demonstrated distinct differences in sensory profiles. They were evaluated for consumer acceptance at three demographic locations; Lagos ($n = 91$), Ibadan ($n = 121$) and Abeokuta ($n = 99$), Nigeria. Fufu made from a paste that produced less environmental waste had the highest acceptance scores, followed by flour and paste made by the traditional method and finally the remaining flours. Average consumer liking between the three locations did not differ. Three distinct consumer segments were identified and the number of consumers in these segments differed between the locations. Consumers differentiated fufu made from pastes and from flour. Internal preference mapping indicated that consumers associated the flours with sensory attributes such as sticky texture and raw cassava odour, while pastes were associated with soft texture, and shiny and creamy appearance. Fufu acceptance varies widely among consumers and is related to preferences for distinct fufu flavour profiles. Correlations between consumer acceptance scores and sensory scores appeared to be non-linear for many attributes but a larger sample size of fufu samples would be necessary to confirm this. The implications of these finding are discussed.
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Keywords: cassava; fufu; flour; Nigeria; West Africa; sensory evaluation; consumer preference; acceptability

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) production in Nigeria is estimated to be 34 Mt per annum and has dramatically increased since 1986. Fufu is a fermented cassava product that is traditionally consumed in Nigeria and other West African countries.[1] It has a sour taste and strong odour. Flavour, appearance and texture are widely recognized as significant factors that determine fufu acceptance and quality. It is considered by consumers to be of good quality when it has a smooth texture, a characteristic sour aroma and is creamy-white, grey or yellow in colour.[2] The quality of fufu, however, varies with processors and season[1] and this variability has been attributed to various local practices by the processors.[3]

Fufu is traditionally sold as a wet paste, which renders it highly perishable, and its poor shelf-life limits its suitability for large-scale processors. A modified process for manufacturing fufu paste that produces less effluent and therefore protects the environment has been developed, but little is known about its acceptability to consumers. Furthermore, fufu flours that can be conveniently reconstituted with hot water have become increasing popular in Nigeria and overseas.[4] The potential for expanding the market for fufu has been reported along with how this can contribute to improving the livelihoods of rural small-scale cassava processors.[5,6]

Little is known regarding the consumer acceptability of widely consumed fermented fufu in West Africa and in particular how fufus made from the traditional paste and flour compare. Some significant differences in the properties of fufu flour from a number of commercial and non-commercial producers have been reported.[7] Fufu flavour is characterized by strong complex flavours associated with processing procedures. A modified process for manufacturing fufu paste that is more environmentally friendly appears promising but its marketing potential depends in part on whether it is acceptable to consumers. Moreover, diverse demographics in Nigeria might have different attitudes relating to the consumer acceptability of fufu. The

* Correspondence to: Keith Tomlins, Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK
E-mail: K.I.Tomlins@gre.ac.uk
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objective of this study was to evaluate the flavour profile and acceptability of six fufu samples from varying processes (wet paste, modified wet paste, flour made from traditional paste or modified paste and two commercial flours) at different urban centres using descriptive analysis and consumer acceptance tests.

MATERIALS AND METHODS

Experimental samples

Fufus were made from products produced by different processes. These were from pastes (traditional wet paste and a modified wet paste that produced less environmental waste) or from flour which was made from dried traditional paste or modified paste.

The six fufu samples used in this study were as follows:

- *Paste (traditional process)*. Peeled cassava roots (11–12 months old; TMS 30 572 variety) were washed and soaked in fermenting vats for 4 days. The fermented roots were then sieved through muslin cloths. The filtrate was discarded while the sediment was collected in baskets and drained. The sediment was then packed in woven polyethylene fibre sacks and allowed to drain.[8]
- *Paste (modified environmentally friendly)*. Cassava roots (11–12 months old; TMS 30 572 variety) were mechanically grated after 3 days of fermentation. This was followed by a second stage of solid state fermentation (this can be described as 'double fermentation'). Finally, the fufu was sieved with a reduced volume of water.
- *Flour (dried traditional)*. Wet fufu paste made by the traditional method was dried in a locally manufactured rotary dryer (Addis Engineering, Lagos, Nigeria). The dryer consisted of an insulated drying chamber in combination with a system of duct and baffles to direct air over and through the circular chamber to promote uniform distribution (185 °C for 20 min).
- *Flour (dried modified)*. Wet fufu paste was dried employing the same method used for drying traditional wet taste.
- *Flour (commercial A)*. Commercial fufu flour purchased from a processor based in Ibadan, Nigeria.
- *Flour (commercial B)*. Commercial fufu flour purchased from a processor based in Lagos, Nigeria.

Preparation of cooked fufu samples for sensory and consumer testing

The fufu flour was made into a fine paste with cold water (flour:water, 2:3) and heated with constant stirring until a stiff paste was formed.

Fufu from paste was made by heating it with constant turning using a wooden pestle until it became a stiff gel.

Consumer acceptability

Consumers ($n = 311$) were tested and interviewed at each of three locations: Lagos ($n = 91$), Ibadan ($n = 121$) and Abeokuta ($n = 99$). The method of central location testing was used[9] and consumers were selected according to criteria of familiarity with the product, gender and age. Testing was carried out in meeting halls in Abeokuta, Ibadan and Lagos. Consumers did not assess the samples in booths since studies have indicated that consumers prefer a non-laboratory type environment.[10] During the testing, cooked fufu samples made from both the pastes and flours were freshly prepared every hour. Fufu samples (40 g) were coded with 3-figure random numbers. Consumers were presented with the six cooked fufu samples in random order and offered mineral water to rinse their mouths between samples. Consumers were asked to score the acceptability of fufu using a 9-point verbal hedonic box scale which varied from 'dislike extremely' to 'like extremely'.[9,11]

After testing the product, consumers were interviewed to obtain demographic information regarding age, education, ethnic group, gender, occupation, food eaten most often, type of fufu usually consumed, how often fufu was eaten, where fufu was eaten and preference for staple foods. The interviews took approximately 30 min. For analysis by Kruskal–Wallis test the data was converted into categorical data. Similarly, the means for each acceptability segment was used to obtain principal component plots to illustrate the relationship of the demographic results to consumer acceptance.

Sensory evaluation

The semi-trained sensory panel consisted of 10 trained assessors at the University of Agriculture, Abeokuta, Nigeria. The fufu samples were scored using a modified version of quantitative descriptive analysis (QDA) since standards were not provided.[9,11] Testing was carried out under controlled temperature and under fluorescent lighting. Since purpose booths were not available at the University of Agriculture, panellists were spaced at least 2 m apart to avoid interaction. The panel generated eight descriptive terms for the cooked fufu. The descriptive terms used were dirty white colour, creamy appearance, shininess, smooth appearance, sour taste, sticky texture, soft texture and raw cassava odour.

At each sensory panel session, three cooked fufu samples were 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. The panellists rinsed their mouths with mineral water before testing each sample. Panel sessions were repeated until all samples were scored in triplicate. Cooked samples were

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prepared using the same method as for the consumer testing.

Statistical analysis

SPSS (Version 10.0) and XLSTAT were used for statistical analysis in this study. Methods applied were analysis of variance (ANOVA), Kruskal–Wallis test, linear regression, cluster analysis (agglomerative hierarchical cluster, Euclidean distance, Ward's method) and principal component analysis (PCA).

RESULTS AND DISCUSSION

Sensory analysis of cooked fufu samples

The six fufu samples were significantly different with respect to all of the sensory attributes (two-way ANOVA; $P < 0.05$ where panellists were included as a factor). There were no significant differences with respect to the replicates (by fufu samples or by panellists; $P > 0.05$).

PCA of sensory attributes (Fig. 1) resulted in a two-factor solution accounting for 83% of the total variation, of which 65% was explained by the first principal component (PC) and 18% by the second. The sensory attributes were largely separated in the direction of PC1, which spanned from creamy appearance, shininess and soft texture in the left hand segments to smooth appearance, dirty white colour, sour taste, sticky texture and raw cassava odour. In the direction PC2 the attributes spanned from sour taste to smooth appearance.

Considering the samples, fufu made from the wet paste (traditional or modified) and flour (commercial A) were in the left-hand quadrants and were associated with creamy appearance, shiny appearance and soft texture. The remaining flour samples lay in the right-hand quadrants. Two flours (commercial B and traditional) were associated with sour taste and raw cassava odour and were the least creamy. The flour made from modified paste was associated with dirty white colour, smooth appearance and sticky texture.

Profile of consumers participating in the research

Three hundred and eleven respondents completed the questionnaire and evaluated the six cooked fufu samples.

The consumers from the three locations differed with respect to highest achieved level of education, occupation, staple usually consumed, how often they ate fufu, where they usually ate it and the form it was purchased ($P < 0.05$) (Table 1). In contrast, gender, age and changes in amount of fufu eating during the previous year did not differ.

Consumer acceptability of cooked fufu

Consumer acceptability did not differ with respect to location ($P < 0.05$); therefore the results were pooled as one group of 311. The mean acceptability of the fufu samples differed significantly ($P < 0.001$; Table 2). In general, consumers gave the highest scores for acceptability to fufu made from the wet paste and lower scores to fufu made from flours.

Consumer acceptability differed by gender, age and how frequently they fufu was eaten ($P < 0.05$). Males (mean score of 6.0) tended to give higher scores to fufu than women (mean score of 5.6). The mean acceptability scores for consumers increased slightly with age from 5.7 to 6.2. Those who ate fufu the most often gave the highest acceptability scores.

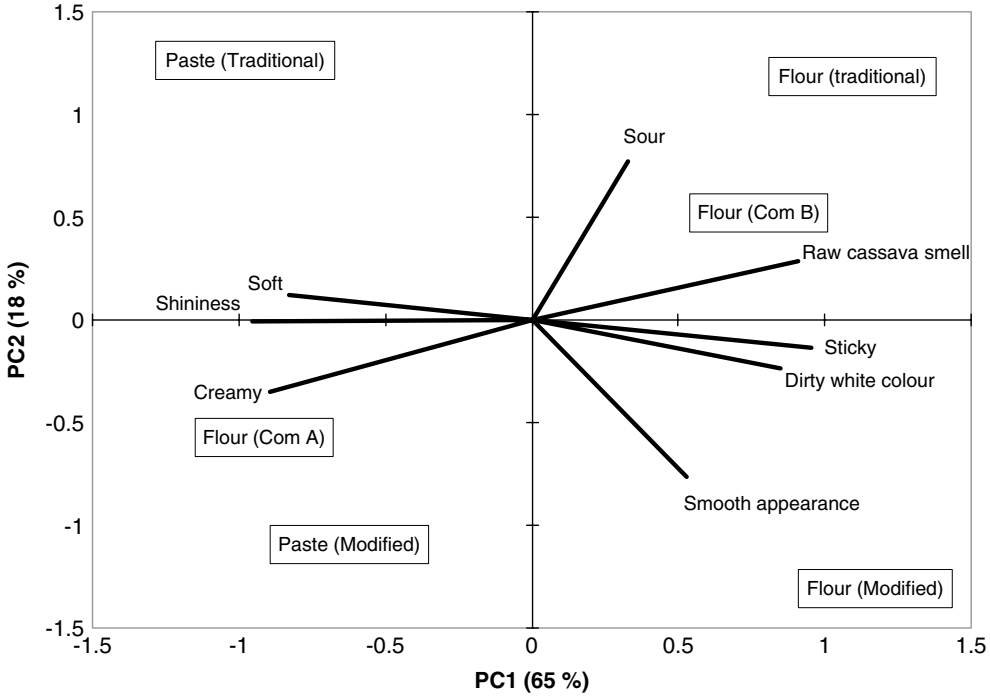

Figure 1. Principal component plot of sensory attributes for cassava-based fufu made from pastes and flours.

Table 1. Demographic and consumption characteristics of fufu consumers interviewed in Lagos, Ibadan and Abeokuta

	Location			
	Abeokuta	Ibadan	Lagos	Total
Number of consumers	99	121	91	311
Gender				
Male	60	64	67	64
Female	40	36	33	36
Age				
18–29	54	54	43	50
30–39	28	20	33	27
40–49	14	19	19	17
50–59	4	7	5	5
60–69	0	1	0	0
Ethnic group				
Yoruba	95	80	84	86
Hausa	2	1	14	6
Igbo	3	19	2	8
Highest level of education				
No formal education	17	0	7	8
Primary school	7	10	12	10
Secondary school	29	25	23	26
OND/NCE	22	10	32	23
HND/BSc	24	55	26	34
Occupation				
Civil service	29	20	73	43
Student	51	38	17	34
Teaching	16	18	2	11
Trading	0	15	7	7
Artisanship	4	8	1	4
Unemployed	0	1	0	0
Staple food usually consumed				
Rice	27	20	27	28
Gari (fermented and fried cassava)	18	15	21	18
Beans	9	18	12	13
Yam	1	38	2	13
Fufu (fermented cassava)	13	10	15	10
Pounded yam	8	0	17	9
Frequency of eating fufu				
Never	1	1	1	1
Occasionally	54	27	29	36
Once a month	3	5	2	3
Once a week	31	34	41	36
Every day	11	32	27	23
Where consumers eat fufu most often				
Home	57	44	61	55
Street food	13	22	9	14
Workplace	4	16	6	8
Form in which fufu is purchased				
Cooked	92	4	51	50
Flour	1	71	2	22
Wet paste	3	13	29	16

Values given are percentages within each column (location).

Agglomerative hierarchical cluster analysis (Ward's method) indicated that consumers were clustered into three different segments as illustrated in the dendrogram (Fig. 2). A maximum of three segments were chosen because dividing into more than this number would lead to segments that contained too few consumers for the analysis to be meaningful.

The segments of consumers differed significantly in acceptability ($P < 0.05$) for the fufu samples, indicating differing acceptability profiles (Fig. 3). The largest consumer segment (3) comprised 66% of consumers followed by segment 1 (21%) and segment 2 (14%). Those in the largest segment (3) generally gave high acceptability scores to all of the fufu samples, with fufu made from modified wet paste ranking highest and the commercial dried sample B lowest. Consumers in segment 1 gave the highest scores for fufu made from the pastes and the lowest for the flours. Consumers in the smallest segment (2) scored the traditional flour highest and the modified paste lowest.

Internal preference mapping[11–13] was used to relate the sensory attributes generated by the sensory panel to the mean acceptability of the consumer segments. The PCA plot, accounting for 95% of the variability, is shown in Fig. 4. The sensory scores were not used 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 majority of sensory attributes lay in the direction of PC1 (75% of variability) apart from sour taste, dirty white colour and raw cassava odour, which were associated with PC2 (20% of variability). Acceptability of consumers in segments 1 and 3 were associated with soft texture, shininess, creamy and smooth appearance and the pastes (modified and traditional). Consumers in segment 2 were very different in their liking compared to consumers in segments 3 and 1. They preferred the flours, in particular the modified and commercial A, and to a lesser extent the traditional. These were associated with the sensory attributes sticky texture and raw cassava odour. The sensory attributes sour taste and dirty white colour did not relate strongly to any of the consumer segments.

This illustrates that the concept of fufu 'flavour' varies widely among consumers. For the flours to become more acceptable to the majority of consumers in segments 3 and 1, the flours need to become creamier in appearance, shiny and soft in texture. Conversely, for consumers in the niche segment (2), they need to become stickier and have more

Table 2. Consumer acceptability of fufu

Fufu type	Mean	Standard deviation
Paste (modified)	6.9a	±2.4
Flour (traditional)	6.4b	±2.2
Paste (traditional)	6.1b	±2.1
Flour (commercial A)	5.6c	±2.2
Flour (modified)	5.5c	±2.2
Flour (commercial B)	4.8d	±2.6

Letters a to d indicate significant differences ($P < 0.05$) using the least significant difference (LSD) test.

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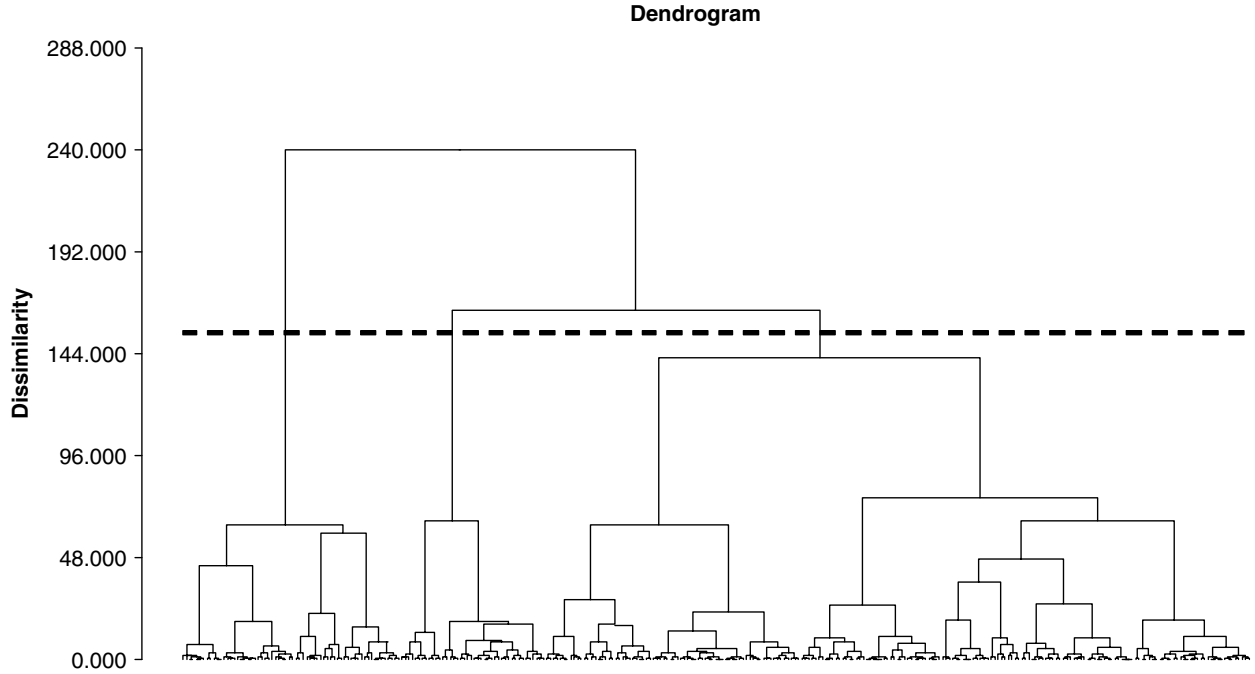

Figure 2. Hierarchical cluster analysis dendrogram for segmenting consumers into groups of similar perceptions of cassava fufu acceptability. Dotted line denotes level of dissimilarity along which the three segments (clusters) were selected.

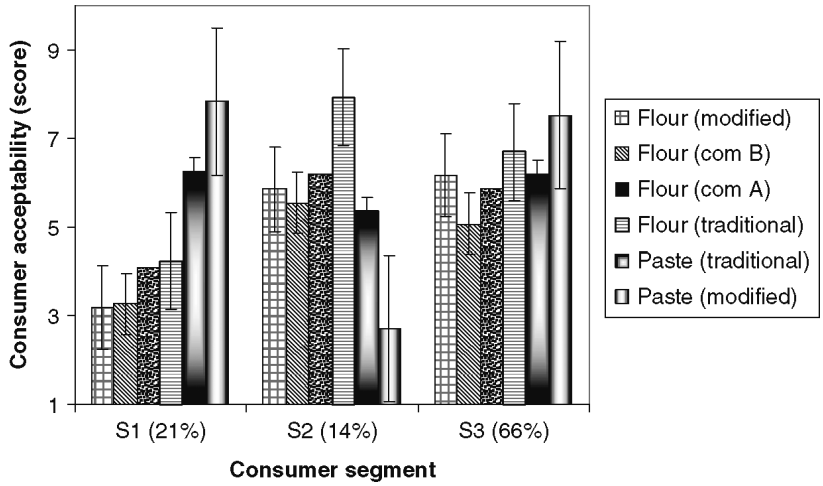

Figure 3. Mean consumer acceptability of cassava fufu (flours and pastes) by consumer segment. Error bars represent standard deviation (±).

raw cassava odour. Other studies,[7] while reporting significant differences in the sensory characteristics of fufu, did not explore variations in consumer response.

Considering the demographics and fufu consumption characteristics of the consumers belonging to each segment, the Kruskal–Wallis test indicated that the segments differed significantly with respect to gender ($P < 0.001$), age ($P = 0.007$), occupation ($P = 0.050$) and the form in which fufu was purchased ($P = 0.023$). The mean values for each segment were used to generate the PC plot illustrated in Fig. 5. Considering the largest segment of consumers (3; 66%), this group consisted of more males (60%), who were more likely to be artisans and civil servants and likely to purchase fufu in the wet form. The second largest segment of consumers (1; 21%) had a higher proportion of females (71%), was the youngest, predominantly traders, teachers and students and purchased fufu most frequently as flour. The smallest segment of consumers (2; 14%) consumed fufu the least frequently, purchased fufu in the cooked form, were the least likely to purchase fufu flour and were the group who said they were consuming more fufu now than previously. Other factors such as location or ethnic group had no effect on acceptability. This appears to be the first time that this has been reported for fufu.

Considering the nature of the relationships between consumer acceptance in each segment and the sensory attributes, linear models relating consumer liking and sensory scores have previously been reported for parboiled rice in West Africa.[11] Examination of the linear coefficients indicated only one significant ($P < 0.05$) relationship between consumer liking (segment 1) and soft texture. Graphical inspection of

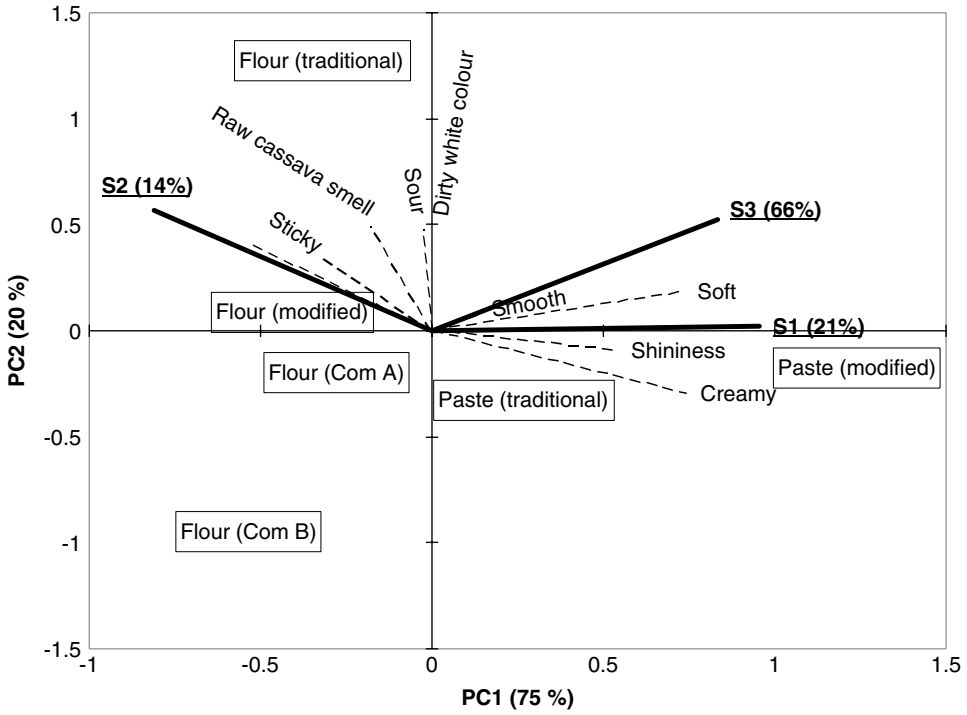

Figure 4. Internal preference map for consumer segments with respect to acceptability and sensory attributes of cassava fufu. S1, S2 and S3 refer to consumer segments; bold line, active variable in PCA; dashed lines, passive variables in PCA.

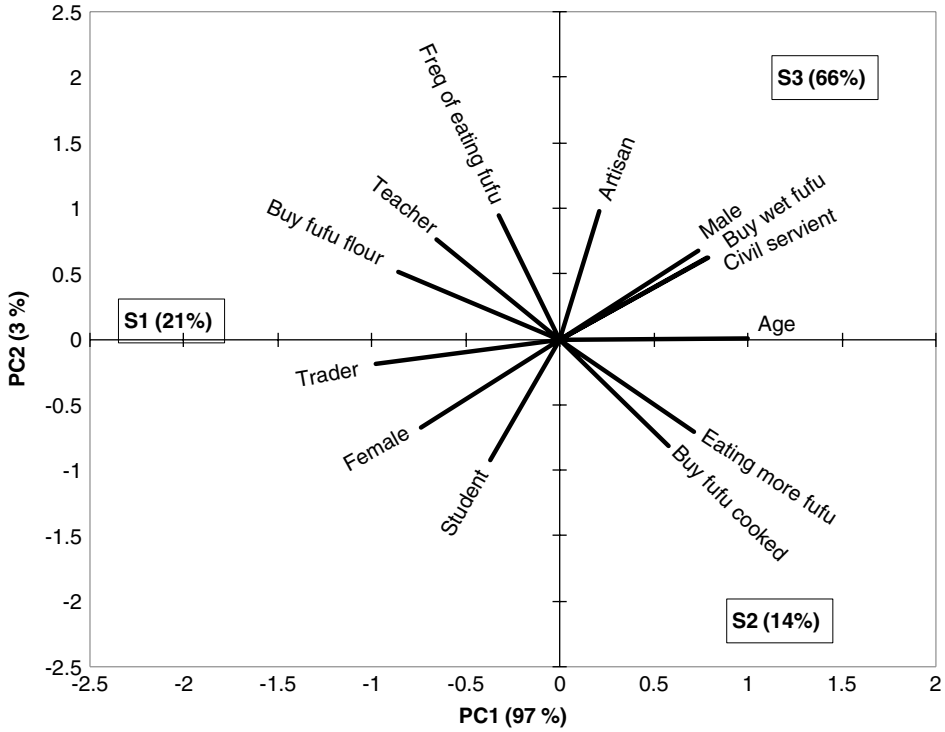

Figure 5. Principal component plot showing the relationship of social and economic profiles of consumers of cassava fufu for each liking segment.

the relationships suggested that for many sensory attributes the relationships with consumer acceptability might be non-linear and therefore second-order polynomial curves were fitted. This suggested potential significant ($P < 0.05$) relationships between consumer liking (segment 1 and soft texture and creamy appearance. The curves for creamy appearance and soft texture for all three consumer segments are illustrated in Fig. 6. The curves differed widely in shape. Although not shown, the curves for the other sensory attributes also appeared to vary widely between the different consumer segments. However, it should be noted that six samples were probably too few to enable non-linear relationships to be distinguished. Nonetheless, non-linear relationships between sensory attributes and consumer acceptability might be reasonable because

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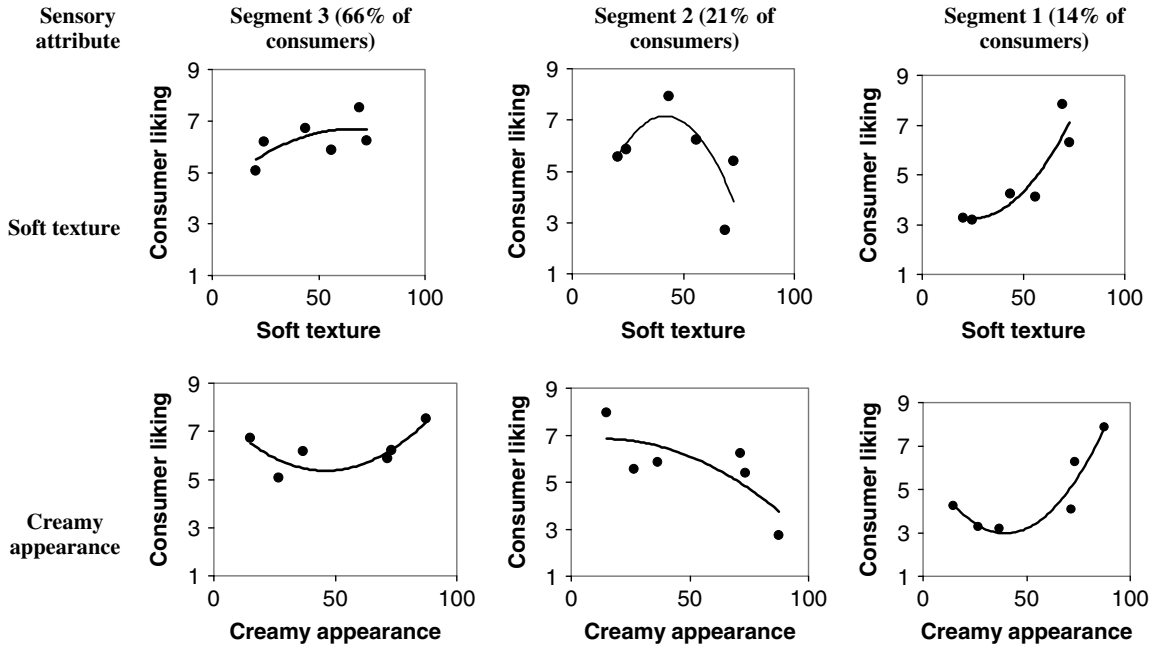

Figure 6. Graphical relationships between consumer acceptability and sensory attributes (soft texture and creamy appearance) for samples of fufu made from either paste or flour. Curves illustrate trends only. Curves are significant ($P < 0.05$) for soft texture and creamy appearance for segment 1 consumers only.

fufu is an acidic product with a strong odour, and extremes in intensity of sensory attributes might result in either liking or not liking the product.

CONCLUSIONS

While sensory evaluation and limited consumer trails have previously been reported for fufu in West Africa, this appears to be the first published study where larger numbers (311) of consumers have been tested and interviewed and segmentation methods applied to explore variations in acceptance within the group. Descriptive analysis and consumer evaluation showed distinctive flavour profiles for all fufus and their relationship with acceptability. The concept of 'fufu' flavour varied widely among consumers and consumers distinguished fufu made from traditionally sold pastes and from flour (which are increasingly being sold to more affluent consumers). These relationships illustrate that fufu acceptance is related to whether it is made from pastes or from flour with differing flavour characteristics, and acceptability varies widely among consumers, with specific segments preferring specific fufu flavour profiles. Fufu paste made using a more environmentally friendly process had the highest acceptance by consumers. This has implications for commercial producers of fufu and policy makers wishing to promote the consumption of traditional products in West Africa, especially since the cost of production is also less.[5,6] Fufu made from flour,[8] which is increasingly being consumed because of its convenience, will increase its acceptance if it can be manufactured to have a softer texture and enhanced creamy and shiny appearance. Acceptance also appears to be related to differing demographic profiles of consumers for each segment. The relationships between consumer acceptance and the sensory attributes appeared to be non-linear in many instances, but the number of samples tested (six) was too few to confirm this. It was speculated that the relationship might be non-linear because fufu is an acidic product with a strong odour.

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