GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES, VOL. 12 NO. 2, MARCH, 2006: 177-182

GENETIC AND CROPPING CYCLE EFFECTS ON PROXIMATE COMPOSITION AND ANTINUTRIENT CONTENTS OF FLOUR MADE FROM ELEVEN MUSA GENOTYPES.

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(Received 13 April, 2005; Revision Accepted 17 July, 2005)

ABSTRACT

Eleven Musa genotypes comprising ten hybrids and one local check were grown for two cropping cycles (plant crop and ratoon crop) in a sub-humid location of southeastern Nigeria. Flour was processed from unripe fruits harvested thereof. Proximate qualities and antinutrient factors were determined for each genotype during the two cropping cycles. Variance components analysis revealed significant ($P < 0.05$) genotype (G), cropping cycle (C) and G x C interaction effects on most of the traits. The percent protein content was not influenced by any of the variance components. However, flour made from bunches harvested during the second cropping cycle (ratoon crop) had significantly ($P < 0.05$) higher values for carbohydrate, fat, energy and tannin than the first cropping cycle (plant crop) harvest. The plantains had lower ash than the cooking and dessert bananas. Principal component analysis suggested carbohydrate, fat, moisture and level of antinutrient factors as major discriminant variables for characterizing bananas and plantains fruit flour into quality groupings. The study showed that the new Musa hybrids have comparable proximate qualities and level of antinutrient as the preferred local check 'Agbagba'. This suggests that the new hybrids could be released for production and consumption.

KEYWORD: Flour quality; *Musa* hybrids; Principal component analysis.

INTRODUCTION

Bananas and plantains (*Musa* species) are important staples for millions of people in the developing countries. In sub-Saharan Africa these crops have assumed a prestigious status as staple foods that are critical to the nutritional and economic well being of the people (INIBAP, 1992).

To combat yield decline and near total crop failure that was associated with landrace genotypes in most developing countries *Musa* breeding stations across the world have selected hybrid genotypes that are high yielding and tolerant to most biotic stresses of *Musa* species. The multilocational performance trials of these hybrids are gradually ensuring that high yielding hybrids are available to rural farmers in Nigeria. These farmers are the major stakeholders of banana and plantain production.

Baiyeri *et al.* (2004 & 2005) reported on adaptation patterns of 36 *Musa* genotypes grown in contrasting cropping systems and locations in Nigeria. Variable post harvest qualities of these genotypes were reported in Baiyeri *et al.* (1999). Nigerian consumers consider the horticultural and cooking qualities of these hybrids poorer relative to the landrace reference genotype 'Agbagba'. As such, bunches of hybrid genotypes commands very low market price.

The development of value added product via processing fruits into flour will not only enhance market price of the hybrids but will ensure diversification of use thereby increasing utilization potential. Besides, processing fruits into flour will ease storage over extended period of time. Earlier report by Adeniji and Empere (2001) showed that the conversion of cooking banana bunches into flour was a means of adding values to the fruits as well as extending shelf life and facilitating transportation.

Banana and plantain flour could be used for making bakery products and for developing complementary weaning foods for infants (Ogazi, 1996; Adeniji and Empere, 2001; Baiyeri, 2004). Packaged plantain flour is currently on sale in several cities in southern Nigeria, an indication that farmers are beginning to adopt processing options as a means of market diversification. Although this is an interesting trend, there is no information on flour proximate quality or the level of antinutrient factors, especially with regards to the hybrids that are been adopted for cultivation by the farmers. The male parent of most of these hybrids is a wild inedible banana 'Calcutta 4' or its derivatives. This wild inedible parent might alongside conferring biotic resistant traits also introgress genes that code for high antinutrient and or poor proximate properties into the hybrids.

Seasonal changes during fruit development could impact on the nutritional value of flour processed thereof. Earlier reports by Chandler (1995), Baiyeri (2000) and Baiyeri and Unadike (2001) indicated that nutritional value of *Musa* fruits varies with ripeness, cultivar grown, the quality of soil and climactic condition under which the fruit was grown.

In this study therefore, the effects of genotypes and season of harvest (cropping cycle) on the proximate composition and antinutrient content of eleven *Musa* genotypes grown for two cropping cycles in southeastern Nigeria were evaluated.

MATERIAL AND METHODS

The experiment was sited in the research farm of the Faculty of Agriculture, University of Nigeria, Nsukka, Nigeria. The soil is a sandy loam Oxisol of Nkpologu series (Ndubizu, 1981). Nsukka is in the derived savanna agro-ecology. It is located on latitude 06° 52'N, longitude 07° 24'E and 447 m altitude. Rainfall is bimodal with an annual total of about 1500 mm.

Genotypes evaluated and layout of experiment: Eleven *Musa* genotypes comprising one land race (as a local check), two cooking banana hybrids, one dessert banana hybrids and seven plantain hybrids were planted on a ploughed and double-harrowed plot on 21-22 September 2001. The genotypes evaluated included AGBAGBA (the local check), BITA 7, FHIA 17, FHIA 25, CRBP 39, PITA 14, PITA 21, PITA 22, PITA 23, PITA 25, and PITA 26. See Table 1 for further

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Table 1: **List of genotypes evaluated.**

Genotypes	Genome class	Ploidy level	Remarks**
AGBAGBA	Plantain	3x	Landrace, consumer preference (local check) genotype, highly susceptible to BSD, unstable yield.
PITA 14	"	4x	Tolerant of BSD, relatively short stature.
PITA 21	"	3x	Tolerant of BSD, fruit morphology and taste of boiled fruit close to those of the preferred landrace, susceptible to wind lodging.
PITA 22	"	3x	Resistant to BSD, very fast cycling, most adaptable to evaluation site, good yield.
PITA 23	"	3x	Tolerant of BSD, good yield
PITA 25	"	3x	Tolerant of BSD, high yield, fruit morphology and taste of boiled fruit close to those of the preferred landrace.
PITA 26	"	3x	Tolerant of BSD, good yield, seedy, poor ripening pattern.
CRBP 39	"	4x	Tolerant of BSD, high yield, susceptible to wind lodging
BITA 7	Cooking banana	3x	Tolerant of BSD, short stature, fast cycling but very poor yield
FHIA 25	"	3x	Resistant to BSD, very high yielding but very long cycling.
FHIA 17	Dessert banana	4x	Tolerant of BSD, high yielding, fairly long cycling

**Remarks were based mostly on field observations in the current evaluation site (Nsukka, southeastern Nigeria); Remarks on yield was a relative comparison with the local check 'Agbagba' as observed in the current study. BSD: Black sigatoka disease (caused by *Mycosphaerella fijiensis*).

characterization of the genotypes. Experiment lay out was randomized complete block design (RCBD). There was a single row plot of five plants replicated three times per genotype and cultural practices were those described by Swennen (1990). Data were collected for two-crop cycles, the plant crop (i.e. the first harvest) and the first ratoon (i.e. the second harvest).

Sample Preparation: The same day bunches were harvested representative fruit samples were obtained from hand number two from the proximal end of the bunch following the recommendation of Baiyeri and Ortiz (2000). Fruits were peeled and the pulps cut into cubes were oven dried at about 70°C until permanent dry weight was obtained. Dry samples were ground to pass through one-millimeter mesh sieve using Thomas Wiley Laboratory Mill (Model 4).

Data collection and statistical analysis: The proximate composition and level of antinutrient (phytate and tannin) of the flours was determined following the official methods of AOAC (1980). The energy (KJ/100g) content of the flours was estimated using the Atwater formula (FAO, 1973). The pH of solution made from the flours was read with Consort Digital pH Meter. Data were collected in three replicates per genotypes per cropping cycle and were subjected to analysis of variance following the procedures outlined for factorial in RCBD. Factorial analysis was necessary to capture the main effects and possible interactions between genotypic and cropping cycle effects. Also, principal components analysis (PCA) was performed on all flour traits measured to identify most important determinant trait for classifying *Musa* species flour. Data were analyzed with GENSTAT Discovery Edition 1 Release 4.23DE (GENSTAT, 2003).

Table 2: Significant test of components of variation associated with proximate and antinutrient composition of eleven *Musa* genotypes evaluated for two cropping cycles.

	Significant tests of effects due to:		
Proximate/antinutrient traits	**Genotypes (G)**	**Crop cycle (C)**	**G x C interaction**
Carbohydrate	**	**	**
Fat	**	*	***
Fibre	**	NS	**
Protein	NS	NS	NS
Ash	***	NS	NS
Moisture	***	*	*
Energy	**	**	***
pH	**	NS	NS
Phytate	***	***	***
Tannin	**	***	***

*; **; ***: Significant at P < 5%, 1% and 0.1% respectively. NS: Non-significant at 5% probability level.

RESULTS

The genetic and general characterizations of the genotypes evaluated are shown on Table 1. Specific remarks on each genotype were essentially based on the observation made during the evaluation. In most cases the plantain hybrids were better than the local check 'Agbagba'.

Variance components analysis and their tests of significance are shown on Table 2. Genotypic variance was significant ($P < 0.05$) for most flour traits except protein. Whereas fibre, protein, ash and pH values of the flours were consistent over cropping cycle, the carbohydrate, fat, moisture, energy and antinutrient factors were statistically influenced by the season the bunch processed into flour was harvested. Genotype by cropping cycle interaction was significant for most of the flour quality traits. Antinutrient factors (phytate and tannin) were evidently affected by genotypes (G), cropping cycle (C) and G x C interaction.

Table 3: Variation in proximate and antinutrient composition of eleven *Musa* genotypes evaluated for two cropping seasons- the main effects of cropping cycle.

Proximate/antinutrient traits	Plant crop	Ratoon crop	$LSD_{(0.05)}$
Carbohydrate (%)	78.95	80.49	1.13
Fat (%)	2.02	2.32	0.11
Fibre (%)	1.87	1.82	NS
Protein (%)	4.76	4.23	NS
Ash (%)	2.85	2.85	NS
Moisture (%)	9.56	8.30	0.95
Energy (KJ/100g)	1477.0	1505.0	5.9
Ph	6.41	6.55	NS
Phytate (%)	0.42	0.13	0.03
Tannin (%)	4.26	5.31	0.28

NS: Non-significant at 5% probability level.

Table 4: Variation in proximate and antinutrient composition of eleven *Musa* genotypes evaluated for two cropping seasons- the main effects of genotypes.

Genotypes	Carbohydrate (%)	Fat (%)	Fibre (%)	Protein (%)	Energy (KJ/100g)	Ash (%)	Moisture (%)	pH	Phytate (%)	Tannin (%)
AGBAGBA	81.90	2.21	2.13	3.76	1517.0	2.75	7.23	6.98	0.31	4.36
PITA 14	75.90	2.50	1.98	4.94	1447.0	2.67	12.01	6.05	0.22	4.33
PITA 21	80.35	2.33	1.48	4.52	1508.0	2.56	8.76	6.22	0.34	5.34
PITA 22	79.29	2.17	1.55	4.42	1483.0	2.82	9.76	6.29	0.28	4.42
PITA 23	78.31	2.50	1.12	4.95	1487.0	2.35	10.78	6.61	0.28	4.30
PITA 25	81.44	1.65	1.99	4.43	1499.0	2.83	7.66	6.57	0.28	4.63
PITA 26	79.82	1.67	1.75	4.43	1473.0	3.15	9.18	6.41	0.37	4.68
CRBP 39	80.14	1.54	2.21	4.55	1475.0	2.60	8.96	6.16	0.26	4.91
BITA 7	79.97	1.78	2.53	3.68	1467.0	3.00	9.03	7.86	0.30	5.20
FHIA 25	79.94	2.82	1.81	5.23	1531.0	3.33	6.87	6.44	0.19	5.12
FHIA 17	79.84	2.67	1.71	4.52	1512.0	3.28	7.99	5.69	0.23	5.35
$LSD_{(0.05)}$	2.66	0.71	0.65	NS	39.4	0.46	2.22	0.88	0.06	0.66

NS: Non-significant at 5% probability level.

Flour made from bunches harvested during the second cropping cycle (ratoon crop) had significantly ($P < 0.05$) higher values for carbohydrate, fat, energy and tannin than the first cropping cycle (plant crop) harvest (Table 3). Data obtained also showed that the flour processed from the ratoon crop harvest had lower moisture and phytate content. However, the values for fibre, protein, ash and pH were similar for the two cropping cycles.

The main effect of genotype on proximate quality and level of antinutrient factors in flours processed from *Musa* species is shown in Table 4. 'Agbagba', a plantain landrace, contained the highest carbohydrate, which was statistically similar to the quantity found in 'PITA 21', 'PITA 25' and 'CRBP 39' (plantain hybrids). Flour made from 'BITA 7', a cooking banana hybrid, contained more fibre (2.53%) although, this quantity was not significantly different from values recorded in 'Agbagba' and 'CRBP 39'. Protein content in *Musa* species flour was not influenced by the genotype from which the flour was processed (Table 4). However, quantity of fat, ash, energy, moisture and the level of antinutrient factors were dependent on the genotype. The plantains had lower ash than the cooking and dessert bananas. 'FHIA 25', a cooking banana hybrid, which had the highest energy and ash contents also had the lowest moisture and phytate contents. Whereas the pH of 'Agbagba' was near neutral (6.98) most of the hybrids except 'BITA 7' were slightly acidic. 'PITA 21' flour was relatively high in phytate and tannin. Generally, the data on Table 4 showed that most of the plantain hybrids had comparable proximate composition and levels of antinutrient factors as the preferred local check 'Agbagba'.

Principal component analysis (PCA) performed on the ten flour quality traits of the eleven *Musa* genotypes evaluated is shown in Table 5. The three component axes retained revealed distinct trait contribution to the general variability in *Musa* flour. PRIN 1, which explained about 30% of the total variability in flour quality, indicated that carbohydrate and moisture contents of flour had the highest eigen vector values on this axis. Similarly, fat and fibre content of flour weighted highest on PRIN 2 (which accounted for about 21% variability in flour quality). PRIN 3 revealed clearly that level of antinutrient factors (phytate and tannin) in the flour of *Musa* genotypes could explain about 13.6% variability in *Musa* species flour quality. From this PCA, six traits namely carbohydrate, moisture, fat, fibre, phytate and tannin, together accounted for about 65% variability in flour quality. These traits could be considered as discriminant variables for classifying flours from *Musa* species into quality groupings.

DISCUSSION

The genetic backgrounds of the genotypes, the season (crop cycle) of harvest, and the interaction of these two factors were important determinants of proximate quality and the level of antinutrient factors found in flour of *Musa* species. Earlier reports by Chandler (1995), Ferris *et al.* (1996) and Baiyeri *et al.* (1999) support this result.

A non-significant crop cycle effect on ash content indicated that nutrient uptake by the plants and transfer pattern to the fruits was consistent over cropping cycles. However, significant genotype effect revealed physiological genetic implication on nutrient uptake. That is, nutrient uptake and transfer pattern is genotype specific. This means that nutritional values of flours processed from bananas and plantains are dependent on the genotype used. Baiyeri and Unadike (2001) comparing some aspect of physicochemical characteristics of a Falsehorn plantain 'Agbagba' and a French plantain 'Obino L'Ewai' reported significant cultivar effect on some of the attributes studied. Similarly, Stover and Simmonds (1987) reported distinct nutritional difference between the dessert bananas (*Musa* AAA) and the plantains (*Musa* AAB), although the reports were based on old cultivars, which were mostly landraces.

Season (crop cycle) effect on some flour quality traits was significant, meaning that even if same genotype is used, those traits would vary with season. It was interesting to note that second crop harvest (ratoon crop) flours had higher energy related attributes, lower phytate and moisture content. Lower moisture content will assure better storage of the flours.

The percent of protein in the flours was not influenced by the three components of variance evaluated, suggesting that breeding program aimed at improving protein content in *Musa* germplasm will likely be difficult.

The PCA suggested energy related traits, moisture content and level of antinutrient factors as the major discriminant variables for characterizing flours from *Musa* species into quality groupings.

It was evident from the study that the new *Musa* genotypes that are being evaluated with anticipation of

Table 5: Eigen vector values for principal components of proximate and antinutrient composition of eleven *Musa* genotypes evaluated for two cropping cycles.

Traits	PRIN 1	PRIN 2	PRIN 3
Carbohydrate	0.52933	-0.09234	0.18633
Fat	-0.03120	0.53149	-0.22634
Fibre	-0.04373	-0.48621	0.12443
Protein	-0.29937	0.35607	0.22433
Ash	0.11417	-0.09248	0.29666
Moisture	-0.50291	-0.09728	-0.33912
Energy	0.41482	0.44971	0.11570
pH	0.09733	-0.33946	-0.02676
Phytate	-0.17620	0.01245	0.66955
Tannin	0.38569	-0.10082	-0.42760
Percent (%) of total variation explained	29.97	20.98	13.58

eventual release to farmers have comparable proximate qualities and level of antinutrient as the local (preferred) check 'Agbagba'. This suggests that consumption of the hybrid genotypes (in spite of the wild male parentage) would not be hazardous to the consumers.

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