African Journal of Food Science Vol 3.(11) pp. 334-339, November 2009
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 ©2009 Academic Journals

Full Length Research paper

Clustering acceptance and hedonic responses to cassava noodles extruded from cassava mosaic disease-resistant varieties

Nwabueze, U. Titus* and Anoruoh, A. Glory

Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, P. M. B. 7267 Umuahia, Abia State, Nigeria.

Accepted 26 October, 2009

Flours processed from eight cassava roots were selected from recently developed Cassava Mosaic Disease resistant varieties (92b/00061, 95/0289, 92/0057, 96/1632, 98/0505, 97/2205, TME419 and 92/0326). They were processed into noodles adapting a locally fabricated cold extruder as a single – screw extruder. The extruded cassava noodles were cooked and subjected to expansion ratio analysis and clustering sensory studies. There were no significant ($P \geq 0.05$) differences in the expansion ratios of noodles from different varieties. However, there were significant ($P \leq 0.05$) changes in expansion ratio due to processing. Those dried were about 1.98 times the diameter of the raw, while those cooked were up to 3 times the diameter of the raw. Principal component and cluster analyses of the parameters were adopted using the correlation matrix. Noodles made from 95/0289 CMD variety had the least acceptable sensory properties while those made from 98/0505 were most generally acceptable. No significant ($P \geq 0.05$) differences were noticed in taste, colour and general acceptability of all the samples. The sensory evaluation of noodles made from the 8 cassava varieties produced 2 principal components which accounted for 85.80% while the functional properties explained 81.30% of the variations. The key sensory properties that made the contributions, selected from the PC analysis based on their loadings ($P \geq 0.5$), were colour, taste, texture and general acceptability. The result showed that cassava flour could serve as a good substitute to wheat flour in noodle production and utilization.

Key words: Cassava mosaic disease, cassava flour, noodles, extrusion, single-screw extruder, sensory evaluation, expansion ratio, principal components, cluster analysis, dendrogram, hierarchical tree, Eigenanalysis, correlation matrix.

INTRODUCTION

Cassava (*Manihot esculenta*) which plays an important role in alleviating the African food crisis is currently being threatened by a virulent form of the Cassava Mosaic Disease (CMD) advancing rapidly from East Africa (IITA, 2005). This initiated the Cassava Mosaic Disease (CMD) Project by the International Institute of Tropical Agriculture (IITA) primarily to develop Cassava Mosaic Disease resistant varieties (Etudaiye et al., 2009).

Although cassava roots are processed by several traditional methods, which vary widely from region to region, into products such as *gari, lafun, foo-foo* and *ighu* (Nwabueze and Odunsi, 2007), high quality cassava flour that can replace wheat and other imported flours in tropical countries (Wheatley and Best, 1991) has been reported.

Extrusion processing currently being used to produce fabricated foods, can be divided into two general types: the non-cooking or forming extrusion (cold extrusion) which transforms the feed into a homogeneous cohesive extrudate without cooking, and the cooking extrusion (high temperature short time, HTST) which cooks the raw ingredients by the combination of heat, mechanical shearing and pressure (Rizvi et al., 1995; Nwabueze and Iwe, 2008). Cold extrusion, followed by low temperature drying, is also used in the production of pasta, macaroni, spaghetti and other noodle products of which Nigerians

*Corresponding author. E-mail: teeubueze@yahoo.co.uk.

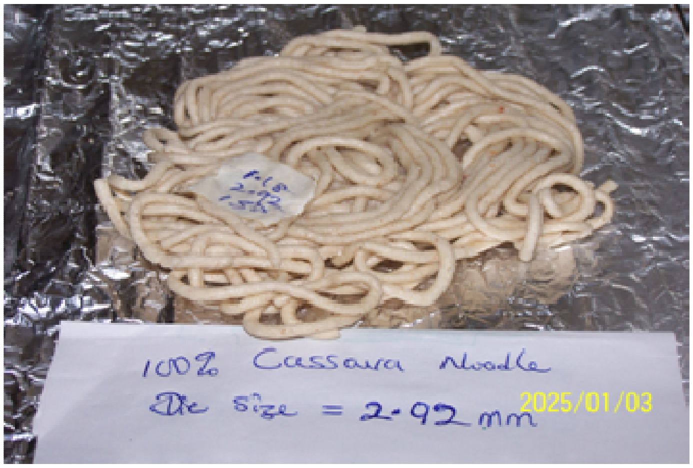

Figure 1. Noodle extrudates from cassava mosaic disease-resistant varieties.

are familiar with and readily patronize (Nwabueze et al., 2007). Commercial instant noodles (chicken flavoured) in the Nigerian market made from cereals include Indomie® and Mimee®. There is a dearth of information on noodles from cassava and especially from cassava mosaic disease (CMD) resistant varieties. This was the thrust of this research.

In this study, a locally fabricated single-screw extruder was adapted for cold noodle extrusion **(**Nwabueze and Anoruoh, 2009) from eight CMD resistant varieties. The extruder was adapted to demonstrate its potential use to local farm families alongside the developed varieties because of its simplicity, low cost, ease of operation and adaptability to small household noodle processing from cassava.

Principal component and cluster analyses of the parameters were adopted using the correlation matrix with the objective of grouping the varieties into functional groups. Cluster analysis is the organization of a collection of patterns (usually represented as a vector of measurements, or a point in a multidimensional space) into clusters based on similarity (Jain et al., 1999).

MATERIALS AND METHODS

Source of materials

About 20 kg of eight CMD root varieties (92b/00061, 95/0289, 92/0057, 96/1632, 98/0505, 97/2205, TME 419 and 92/0326) were obtained from National Root Crops Research Institute (NRCRI), Umudike, Nigeria. All the varieties were harvested 4 months after planting.

Production of cassava flours

The cassava roots were washed, peeled and re-washed with clean borehole water. They were cut separately into thin chips of 1.5 mm (mean thickness) with the aid of a chipping machine and put in different previously labeled plastic bowls. The cassava chips were sun-dried and mechanically milled into flour of 0.5mm particle size. Recovered flours were packaged separately by variety in polyethylene bags and stored at room temperature until needed for analysis.

Cold extrusion of cassava noodles

The cassava flours were each evenly mixed with warm water to form a paste which was slowly mixed with a dry sample of the same flour until smooth dough was formed. About 0.02 g of alum was dissolved in water and added to the dough for stabilization. The noodles were extruded through a die of 1.64 mm diameter into boiling water. The noodles remained in the water for about 5 min after which the extrudates were transferred into a bowl of cold water and allowed to remain there for 15min. The extrudates obtained (Figure 1) were spread on the laboratory table at room temperature (29±1°C) for 4 h before drying in a Carbolite (Aston Lane, Hope, Sheffield, England) electric oven at 65°C for 2 h.

Expansion ratio of noodle extrudates

The expansion ratios of raw, dry and boiled noodle extrudates were determined as the mean of 10 determinations per sample run using the method described by Nwabueze and Iwe (2006). A micrometer screw gauge (Mututoyo, Corp., Japan), accurate to 0.01 mm was used. The expansion ratio was expressed as the ratio of the diameter of the noodle to that of the die orifice.

Sensory analysis of noodle extrudates

The cassava noodles were cooked and served to 30 taste panelists, all students of the University community. A descriptive 9-point hedonic scale rating was used to score samples for colour, taste, flavour and general acceptability with 9 as like extremely and 1 as dislike extremely and 5 neither like nor dislike.

Statistical analysis of sensory attributes of noodle extrudates

A complete random design was adopted for statistical analysis. Statistical significance was determined by analysis of variance at 0.05% level of significance (SAS, 1989). Principal component analysis of the observations of the sensory attributes of noodle extrudates including Hierarchical cluster and Amalgamation steps (Squared Euclidean Distance) were adopted using the correlation matrix.

RESULTS AND DISCUSSION

Expansion ratio of noodle extrudates

Data on the effect of processing on the expansion ratio (ER) of noodles made from eight CMD varieties are shown in Table 1. There were no significant ($P \geq 0.05$) differences in the expansion ratios of raw, dry or boiled noodles between the eight varieties. The expansion ratio of the raw noodles ranged from 1.0 in 92/0057 to 1.06 in 98/1632 which significantly ($P \leq 0.05$) increased to1.23 and 1.12 when dried, and 2.57 and 2.13 when boiled respectively. Expansion ratio ranged from 1.09 in 97/2205

Table 1. Effect of processing on expansion ratio of noodles made from eight CMD varieties.

Variety	Raw	Dried	Boiled
97 / 2205	1.02^{a} ± 0.002	1.09^{b} ± 0.005	2.02^{c} ± 0.003
92b / 00061	1.02^{a} ± 0.005	1.16^{b} ± 0.005	2.46^{c} ± 0.005
92 / 0057	1.00^{a} ± 0.001	1.23^{b} ± 0.002	2.57^{c} ± 0.003
92 / 0326	1.03^{a} ± 0.002	1.37^{b} ± 0.003	2.59^{c} ± 0.002
95 / 0289	1.01^{a} ± 0.001	1.27^{b} ± 0.001	2.57^{c} ± 0.001
TME 419	1.02^{a} ± 0.005	1.39^{b} ± 0.005	2.55^{c} ± 0.004
98/0505	1.01^{a} ± 0.005	1.37^{b} ± 0.002	2.80^{c} ± 0.005
98/1632	1.06^{a} ± 0.003	1.12^{b} ± 0.002	2.13^{c} ± 0.005

Means with different superscripts within the same rows are significantly (P ≤0.05) different.

Table 2. Sensory evaluation of cooked noodles made from eight CMD resistant varieties.

Variety	Colour	Flavour	Texture	Taste	General acceptability
97/2205	6.60^{a} ± 0.426	7.00^{a} ± 0.487	5.25^{bcd} ± 0.497	6.60^{a} ±0.426	5.30^{e} ± -0.341
92b/00061	5.95^{a} ± 0.387	5.80^{ab} ± 0.374	6.55^{ab} ± 0.344	5.95^{a} ± 0.387	5.65^{a} ± 0.393
92/0057	6.05^{a} ± 0.413	5.80^{ab} ± 0.329	6.15^{abc} ± 0.372	6.05^{a} ± 0.413	5.90^{a} ± 0.340
92/0326	6.45^{a} ± 0.387	5.30^{b} ± 0.476	5.05^{cd} ± 0.559	6.45^{a} ± 0.387	5.85^{a} ± 0.573
95/0289	5.45^{a} ± 0.373	5.10^{b} ± 0.502	3.95^{d} ± 0.484	5.45^{a} ± 0.373	5.30^{a} ± 0.576
TME 419	5.85^{a} ± 0.350	5.70^{ab} ± 0.371	6.15^{abc} ± 0.342	5.85^{a} ± 0.350	5.60^{a} ± 0.419
98/0505	6.35^{a} ± 0.418	6.80^{a} ± 0.329	7.10^{a} ± 0.470	6.35^{a} ± 0.418	7.00^{a} ± 0.487
96/1632	5.95^{a} ± 0.450	6.10^{ab} ± 0.441	5.40^{bc} ± 0.432	5.95^{a} ± 0.450	5.60^{a} ± 0.419

Means with different superscripts within columns are significantly (*P* ≤0.05) different.

to 1.39 in TME 419 when dried in the sun and from 2.02 in 97/2205 to 2.80 in 98/0505 variety when boiled at 100℃. Low moisture feeds exhibit more drag and therefore exert more pressure at the die resulting in greater expansion at the exit of the die than higher moisture feeds.

The high ER shown by variety 98/0505 (≈ 3x) could result from its lower gelatinization temperature and high gelation capacity. The degree of expansion of cassava extrudate depended on the degree of dextrinization which was influenced by total carbohydrate composition of the feed material. When further processed, noodles made from variety 97/2205 showed a consistently lower ER whether dried or boiled.

Table 2 shows that there were no significant ($P \geq 0.05$) differences in the taste, colour and general acceptability of cooked noodles made from the eight CMD cassava flours. Noodles colour on exiting the die orifice ranged from grey to milky-grey. Although noodles were cold extruded, the effect of extrusion processing on extrudate colour has been variously described in the literature (Nwabueze et al., 2008).

Sensory attributes of noodle extrudates

Noodles made from 95/0289 CMD variety had the least acceptable sensory properties while those made from 98/0505 were most generally acceptable (Table 2). General acceptability gives a general idea of the panelists' total impression towards the noodles. Acceptability of noodles made from 98/0505 was supported by their good sensory scores on taste, flavour and texture. Texture has been described as one of the most important characteristics affecting consumer acceptance of snack products (Suknark et al. 1998).

Although mean scores (6.35) for noodles' colour of milky-grey contributed to the high acceptability of noodles made from 98/0505, texture (7.10) would have contributed more as an indicator of food quality (Lawless and Heymann, 1998) than either colour or flavour. It was observed that the experience of the panelists as traditional consumers of more familiar cassava products such as *fufu* and *gari* affected their sensory assessments on general acceptability of cassava noodles (5.30 - 7.0), particularly when the noodles examined were not seasoned to taste. This could probably constitute a major factor in developing good textured noodles from CMD resistant varieties with a high general acceptability.

Clustering analysis of observations of sensory attributes of noodle extrudates

The principal component analysis of the sensory evaluation of noodles produced 2 principal components which accounted for 85.80% of the variations in the sensory

Table 3. Principal component analysis of sensory attributes of noodle extrudates.

Variable	PC1	PC2	PC3	PC4	PC5
X_1	0.499	-0.396	0.255	0.173	0.707
X_2	0.475	-0.083	-0.722	-0.496	-0.000
X_3	0.378	0.589	-0.272	0.660	0.000
X_4	0.499	-0.396	0.255	0.173	-0.707
X_5	0.366	0.577	0.524	-0.509	-0.000
Eigen analysis of the correlation matrix					
Eigen value	3.1218	1.2008	0.4386	0.2388	0.0000
Proportion	0.624	0.240	0.088	0.048	0.000
Cumulative	0.624	0.865	0.952	1.000	1.000

PC = principal component for the variables 1-5. X_{1-5} = colour, flavour, texture, taste, and general acceptability.

Table 4. Hierarchical cluster analysis of observations of the sensory attributes of noodle extrudates and amalgamation steps using squared Euclidean distance.

Step	No. of cluster	Similarity	Distance level	Cluster joined		New cluster	No. of observations in new cluster
1	7	98.96	0.180	3	6	3	2
2	6	98.60	0.242	2	3	2	3
3	5	92.35	1.325	4	8	4	2
4	4	82.45	3.040	2	4	2	5
5	3	76.35	4.097	1	2	1	6
6	2	55.00	7.795	1	7	1	7
7	1	0.00	17.322	1	5	1	8

Table 5. Final partition of the sensory attributes of noodle extrudates from the eight cassava varieties.

No. of cluster groups	No. of observations	Within cluster sum of squares	Average distance from controid	Maximum distance from controid
Cluster 1	7	8.450	0.993	1.804
Cluster 2	1	0.00	0.00	0.00

evaluation of the noodle extrudates (Table 3). This can be expressed thus:

$$PC_1 = 0.500X_1 + 0.464X_2 + 0.383X_3 + 0.500X_4 + 0.371X_5 \quad 1$$

$$PC_2 = -0.395X_1 -0.097X_2 + 0.588X_3 -0.395X_4 + 0.577X_5 \quad 2$$

The key sensory properties that contributed the 85.80% of the variables, selected from the PC analysis based on their loadings (≥ 0.5), were colour and taste for PC_1, and texture and general acceptability for PC_2. Other principal components (PC_3-PC_5) were neglected because of their little or no contribution to the total variations in the variables.

Hierarchical cluster analysis of observations of the sensory attributes of noodle extrudates is shown in Table 4. It describes a simple distance measure like Euclidean Distance which can be used to reflect dissimilarity between two patterns. The distance measures with low coefficients are grouped together. A variety of distance measures are in use in the various communities (Jain and Dubes, 1988).

The operation of a hierarchical clustering algorithm produced a nested series of partitions based on a criterion for merging or splitting clusters based on similarity. Table 5 shows the final partition of the sensory attributes of noodle extrudates from the 8 cassava varieties. Partitioned clustering algorithms identify the partition that optimizes a clustering criterion (Jain et al., 1999). The centroid of each of these clusters was determined by computing the mean of the moment vectors of the sensory attributes falling into the cluster. The clustering obtained in this work demonstrated that the sensory attributes of noodles produced from each CMD-resistant variety fall into two distinguishable clusters (Table 5). The number of clusters is demonstrated in dendrograms (Figures 2 and 3) obtained from the single- link algorithm

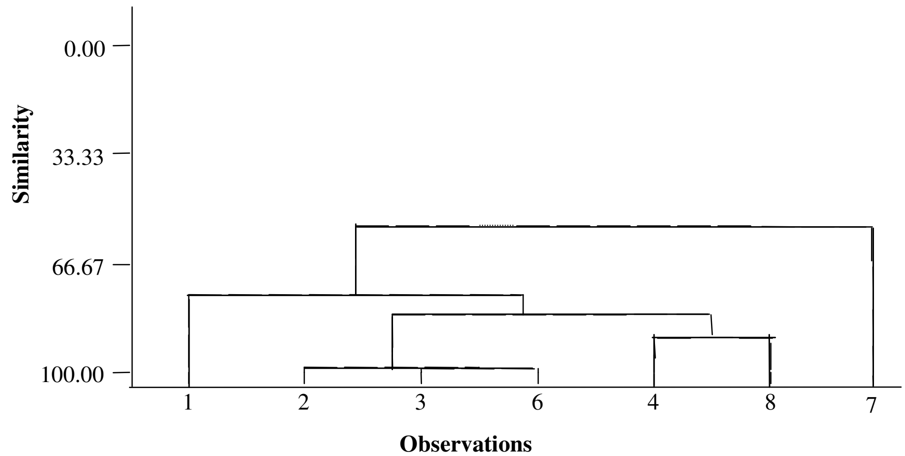

Figure 2. A hierarchical tree diagram or dendrogram showing noodle extrudates in cluster group 1 based on the similarities of their sensory attributes. The 7 observations (1, 2, 3, 6, 4, 8 and 7) are the cassava varieties (97/2205, 92b/00061, 92/0057, TME 419, 92/0326, 96/1632 and 98/0505) in the cluster group. The CMD-resistant variety 98/0505 (observation 7) has the highest sensory attributes.

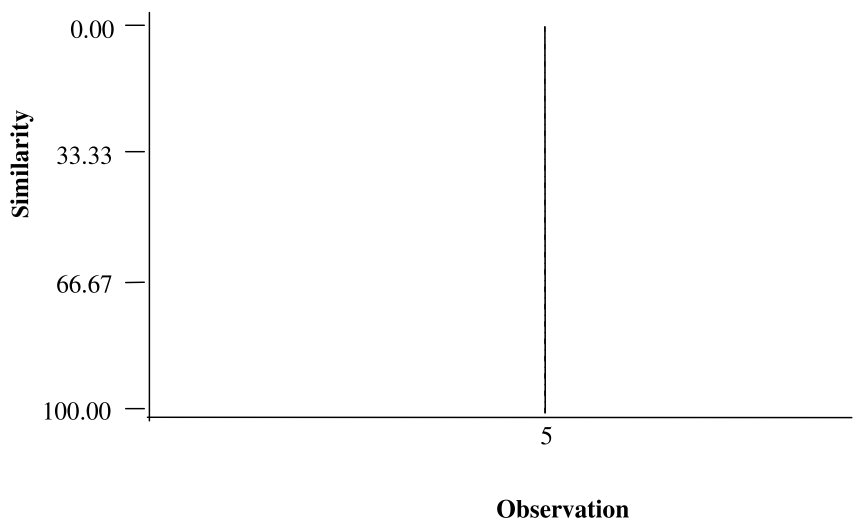

Figure 3. A hierarchical tree diagram or dendrogram showing noodle extrudate in cluster group 2 based on its sensory attribute. The observation 5 means that only cassava variety 95/0289 belongs to this cluster group.

(Jain and Dubes, 1988). The dendrogram can be broken at different levels to yield different clustering of the data (Nwabueze, 2009).

A dendrogram represents the nested grouping of patterns and similarity levels at which groupings change (Jain et al., 1999). It is a hierarchical tree diagram or plot which shows the relative size of the proximity coefficients at which cases were combined. Cases with low distances are close together with a line linking them. A short distance from the left of the dendrogram indicates that they are agglomerated into a cluster at a distance coefficient indicating similarity.

In this study, the hierarchical tree diagram or dendogram dendrogram demonstrated in Figures 2 and 3 and 7 observations (1, 2, 3, 6, 4, 8 and 7) or cassava varieties 97/2205, 92b/00061, 92/0057, TME 419, 92/0326, 96/1632 and 98/0505, belong to one cluster group while a single observation (5) or variety 95/0289 falls into the second cluster group . One can therefore select 98/0505 cassava variety from cluster group 1 (observation 7, Figure 3) with the best sensory scores and the other single observation (95/0289) from cluster group 2 with the least of the sensory attributes, for processing into cassava noodles as representatives of the 8 varieties on on the basis of their sensory attributes.

Conclusion

The flours were found suitable for cold extrusion of good and acceptable noodles. Noodles made from 95/0289 CMD variety had the least acceptable sensory properties while those made from 98/0505 were the most generally acceptable. There were no varietal differences in the diameters of the noodles determined as expansion ratios. Processing whether by drying or by boiling in water at 100°C showed significant ($P \leq 0.05$) differences in expansion ratios from the original raw noodles. This information encourages processing of the CMD flours into noodles especially the 98/0505 (or observation 7) cassava variety from group 1 with sensory scores as high as 7 on a 9-point hedonic scale. Adaptation of locally fabricated single-screw extruder for noodle production is a development that could easily sell at household levels as it will also introduce variety in cassava processing and utilization. The extruder is simple, low cost and easy to operate. This could in turn lead to an increase in food availability and help improve the nutrition of the Nigerian population.

REFERENCES

Etudaiye HA, Nwabueze TU, Sanni LO (2009). Quality of *fufu* processed from Cassava Mosaic Disease (CMD) resistant varieties. Afr. J. Food Sci. *3*(3): 061-067.

IITA (2005). Pre-emptive management of the virulent cassava mosaic disease in Nigeria. Annual report, July 2003-June, 2004. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Jain AK, Dubes RC. (1988). Algorithms for Clustering Data. Prentice-Hall advanced reference series. Prentice-Hall, Inc., Upper Saddle River, NJ.

Jain AK, Murty MN, Flynn PJ (1999). Data clustering: A Rev. ACM Comput. Surv. 31(3):264-323.

Lawless HT, Heymann H (1998). Sensory evaluation of food: Principles and Practices. New York: Chapman and Hall. p. 827.

Nwabueze JC (2009). Statistical grouping of Cassava Mosaic Disease-resistant varieties cultivated by the National Root Crops Research Institute, Umudike, Nigeria. Afr. J. Math Compu. Sci. Res. http://www.academicjournals.org/AJMCSR.

Nwabueze TU, Iwe MO (2006). Mass flow rate, nutrient composition and some functional properties of single screw extruded Africa breadfruit (*Treculia africana*) blends. J. Food Technol. *4*(1), 50-58.

Nwabueze TU, Odunsi FO (2007). Optimization of process conditions for cassava (*Manihot esculenta*) *lafun* production. Afr. J. Biotechnol., *6*(5): 603-611.

Nwabueze TU, Iwe MO, Akobundu ENT (2007). Unit operations and analyses for African breadfruit based spaghetti-type products at extreme process combinations. J. Food Technol. *5*(1): 42-48.

Nwabueze TU, Iwe MO. (2008). Residence time distribution (RTD) in a single -screw extrusion of African breadfruit mixtures. Food and Bioprocess Technology. Springer Publication: 16 February 2008. http://dx.doi.org/10.1007/s11947-008-0056-z.

Nwabueze TU, Iwe MO, Akobundu NT (2008). Physical characteristics and acceptability of extruded African breadfruit-based snacks. J. Food Quality. 31: 142-155.

Nwabueze TU, Anoruoh GA (2009). Evaluation of Flour and Extruded Noodles from Eight Cassava Mosaic Disease (CMD) Resistant Varieties. Food and Bioprocess Technol. An Int. J. DOI: 10.1007/s11947-009-0200-4.

Rizvi SSH, Mulvansy SJ, Sokhey AS. (1995). The combined application of supercritical fluid and extrusion technology. Trends Food Sci. Technol. 6: 232- 240.

SAS (1989). RSREG procedure, SAS/STAT User's Guide Version 6, vol. 2, 4th edition. Cary, NC: SAS Institute Inc. SAS Circle, pp.1457-1478.

Suknark K, McWatters KH, Phillips RD (1998). Acceptance by American and Asian consumers of extruded fish and peanut snack products. J. Food Sci. 63: 721 - 725.

Wheatley CC, Best R (1991). How can traditional forms of nutrition be maintained in urban centres: the case of cassava. Entwicklung Landlicher Raum. 25(1): 13-16.