Relative Changes in the Nutrient Composition of Six Cultivars of White Yam Grown in Three Ecozones of Southeastern Nigeria

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Abstract

The relative changes in the composition of six cultivars of white yam (*Dioscorea rotundata* Poir) were investigated in three major yam ecozones in southeastern Nigeria. The component parameters measured were crude protein, starch and total soluble sugar of the six cultivars at maturity. Each of the six cultivars was grown in the three locations which represent subhumid savanna (Zaki-Biam), forest-savanna transition (Abakaliki) and riverine alluvial areas (Atani) for two seasons (1986 and 1987). Samples analyzed were obtained from unfertilized plots which formed part of the split plot design used in each location with fertilizer as main plot and cultivar as subplot treatments.

The study showed that some cultivars (e.g., Agatu) performed better in their test sites because increase in protein contents of up to 53 percent, starch contents of up to 33 percent and soluble sugar content of up to 16 percent were obtained in the test site. On the other hand, some cultivars (e.g., Nyeji) performed better in their source site, and decrease of up to 43 percent protein, 56 percent soluble sugar and 10 percent starch were obtained. The soil properties that may contribute to these variations are soil acidity and base saturation, organic matter and total nitrogen. When these properties are adequately amended in each of the locations, the quality of the yam cultivars grown in each location is likely to be higher.

Introduction

Yams (*Dioscorea* sp) constitute a major staple food in southeastern Nigeria (Okorji 1986) and have been ranked second only to cereals as the most important food crop in West Africa (Soursey 1967; Onwueme 1978). White yam (*D. rotundata* Poir) is the most widely grown and eaten cultivar in West Africa (Okonkwo 1985).

Yam consumers tend to associate their preference for different cultivars of yam to their sources. The reason may stem from the influence of environment on the chemical composition of the tubers.

The major nutrient obtained from yam tuber is carbohydrate but Baquar and Oke (1976) have shown that some clones of *D. rotundata* and *D. dumetorum* have protein contents of up to between 3.2 and 13.9 percent/dry weight. Oke (1967) earlier noted that a yam meal could supply 100 percent of the energy and protein needs of an adult. Yams are known to be superior to cassava as a source

protein, hence Purseglove (1972) pointed out that the displacement of yam by cassava in certain areas may increase the incidence of kwashiorkor in such areas. Most yams, according to Eka (1985), are also rich in phosphorus and some vitamins. However, IITA (1982) noted that there are variabilities in the chemical composition of yam tuber, and this composition may vary even within the same cultivar, depending on the environmental conditions under which the tuber was produced.

Thus, the objective of the study was to assess the relative variations in the composition of six cultivars of *D. rotundata* Poir grown across three major yam ecozones in southeastern Nigeria.

Materials and Methods

Three sites representing subhumid savanna, the forest-savanna transition and the riverine alluvial areas were chosen for the production of the six cultivars.

Zaki-Biam (7°27'N, 9°29'E) was chosen in the subhumid savanna of Benue State; Abakaliki (6°25'N, 8°05'E) was chosen in the forest-savanna transition of Anambra State while Atani (6°01'N, 6°44'E) was chosen in the riverine alluvial area along the river Niger, also in Anambra State.

Two popular cultivars of *D. rotundata* in each of the locations were selected for the study which lasted for two cropping seasons in 1986 and 1987. The six cultivars were Agatu and Gbango, both from Zaki-Biam; Igun and Nyeji from Abakaliki, and Aga and Ekpe from Atani. All six cultivars were grown in each location using a split-plot design with fertilizer as the main plot and cultivar as the subplot. There were four replications in each location.

Harvests made at maturity (8 months after planting) from unfertilized plots were used for the laboratory analysis. The protein, total soluble sugar and starch contents of tubers were determined using standard methods outlined by AOAC (1965).

The relative percentage increase or decrease in the composition of the tubers was determined from 100 y/x, where x is the value of the parameter (protein, total soluble sugar or starch) obtained from the source site and y is the value from the test sites. Any value above 100 denotes increase in the yield of the parameter, 100 denotes no change and values below 100 imply a decrease in the respective parameters in the test sites. Note that the test sites refer to those locations where the respective cultivars were newly introduced. Prior to the establishment of the research plots, the soils were fully characteriszed and classified. Regression analyses were conducted between protein contents, total soluble sugar contents and soil pH, organic carbon, total N, available P, exchangeable K and base saturation.

Results and Discussion

The soils of each location were classified according to the soil properties determined.

Zaki-Biam soils:	Typic Haplustaff, Coarse loamy, mixed, isohyperth and Ultic Haplustaff coarse loamy, mixed isohyperthermic in USDA (1975) Soil Classification system (Soil Taxonomy) and correlated as Haplic Luvisols in the FAO/UNESCO World Map Legend.
Abakaliki soils:	Udic Rhodustalf, loamy, mixed, isohyperthermic in the USDA (1975) system and respectively correlated as Chromic and Haplic Luvisols in the FAO/UNESCO World Map Legend.
Atani soils:	Aquic Dystropept, fine loamy, mixed isohyperthermic in the USDA (1975) system and correlated as Dystric Fluvisols in the FAO/UNESCO World Map Legend.

Results of Biochemical Analysis

The analysis of variance (ANOVA) of the combined data from the three locations showed that cultivar effect was significant ($P = 0.05$) and highly significant ($P < 0.001$) on crude protein and total soluble sugar contents, respectively, only in 1986 harvests. The effects of location, cultivar, and location x cultivar interaction were not significant on the other parameters measured.

The mean values of crude protein, starch and total soluble sugar contents of the tubers are shown in table 1. The values indicated only very slight variations in protein contents averaged over the three locations. In 1986 and 1987 trials crude protein contents averaged 1.73 percent and 1.60 percent at Zaki-Biam; 1.65 percent and 1.71 percent at Abakaliki, while the corresponding values obtained at Atani were 1.69 percent and 1.68 percent. The starch contents (table 1) also showed little variation among the three locations. For both years the difference between highest starch content (dry weight basis) which was obtained from the Zaki-Biam location (73.59%) and the least (70.3%) from Abakaliki

location was only 3.29 percent. On fresh weight basis the highest value (30.13%) was obtained from the Atani location while the least (26.65%) was also got from the Abakaliki location. The least variations were observed in total soluble sugar contents. The changes in values based on both the dry weight and fresh weight of tubers were only very slight (table 1).

The mean values of crude protein, starch and total soluble sugar contents averaged over cultivar are given in table 2. The cultivars in both years are listed in table 2. In both years cultivars Nyeji and Gbango gave the highest values of protein, while the least values were obtained from Aga (1.4%, 1986 trial) and Ekpe (1.2%, 1987 trial). The values obtained from Nyeji and Gbango in the 1986 trial were approximately 2 percent while their corresponding values in the 1987 trial were 2 percent and 2.3 percent.

The starch contents (dry weight basis) for both years ranged from 66.3 percent to 79.1 percent. The highest value in the 1986 trial (76.4%) was obtained from Aga and the least for the same year (66.3%) from Ekpe. In the 1987 trial Ekpe also gave the least value (67.8%) while Agatu (79.1%) gave the highest. On fresh weight basis Ekpe gave the least values in both years with 24 percent in 1986 trial and 26.5 percent in the 1987 trial. The highest values in both years (29.3% and 33.1%) were obtained from Gbango.

The total soluble sugar (dry weight) content was highest in Nyeji (4.6%) in 1986 trial and lowest in Aga (3.8%) for the same year. On a fresh weight basis the highest value (5.4%) was obtained from Igun and the least from Agatu (1.4%). Results from the 1987 trials (table 2) also indicated that Igun gave the highest values for both dry weight (5.56%) and fresh weight (2.28%) basis while Aga gave the least values. On a dry weight basis Aga gave 3.81 percent, while on fresh weight basis 1.49 percent was obtained.

The mean yields of protein obtained from all the cultivars relative to the three locations on which they were grown are listed in table 3. The result showed that Igun (source: Abakaliki) with the highest relative protein content (120–122%) was harvested from Atani. Thus, there was an increase of more than 20 percent protein in the cultivars grown at Atani. This increase was 18 percent (fresh weight basis) and 9 percent (dry weight basis) for Igun grown at Zaki-Biam. The protein content of Nyeji (source: Abakaliki) was highest when grown at Abakaliki. The values obtained from Zaki-Biam and Atani showed a decrease in protein content of more than 30 percent in the cultivar (Nyeji) harvested in both locations.

The protein content of Agatu (source: Zaki-Biam) harvested from Atani increased by more than 45 percent and at Abakaliki the increase was more than 15 percent. The increase in protein content (fresh weight basis) was similar (25%) at Atani and Abakaliki.

The increase in the protein content of Aga (source: Atani) grown at Zaki-Biam was only slight (less than 10 percent). At Abakaliki the values showed a decrease in the protein content of Ekpe (source: Atani grown at Abakaliki). There was an increase of more than 20 percent for harvests at Zaki-Biam.

The mean yields of starch from the cultivars grown in each of the three locations are shown in table 4. The increase in the starch content of Igun (source: Abakaliki) grown at Zaki-Biam was only 8 percent while the starch content of Igun grown at Atani showed a very slight decrease of 1 percent there was a decrease in the starch content of Nyeji (source: Abakaliki) harvested at Zaki-Biam and Atani. Hence, in terms of starch content, Igun and Nyeji performed better in their original source site (Abakaliki). The starch content of Agatu (source: Zaki-Biam) harvested from Atani increased by more than 25 percent. Gbango (source: Zaki-Biam) generally decreased in starch content when grown at Abakaliki and Atani. Similarly the starch content of Aga (source: Atani) decreased when it was grown at Abakaliki and Zaki-Biam. There was only a slight increase (13 percent) in starch content (fresh basis) of Ekpe grown at Zaki-Biam. In terms of starch content, Aga might be considered suitable for Atani, the original source.

The mean soluble sugar content of the cultivars harvested from each location is shown in table 5. On a dry weight basis, there was only a slight increase (2%) in soluble sugar content in Igun harvested from Zaki-Biam. The values obtained showed that in terms of soluble sugar all the cultivars except Aga and Agatu performed best in their original source sites. There was a 10 percent increase in soluble sugar of Agatu (source: Zaki-Biam) grown at Atani. Similarly, there was also a 12 percent increase in soluble sugar of Aga (source: Atani) grown at Zaki-Biam. On a fresh weight basis (table 5) the increases in soluble sugar were less than 10 percent in each case.

The protein contents of the cultivars are generally low, as indicated by the results obtained and reported earlier by Eka (1978). The values are, however, higher than those obtained from earlier work reported by Eka (1978). The values are, however, higher than those obtained from cassava and according to Oke (1967) the protein content of yam can satisfy adult needs. Hence Purseglove (1972) categorically stated that the displacement of yam by cassava in food consumption patterns of some farming communities may increase the incidence of kwashiorkor in such areas. Thus, to increase the protein content of yam grown in those locations, the best cultivars for the Zaki-Biam location are Ekpe and Igun sourced respectively from Atani and Abakaliki. Those recommended for Abakaliki were Gbango and Agatu, both sourced.from Zaki-Biam, while Agatu and Igun were recommended for Atani locations.

Because of their starch content, Ekpe and Igun were also recommended for the Zaki-Biam location, while Agatu and Nyeji were recommended for Abakaliki. For Atani, Agatu and Ekpe were recommended. Apart from Igun and Nyeji which yielded the highest total soluble sugar in their source sites at Abakaliki, all other cultivars yielded better in their test sites. Cultivars recommended for Zaki-Biam and Atani were Aga and Agatu, respectively.

The results of multiple regression analysis between protein contents, total soluble sugar contents and selected soil properties showed inconsistent trends. The parameters with significant correlation coefficients on protein contents and total soluble sugar contents were not applicable to all the cultivars. The results presented in table 6 indicate that soil pH has significant correlation

and total soluble sugar contents were not applicable to all the cultivars. The results presented in table 6 indicate that soil pH has significant correlation with the protein content of Agatu. All other coefficients were not significant. The results presented in table 7 show that base saturation has a significant correlation coefficient on the total soluble sugar content of Agatu and total N has significant correlation with the total soluble sugar contents of Igun and Aga. All other parameters have no significant correlation coefficients on total soluble sugar contents.

Summary and Conclusions

Six popular cultivars of white yam (*D. rotundata* Poir) were selected and grown in three major yam ecozones in southeastern Nigeria to assess the relative changes in their composition when grown across the three zones. The experimental design in each location was a split plot, replicated four times with fertilizer as main plot and cultivar as subplot treatments. The study was done for two cropping seasons (1986 and 1987), and tubers harvested at maturity from unfertilized plots were analyzed for crude protein, starch and total soluble sugar. These parameters were compared for each location and also regressed against selected soil properties.

The study showed that increases in protein contents of up to 53 percent may be achieved by growing some exogenous cultivars in areas other than where they are presently grown. Protein contents of some cultivars may, on the other hand, diminish by up to 43 percent if grown in any location other than the original source sites. Based on the relative performance of each of the cultivars with respect to the parameters relative to the source sites, cultivars best suited to each location were as follows: Ekpe (source: Atani) and Igun (source: Abakaliki) for the Zaki-Biam location, and Agatu for Atani location.

Apart from Igun and Nyeji, which yielded highest total soluble sugar in their source site (Abakaliki), all other cultivars generally performed better in their test sites, hence the introduction of exogenous cultivars in the sites would be of advantage in improving the quality of the yams. However, the soil properties that may affect this quality are soil acidity and base saturation, organic matter and total nitrogen contents of the soils. If these properties are adequately amended, yams of high quality could be produced on any of the locations.

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Table 1 Mean values of protein, starch and soluble sugar contents of yam tubers averaged over location

Location	Parameters (%) 1986'Trial				
	Protein (dw)	Starch (fw)	Starch (dw)	Total sol. sugar (fw)	Total sol. sugar
Zaki-Biam	1.73	72.6	28.32	4.54	2.72
Abakaliki	1.65	70.3	26.65	4.19	2.84
Atani	1.69	72.3	28.71	4.73	2.87
SE (±)	0.04	1.25	1.09	0.27	0.08
			1987 Trial		
Zaki-Biam	1.60	73.59	28.89	4.73	1.94
Abakaliki	1.71	73.50	28.50	4.41	1.71
Atani	1.68	70.08	30.13	4.72	1.94
SE (±)	0.06	2.00	0.95	0.18	0.10

+SE, dw, fw: Standard error, dry weight, fresh weight, respectively.

Table 2. Mean values of protein, starch and soluble sugar contents of yam tubers averaged over cultivar

Parameters (%)	1986 Trial Cultivars					
	Igun	Agatu	Aga	Nyeji	Gbango	Ekpe
Protein	1.652	1.438	1.395	2.058	2.005	1.582
Starch (dw)	72.6	73.7	76.4	71.7	69.5	66.3
Starch (fw)	29.0	27.6	28.6	28.9	29.3	24.0
Total soluble sugar (dw)	4.8	4.2	3.8	5.1	4.6	4.4
Total soluble sugar (fw)	5.4	1.4	1.5	5.1	2.0	1.6
	1987 Trial					
Protein	1.47	1.49	1.56	2.00	2.27	1.19
Starch (dw)	75.5	79.1	77.5	69.9	75.6	67.8
Starch (fw)	29.6	30.8	29.9	27.2	33.1	26.5
Total soluble sugar (dw)	5.56	4.49	3.81	4.71	4.58	4.61
Total soluble sugar (fw)	2.28	1.75	1.49	1.87	2.03	1.68

+dw, fw: dry weight and fresh weight, respectively.

Table 3. Mean values of Protein content of each cultivar relative to locations (1986 and `1987 trials combined)

Source	Cultivar	Test sites					
		%Protein (fw)			%Protein (dw)		
		Abakaliki	Zaki-Biam	Atani	Abakaliki	Zaki-Biam	Atani
Abakaliki	Igun	1.30	1.53	1.58	3.73	3.73	4.10
"	Nyeji	2.73	1.72	1.55	6.45	4.74	4.04
Zaki-Biam	Agatu	1.42	1.20	1.84	3.74	3.13	4.57
"	Gbango	2.43	1.95	2.44	5.78	5.69	5.95
Atani	Aga	1.48	1.69	1.55	3.13	3.83	3.75
"	Ekpe	0.90	1.51	1.17	2.63	3.55	5.21

Table 4. Mean values of starch content of each cultivar relative to locations they were grown (1986 and 1987 trials combined).

Source	Cultivar	Test sites					
		% starch (fw)			% starch (dw)		
		Abakaliki	Zaki-Biam	Atani	Abakaliki	Zaki-Biam	Atani
Abakaliki	Igun	28.94	31.17	28.70	76.22	75.90	74.41
"	Nyeji	29.69	26.65	25.37	70.24	73.25	66.20
Zaki-Biam	Agatu	27.94	27.67	36.72	73.69	72.39	91.08
"	Gbango	31.35	37.12	30.77	74.67	77.04	74.97
Atani	Aga	28.32	27.77	35.56	73.80	75.13	83.56
"	Ekpe	24.81	28.95	75.63	72.39	67.81	78.23

Table 5. Mean values of soluble sugar content of each cultivar relative to locations (1986 and 1987 trials combined).

Source	Cultivar	Test sites					
		% soluble sugar (fw)			% soluble sugar (dw)		
		Abakaliki	Zaki-Biam	Atani	Abakaliki	Zaki-Biam	Atani
Abakaliki	Igun	2.23	2.28	2.16	5.84	5.56	5.59
"	Nyeji	2.82	1.23	1.56	6.66	3.38	4.08
Zaki-Biam	Agatu	1.42	1.77	2.06	3.74	4.62	5.10
"	Gbango	1.59	2.74	1.76	3.78	5.69	4.08
Atani	Aga	1.06	1.78	1.64	2.15	4.81	4.28
"	Ekpe	1.48	1.85	1.71	4.31	4.32	5.21

Table 6. Regression coefficient between soil properties and protein contents of yam tubers for all the locations combined

Soil properties		Cultivar					
		Igun	Agatu	Aga	Nyeji	Gbango	Ekpe
Base saturation	(X_6)	0.005	0.042	-0.005	-0.012	0.026	0.089
pH	(X_1)	-0.256	0.562	0.715	0.077*	-0.934	-0.584
Organic C.	(X_2)	-0.466	8.570	-5.764	3.012	0.004***	9.630
Total N.	(X_3)	-4.132	-0.359**	3.547	6.657	-3.216	4.799
Av. P	(X_4)	-0.074	-0.517	-0.383	0.210	0.050	0.626
K+	(X_5)	1.827	21.239	18.765	-6.394	-6.943	-27.889

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels , respectively

Table 7. Regression coefficients between soil properties and total soluble sugar contents of yam tubers for yam tubers for all locations combined

Soil properties		Cultivar					
		Igun	Agatu	Aga	Nyeji	Gbango	Ekpe
Base saturation	(X_6)	0.040	-0.002**	-0.032	-0.128	-0.084	-0.028
Soil pH	(X_1)	-0.619	-0.497	0.573	2.081	1.800	0.411
Organic C	(X_2)	2.044	-3.788	-4.197	6.695	-8.262	-3.745
Total N	(X_3)	1.458*	-4.907	-0.363**	27.031	7.355	2.105
Av. P.	(X_4)	0.222	-0.240	-0.311	-0.359	-0.569	-0.243
K+	(X_5)	-11.353	6.173	14.879	29.033	31.556	11.850

***,** Significant at 0.05 and 0.01 probability levels, respectively.**