American Journal of Experimental Agriculture
4(1): 114-124, 2014

SCIENCEDOMAIN ***international***
www.sciencedomain.org

Studies on Some Important Consumer and Processing Traits for Breeding Sweet Potato for Varied End-uses

S. O. Afuape[1*], I. I. M. Nwankwo[1], R. M. Omodamiro[1], T. N. C. Echendu[1] and A. Toure[2]

[1]National Root Crops Research Institute, Umudike, PMB 7006, Umuahia, Abia State, Nigeria.
[2]CSIR Office Complex, Agostino Neto Road, Airport Residential Area, PMB KIA 114, Airport Alliance for Green Revolution for Africa (AGRA), Accra, Ghana.

Authors' contributions

Author SOA the project team leader, designed the study and led field activities. Authors IIMN and TNCE were involved in day-to-day field activities and data collection. Author AT proof-read the first draft of the manuscript and contributed significantly to the final draft. He also supervised aspects of the project. Author RMO carried out all laboratory analyses and sensory evaluations. All authors read and approved the final manuscript.

Original Research Article

Received 3rd July 2013
Accepted 5th October 2013
Published 24th October 2013

ABSTRACT

Aims: To determine; (1) the variability among the elite sweet potato lines for root processing quality traits; (2) the heritability of each trait and the correlation among them; (3)the acceptability of the boiled and fried roots by sweet potato consumers; and (4) an easy-to-measure traits that are linked to consumer acceptability of sweet potato roots.
Study Design: Completely randomized design with three replications.
Place and Duration of Study: The National Root Crops Research Institute, Umudike, Nigeria.
Methodology: Fourteen advanced sweet potato lines were evaluated for processing traits such as dry matter, starch yield, flour yield, peel-loss, and total carotenoid. Correlation analysis among the traits was carried out, and broadsense heritability for each trait was calculated. Sensory evaluation was carried out on roots of the lines using selected panelists. Culinary traits that most influenced acceptability of boiled and fried sweet potato

**Corresponding author: Email: solomonafuape@yahoo.com;*

roots were determined using forward selection multiple regression analysis.
Results: There was significant (P=.05) variation among the 14 advanced lines for dry matter, starch content, flour content and peel loss. Dry matter ranged between 24.16 and 34.17%, starch content between 17.58 and 22.0%, flour yield between 21.34 and 32.32% and peel loss between 18.17 and 24.01%. Correlation studies showed that dry matter had significant ($P<0.05$) correlation with starch and flour yield. There were significant ($P<0.05$) differences among the genotypes for root colour and general acceptability for boiled roots, and root colour, mouth-feel, taste, aroma and general acceptability for fried roots. Forward selection multiple regression analyses for boiled and fried sensory traits identified fresh root colour as an easy-to-select trait to breed for consumer acceptability.
Conclusion: All the processing traits evaluated were heritable and most of them acceptable for boiled and fried food forms. The identification of root flesh colour as an easy-to-measure trait that influences consumer acceptability is a major achievement of this work.

Keywords: Sweetpotato; processing traits; heritability; regression analysis; sensory evaluation.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L. Lam) is the only species that produce tuberous roots out of the about 500 other species of the genus *Ipomoea*. It is the 7^{th} most important crop in term of annual production globally. China is the highest producer of sweet potato with production figure of 75.6 million tonnes in 2011, followed by Tanzania and Nigeria with production figures of 3.57 and 2.73 million tonnes respectively [1]. Nigeria is not an exporter of sweet potato in any form, and as such, all the sweet potato produced are usually consumed within the country. The major forms by which sweet potato roots are consumed in Nigeria are by boiling and eating, frying, and as a sweetener in local non-alcoholic beverage called kunnu, which is popular in northern Nigeria. Other lesser forms include portage and pounding [2]. Industrial processing and utilization of sweet potato is not common. However, the emergence of commercial sweet potato fried chips in urban centers and cities, as well as the road-side fries are the first forms of commercial processing of sweet potato that has evolved or is evolving in the country. Other root crops like cassava and potato (*Solanum tuberosum*) enjoy higher levels of processing than sweet potato. While potato fries dominate the fries industry in major eateries across the country, cassava is used in the production of industrial starch, syrup as well as bakery products. However, sweet potato’s shorter growth cycle of about 4 months, ability to grow well in all agro-ecologies of Nigeria, its adaptability to marginal lands, and its high productivity within four months will ensure constant availability of roots for processing compared to any other root crop.

The development of new sweet potato varieties with higher productivity has largely focused on increasing yield and resistance to biotic factors. Improving the processing qualities of sweet potato has not enjoyed commensurate attention as increasing yield on farmers’ fields. This is probably why most of the cultivars available are only suitable for consumption as fresh roots, and not suitable for processing. The processing industries require high dry matter, high flour yield as well as high starch contents and quality. These quality traits make such product fit for the downstream industries like textile, paper, pharmaceutical etc that use starch as raw materials, and the bakeries that require high quality flour. Developing new varieties that satisfy these processing requirements will rely on adequate information about the availability of the genes in the gene pool of the breeding program, the relationships among the quality traits, identification of easy-to-measure trait that has large influence on acceptability, and the heritability of the root quality traits. Therefore, the objectives of this work are to determine the variability among the breeding lines in terms of root processing qualities, dry matter content, starch content, flour content, peel loss and total carotenoid, to determine the heritability and the relationships among these traits, to determine the acceptability of the boiled and fried roots, and to identify traits that are linked to consumer acceptability of sweet potato roots, and that are also easy to measure.

2. MATERIALS AND METHODS

Fourteen advanced sweet potato lines of various flesh colours (white/cream, orange and yellow) were evaluated at Umudike, southeastern Nigeria in 2011. The genotypes were laid out in a randomised complete block design with three replications. The plot size was $9m^2$ (3m X 3m) containing 30 plants per plot with plant spacing of 1m X 0.3m, giving plant density of 33,333 stands per hectare. Fertilizer, NPK 15:15:15, was applied at the rate of 400kg/hectare after the first weeding at five weeks after planting. Harvesting was done at four months after planting. At harvest, three medium root samples (which were the dominant root size) from each plot were collected, bagged in black polythene, labeled and sent to the laboratory for immediate analyses. Each root was weighed before manual peeling, and re-weighed after peeling to determine peel-loss per root per plot. One root was re-bagged and store in the freezer in the dark for carotenoid content determination. The average peel-loss for each plot was calculated and recorded. The roots from each plot were sliced and mixed together, from which 100g was taken for dry matter, starch content (on wet basis) and flour content analyses. For total carotenoid determination, the HarvestPlus procedure was followed [3]. While working in the dark, the fresh roots in the freezer were retrieved and washed. Acetone carotenoid extraction procedure was used by homogenizing 5g of sweet potato roots with 50mL of cold acetone for 1 min, and the slur was filtered. The residue was washed with acetone until there was no more carotenoid colour. 40mL of petroleum ether (PE) was added to the filtrate, and separate layers of PE+carotenoid (top layer) and acetone (down layer) were formed as water was added. The PE-carotenoid phase was carefully collected. The volume was made up to 50mL with PE. Thereafter, absorbance at 450 nm was taken. Total carotenoid (µg/g) was calculated as:

$$(A \text{ X Volume (mL) X } 10^4) / (A1^{1\%}{}_{cm} \text{ X Sample weight (g)}$$

Where; A = absorbance; Volume = total volume of extract (50mL); $A1^{1\%}{}_{cm}$ = absorption coefficient of β-carotene in PE (2592). (Absorption coefficient of β-carotene in PE is usually used for total carotenoid in sweet potato because over 80% of its total carotenoid is β-carotene.

2.1 Sensory Evaluation

Some root samples from each advanced breeding line were also taken from the field for sensory (culinary) analysis. Some fresh roots from each line were boiled while some fried. Twenty untrained panelists who eat sweet potato as their staple food naturally were invited to score each breeding line for storage root colour after boiling and frying, mouth-feel, taste, aroma and general acceptability. Each panelist was encouraged to rinse his/her mouth after tasting one or two samples so as to keep the taste buds fresh as much as possible before tasting the other samples. The panelists were asked to indicate the degree of likeness of each line using a 9-point Hedonic scale, where 9= like extremely, 5=neither like nor dislike and 1= dislike extremely.

2.2 Statistical Analysis

All statistical analyses were carried out on the various data ~~were done~~ through the various procedures of SAS software version 9.2 [4]. Analysis of variance was performed on the root processing quality traits using SAS GLM procedure, while Fisher's $LSD_{0.05}$ was used to separate the means of the advanced breeding lines for each trait. Correlation analysis was performed to determine the relationships that exist among the traits using SAS Proc. Corr command. Principal component biplot between principal component 1 and principal component 2 was generated for the processing traits using the SAS Princomp procedure. Phenotypic variance, genotypic variance and broadsense heritability estimates were calculated using the expected means square method. The variance components were calculated from a linear function of the means squares of the ANOVA thus:

d^2e = MSE; d^2g = (MSG – MSE) /r; $d^2p = d^2g + d^2e$; and $h^2B = d^2g / d^2p$; where
d^2e = environmental variance component;
MSE = mean square of error;
d^2g = genotypic variance component;
d^2p = phenotypic variance component;
MSG = mean squares of genotypes;
R = number of replicates;
H_B = broadsense heritability.

Sensory evaluation data of the boiled and fried root samples were analysed, using SAS GLM procedure for randomized complete block design. Panelists were used as blocks. Fisher's $LSD_{0.05}$ was used to separate the means of the scores of each breeding line. Lastly, forward selection multiple regression analyses were performed on the sensory (culinary) traits to identify easy-to-select trait that has positive effect on general acceptability of sweet potato varieties.

3. RESULTS AND DISCUSSION

3.1 Variability Studies among the Genotypes for Root Processing Traits

Table 1 shows the mean squares of the analysis of variance (ANOVA) of the processing quality traits (dry matter, starch content, flour content, peel-loss and total carotenoid content) of 14 advanced sweet potato breeding lines. The advanced lines showed significant (*P*=.05) variation in dry matter, starch content, flour content, peel-loss and total carotenoid content. Dry matter content ranged between 24.16 and 34.17%, starch content was between 17.58 and 22.00%, flour content was between 21.34 – 32.32%, peel-loss between 18.17 – 23.31%, and total carotenoid between 0.58 and 20.82 µg/g (fresh weight basis) (Table 2). Sweet potato genotypes had been reported to exhibit significant differences in dry matter (*P* <.0001), starch content (*P* <.0001) and β-carotenoid content (*P* <.0001 [5]. Dry matter (and auto-correlated traits to dry matter like starch and flour contents) often differ as a result of cultivar, location, climate, day length, soil type, pest and disease incidence and cultivation practices [6]. In previous works, dry matter range of 15.0 – 35.0% [5], 18.5 - 29.2% [7] and 20.0 – 37.8% [8] had been reported. The sweet potato genotypes evaluated in this study had dry matter content ranging from 24.16 to 34.16%. The range of 5.4 – 21.9% for starch content had also been reported [5]. The sweet potato genotypes in this study had a starch range of 17.58 - 22.00%. The dry matter and starch contents of the breeding lines showed narrower values compared to the reports of the previous three authors, probably because our genetic materials at advanced stage of the breeding cycle had passed through many selection cycles for the measured traits. More than 70% of our lines had <5 µg/g carotenoid. Similar result had been reported before [5].

Table 1. Mean squares of the analysis of variance of dry matter, starch content, flour yield and peel loss of 14 advanced breeding lines of sweet potato evaluated in 2011

Source	Degree of freedom	Mean squares of the analysis of variance for each trait.				
		Dry matter	Starch yield	Flour yield	Peel loss	Total carotenoid
Genotypes	13	18.0289***	3.3886**	21.5679***	6.1882***	113.6939***
Error	14	0.2532	0.6859	0.2507	0.1982	0.02348
Total	27					

**** = P<0.0001, ** = P<0.01.*

Table 2. Means of dry matter, starch yield, flour yield and peel loss of 14 advanced sweet potato breeding lines evaluated in the rainforest belt of Umudike in 2011

Breeding lines	Source	Dry matter (%)	Starch yield (%)	Flour yield (%)	Peel loss (%)	Total carotenoid (µg/g fresh weight basis)
TIS 87/0087	IITA, Ibadan	34.17	21.32	32.32	21.02	2.38
EX-IGBARIAM	NRCRI, Umudike	33.33	21.20	27.89	21.74	2.73
NRSP/05/1B	NRCRI, Umudike	30.15	22.00	29.46	18.98	n.a
NRSP/05/7C	NRCRI, Umudike	30.14	20.26	29.01	19.21	1.88
NRSP/05/022	NRCRI, Umudike	29.38	20.51	21.34	19.62	7.14
EX-OYUNGA	CIP, Kenya	29.38	17.58	25.14	20.01	19.60
CIP 440163	CIP, Kenya	28.08	19.65	24.53	23.31	1.61
NRSP/05/3D	NRCRI, Umudike	27.04	19.22	24.72	18.21	0.58
SHABA	CIP, Kenya	27.03	20.76	22.34	20.31	3.64
NRSP/05/3B	NRCRI, Umudike	26.65	19.42	22.83	20.33	1.15
NRSP/05/10D	NRCRI, Umudike	25.79	18.92	24.81	18.86	2.41
CIP 440293	CIP, Kenya	25.44	18.04	21.60	18.17	20.82
CENTENNIAL	CIP, Kenya	25.04	18.47	24.22	24.01	17.80
CIP 199034.1	CIP, Kenya	24.16	20.23	22.73	19.70	3.02
$FLSD_{0.05}$		1.08	1.78	1.07	0.95	0.03

**CIP, Kenya = International Potato Center, Regional Office, Nairobi, Kenya; NRCRI, Umudike = National Root Crops Research Institute, Umudike, Nigeria; IITA, Ibadan = International Institute for Tropical Agriculture, Ibadan, Nigeria.*

3.2 Studies on Relationships among Root Processing Quality Traits

The phenotypic correlation coefficients among dry matter (%), starch content (%), flour content (%) and total carotenoid (µg/g fresh weight basis) are presented in Table 3. Dry matter exhibited positive and significant correlation with starch content (r = .52, *P* <.01) and flour content (r = .76, *P* <.0001). As has been reported by other authors [5], there was an inverse and significant relationship between dry matter and total carotenoid (r = -.69, *P*

<.01), and between starch content and carotenoid content (r = -.64, *P* <.01). The positive correlation between dry matter and flour content was expected as dried tuberous roots were milled to produce flour. Since dry matter content is influenced by starch content, it is also expected, as shown in Table 3, that there will be positive relationship between the two traits. Peel-loss had no significant (*P* >.05) correlation with any of the other traits. This is not unexpected as tuberous roots are usually peeled before other traits are assayed.

Fig. 1 shows the biplot between principal components 1 and 2. The biplot shows the relationships between processing traits and each genotype. The closeness of a genotype to a trait shows the strength of the relationship that exists between the genotype and the trait. The biplot showed that genotype TIS 87/0087 was characterized by high dry matter, high flour content and high starch content. Same traits also characterized genotypes NRSP/05/7C and Ex-Igbariam. CIP 440163 exhibited high peel-loss, while CIP 440293 exhibited the strongest relationship with high total carotenoid. Ex-Oyunga and Centennial also showed high relationship with carotenoid content. The negative relationship that exists between starch and dry matter contents on one hand and total carotenoid on the other explains the differential in planar orientation between them.

Table 3. Phenotypic correlation among four industrial quality traits of 14 sweet potato advanced lines evaluated in the rainforest belt of Umudike in 2011

	Dry matter (%)	Starch yield (%)	Flour yield (%)	Total carotenoid (µg/g fresh weight basis)
Peel-loss	0.1106^{ns}	0.0577^{ns}	0.0927^{ns}	0.06^{ns}
Dry matter		0.5206**	0.7634***	- 0.69**
Starch content			0.4599*	-0.64**
Flour content				-0.30^{ns}

**** = P<.0001, ** = P<.01, * = P=.05, ns = P>.05.*

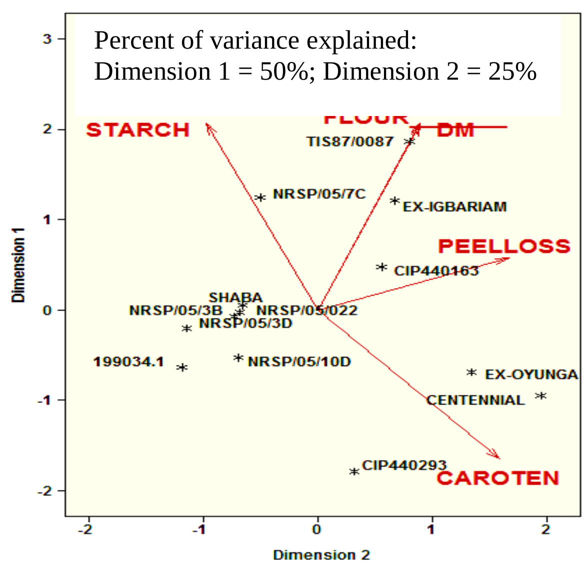

Fig. 1. Principal component biplot showing the relationships between genotypes and the root processing quality traits

3.3 Heritability Estimates

Heritability is a measure of observed phenotype that is accounted for by genetic effects. High heritability estimate for a trait depicts that the control of the trait is more under genetic control than the environment, and that breeding progress can be made by phenotypic observation and mass selection. All the traits under study showed high broadsense heritability (H_B) (Table 4). Each trait had H_B >0.90 except starch content with H_B of 0.66. The intermediate starch H_B estimate suggests additive gene action. This is corroborated by the findings of [9] that starch content in sweet potato was under the control of additive gene effect. Reported heritability estimate (h^2 = 0.65) for dry matter [10], was lower than the H_B obtained from the genotypes evaluated in this study. Total carotenoid is the chief determinant of the orange flesh colour in sweetpotato. Wolfgang Gruneberg (International Potato Center, Peru, Unpublished results) and Some Koussao (INERA, Burkina Faso, unpublished results) both reported heritability estimates for total carotenoid as 0.88 and 0.90 respectively at the 2013 Sweet potato Breeders' Meeting held Kigali, Rwanda. These estimates were in agreement with the high heritability estimate of 0.98 reported in this study.

Table 4. Broadsense heritability estimates for dry matter content, starch content, flour content, peel loss and total carotenoid in 14 sweet potato breeding lines evaluated in 2011

Trait	d^2g	d^2p	H_B
Dry matter content	8.89	9.14	0.97
Starch content	1.35	2.05	0.66
Flour content	10.66	10.91	0.98
Peel loss	3.00	3.19	0.94
Total carotenoid	56.84	57.86	0.98

3.4 Sensory Evaluation of Breeding Lines

Farmer participatory selection is an approach that plant breeders use to involve farmers and consumers in the breeding process. It helps to enhance adoption of the new variety to be released later. The results of the sensory evaluation of boiled and fried storage roots of the advanced sweet potato breeding lines are presented in Tables 5 and 6. For boiled roots, only four lines had the flesh colour of the boiled roots 'disliked', while the root flesh colour of the rest genotypes was either 'neither liked nor disliked', or 'liked'. Only two lines had their feel in the mouth (mouth-feel) 'disliked', while the taste of three lines were also 'disliked'. The aroma and the 'general acceptability' of genotype Shaba alone were not accepted.

For the fried storage roots, all the breeding lines were accepted for the five sensory (culinary) traits; only two lines were outrightly 'disliked' for colour and mouth-feel, three for taste, and four for aroma. However, for general acceptability, only one line was rejected. As observed in the boiled roots, all the lines were either 'neither liked nor disliked', or 'liked'. The general acceptability of all the lines except Shaba could be because the lines had undergone series of selection for farmer-preferred traits before now.

Table 5. Sensory evaluation test for four culinary traits for boiled 14 advanced sweet potato breeding lines in 2011.

Breeding lines	Colour	Mouth-feel	Taste	Aroma	General acceptability
TIS 87/0087	5.63	6.31	6.06	6.38	6.50
EX-IGBARIAM	5.56	5.88	5.75	6.19	6.31
NRSP/05/1B	5.81	6.00	6.19	6.00	6.38
NRSP/05/7C	6.38	5.88	6.13	5.81	6.81
NRSP/05/022	5.69	5.75	5.56	5.00	5.69
EX-OYUNGA	3.94	5.25	5.31	5.38	5.44
CIP 440163	3.88	5.63	5.44	5.56	5.44
NRSP/05/3D	4.44	5.44	5.63	5.25	6.13
SHABA	3.69	4.50	4.63	4.75	4.69
NRSP/05/3B	5.25	4.81	4.88	5.25	5.25
NRSP/05/10D	5.50	5.19	4.75	5.75	5.44
CIP 440293	6.31	5.50	5.13	5.38	5.69
CENTENNIAL	6.44	6.06	5.63	5.25	5.38
CIP 199034.1	4.56	5.63	5.44	5.38	5.69
$FLSD_{0.05}$	1.25	1.16	1.12	1.01	1.21

Sensory scores are on a 9-point hedonic scale where 1 = dislike extremely, 5 = neither like or dislike, and 9 = like extremely.

Table 6. Sensory evaluation test for four culinary traits for fried 14 advanced sweet potato breeding lines in 2011

Breeding lines	Colour	Mouth-feel	Taste	Aroma	General acceptability
TIS 87/0087	5.94	6.50	5.44	5.94	6.56
EX-IGBARIAM	6.81	6.25	5.81	5.56	6.25
NRSP/05/1B	6.44	6.50	5.81	5.50	6.38
NRSP/05/7C	6.13	5.81	5.69	4.94	6.60
NRSP/05/022	5.50	5.38	5.50	5.13	6.13
EX-OYUNGA	6.44	5.63	5.25	5.19	5.94
CIP 440163	5.44	6.25	5.63	6.38	6.50
NRSP/05/3D	5.06	5.00	4.56	4.81	5.56
SHABA	5.75	5.06	6.19	6.25	5.06
NRSP/05/3B	5.44	6.38	6.88	6.69	3.63
NRSP/05/10D	6.38	5.75	6.13	5.81	7.13
CIP 440293	3.94	4.63	3.44	3.63	4.56
CENTENNIAL	4.06	4.56	4.31	4.19	4.75
CIP 199034.1	5.94	5.94	6.31	7.19	7.56
$FLSD_{0.05}$	1.10	1.12	1.32	1.13	1.21

Sensory scores are on a 9-point hedonic scale where 1 = dislike extremely, 5 = neither like or dislike, and 9 = like extremely.

3.5 Forward Selection Multiple Regression Analysis (FSMRA)

In plant breeding, few, easy-to-measure traits are often used as an indirect way of increasing the gain in a more difficult-to-measure trait of interest. This is only possible if the easy-to-measure trait has a significant contribution to the phenotype of the major but difficult-to-measure trait. This technique increases the effectiveness, and reduces the cost of breeding for difficult-to-measure traits. To effectively find such few traits that exert significant effect on a major trait, forward selection multiple regression analysis (FSMRA) is a tool that can be used. The statistical tool had been used to identify three major yield components out of 13 traits in sweet potato [11]. In order to identify one or two easy-to-measure sensory traits to enhance selection for consumer preferences at the early breeding stage when variability is still very high among the genotypes, the sensory tests data were subjected to FSMRA, using general acceptability as the dependent variable and other traits as independent variables. Tables 7 and 8 present the results of the FSMRA for boiled and fried root samples respectively. For boiled roots, root flesh colour, mouth-feel and aroma had significant effects on general acceptability. For the fried root samples, only root flesh colour and taste significantly influenced general acceptability. Flesh colour is the only trait that is important in the regression models of the two food processing forms, and among all the sensory traits, it is the easiest to measure. Thus, fresh root flesh colour will serve as an easy-to-measure trait to use as an indirect selection criterion to develop varieties that will increase the adoption of sweet potato for direct consumption, and for the emerging small and medium scale fry and crisp business in Nigeria. The fry and boil forms presently dominate sweet potato utilization in Nigeria.

Table 7. Forward selection multiple regression analysis using general acceptability as dependent variable against flesh colour, mouth-feel, taste and aroma for boiled roots

Variable	Estimate	t value	Pr>t
Intercept	0.698	1.92	0.056
Root flesh colour	0.153	3.10	0.002
Mouth-feel	0.236	3.82	0.0002
Aroma	0.537	7.56	<0.0001

Regression equation for boiled roots is given as:

$$\mathbf{General\ Acceptability} = \mathbf{0.698} + \mathbf{0.153} * (\mathbf{Colour}) + \mathbf{0.236} * (\mathbf{Mouth - feel}) + \mathbf{0.537} * (\mathbf{Aroma})$$

Table 8. Forward selection multiple regression analysis using general acceptability as dependent variable against flesh colour, mouth-feel, taste and aroma for fried roots

Variable	Estimate	t value	Pr>t
Intercept	2.176	5.41	<0.0001
Root flesh colour	0.384	5.13	<0.0001
Taste	0.283	4.39	<0.0001

Other traits did not meet the entry criterion of leaving the model significant after entry at P<0.05.

Regression equation for fried roots is given as:

$$\mathbf{General\ Acceptability} = \mathbf{2.176} + \mathbf{0.384} * (\mathbf{Colour}) + \mathbf{0.283} * (\mathbf{Taste})$$

4. CONCLUSION

The wide variation among the genotypes for root processing quality traits depicts that different genotypes could be used for varied products. The high carotenoid content could positively impact the government’s efforts at combating vitamin A deficiencies among rural and urban poor. All the processing traits evaluated were heritable and could be improved through breeding with the high broadsense heritability estimates. The acceptability of most of the genotypes for boiled and fried food forms is a positive indication that the genotypes will be adopted as new varieties for production and consumption. Finally, the identification of the easy-to-measure root flesh colour as an important trait that positively influence consumer acceptability is a major achievement of this work.

ACKNOWLEDGEMENTS

This work was funded by the Alliance for Green Revolution in Africa (AGRA) through the 2010 PASS 002 Sweet potato Breeding Project domiciled at the National Root Crops Research Institute, Umudike, Nigeria. The contributions of the technical staff, especially Mrs. Esther Ogbo and Mr. K. C. Nwankwo during field establishment and data collection are acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist

REFERENCES

1. FAOSTAT. Food and Agricultural Organization of the United Nations 2011 Crop Production Figures for Sweetpotato, released by FAO Statistics Division, February 10, 2013.
2. Agbo MO, Ene LSO. Studies of sweet potato production and research in Nigeria. International Potato Centre. Sweet potato Situation and Priority Research in West and Central Africa. CIP, Lima, Peru, 124p; 1994.
3. Rodriguez-Amaya DB, Kimura M. HarvesPlus Handbook for Carotenoid Analysis. HarvestPlus Technical Monograph Series 2; 2004.
4. SAS (Satistical Analysis Systems) Institute. 2008 SAS 9.2 for Windows. SAS System for Personal Computers 1002-SAS Institute Inc., Carry, NC 27512-8000, USA.
5. Cervantes-Flores JC, Sosinski B, Pecota KV, Mwanga ROM, Catignani GL, Truong VD, Watkins RH, Ulmer MR, Yencho GC. Identification of quantitative trait loci for dry-matter, starch, and β-carotene content in sweetpotato. Mol. Breed. 2011;28:201-216.
6. Bradbury JH, Holloway WD. Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in the Pacific, Australian Centre for International Agric. Res., Canberra. 1988;53-77.
7. Vimala B, Sreekanth A, Binu H, Wolfgang G. Variability in 42 orange-fleshed sweet potato hyrids for tuber yield, carotene and dry matter contents. Geneconserve. 2011;40:190-200.
8. Karuri HW, Ateka EM, Amata R, Nyende AB, Muigai AWT. Characterization of Kenyan sweet potato genotypes for SPVD resistance and high dry matter content using simple sequence repeat markers. Afr. J. Biotech. 2009;8(10):2169-2175.
9. Dai QW, Qiu RL, Xu PL, Xie YZ. Genetic parameters of quantitative traits and breeding strategy for high starch content and high yield in sweet potato. Sci. Agric. Sinica. 1988;21:33-38.
10. Jones A. Heritabilities of seven sweet potato roots traits. J. Amer. Soc. Hort. Sci. 102. 1977;440-442.

11. Afuape SO, Okocha PI. Njoku D. Multivariate assessment of the agromorphological variability and yield components among sweet potato (*Ipomoea batatas* (L.) Lam) landraces. Afr. J. Plant Sci. 2011;5(2):123-132.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=272&id=2&aid=2362