Pakistan Journal of Nutrition 7 (2): 342-344, 2008
ISSN 1680-5194

The Investigation of Chemical Composition and Functional Properties of Water Yam (*Dioscorea alata*): Effect of Varietal Differences

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Abstract: The nutrient components and functional properties of *Discorea alata* were determined. The average crude protein of *D. alata* was 6.7%. Carbohydrate (81.6- 87.6%) was the predominant fraction of the tuber dry mater. The mineral contents of the yam tuber varieties were also evaluated with values ranging from 240-400mg/100g, k; 190-380mg/100g, Na; 180-340mg/100, P; 20.2-80.2mg/100g, C and 24.3-97.2mg/100g, Mg. Vitamin C content of the yam tubers ranged from 16.7-28.4mg/100g, fresh weight. Significant differences in the crude protein and mineral contents were observed among the varieties. Functional property levels in the yam tubers were found to be in the range of 0.64-0.76g/cm^3 (BD); 2.90-3.65g/g (WAC); 27.0-3.5 sec (wettability) and 30-50% w/v (gelation). Significant differences in the functional properties of the yam tuber varieties were also observed. The overall results are indication of good nutritional quality and functional properties of *D. alata.*

Key words: Water yam, crude protein, staple food

Introduction

Yam (*Diocorea spp*) are climbing plants with glaborous leaves and twining stems, which coil readily around a stake. They are perennial through root system but are grown as annual crops. Water yam (*Dioscorea alata*) is one of the most economically important yam species, which serves as a staple food for millions of people in tropical and subtropical countries (Hahn, 1995). *D. alata* is popular and prevalent within Abakaliki agro ecological zone of Ebonyi State, Nigeria where it is called "Mbala or Nvula" (Igbo names).

They are consumed boiled, roasted, fried or pounded and eaten in association with protein rich sauces. *D. alata* can also be processed into flour and reconstituted into fufu dough. Generally, they contain less sugar and have an extended shelf life (Raemackers, 2001), which ensure availability in periods of scarcity.

Five high yielding and disease resistant water yam varieties developed by International Institute of Tropical Agriculture (ITTA) and two landraces were evaluated within Abakaliki agro ecological zone (Oselebe and Okporie*,* 2005). Most of these improved varieties showed remarkable potential for high yield over the landraces. This suggests a possible preference of local farmers for the new varieties over the landraces that were selected because of high yield. It also indicates progress in breeding for higher yield and disease resistance by the Research Institutes.

To establish the acceptability of the new varieties, analysis of the nutrient component and functional properties of the *D. alata* varieties were investigated.

Materials and Methods

Seven varieties: TDa 98/01168, TDa 98/01178, TDA 99/00240, TDa 98/01166, TDa 99/00169 and two landraces, TDa 297 (the Institutional check) and "Okwalenkata or Nwawafu" (the best local variety) were collected from the Faculty of Agriculture, Ebonyi State University, Abakaliki, Nigeria. The varieties were cultivated in the same environment and all were given the same treatment. In this study, the yam tubers were harvested mature at the same time.

Preparation of flour samples: The yam tubers were peeled, washed, sliced into cubes and dried in hot air oven at a temperature of 65^{o}C for 48h. The dried yam chips were then milled using local attrition mill to obtain a fine powder and packaged in polyethylene containers for further analysis.

Fresh *D. alata* tubers were peeled, diced and pounded using laboratory mortar and pestle for the determination of Vitamin C.

Chemical analysis: Flour samples were analyzed in duplicates for moisture, and ash using (Pearson, 1976), while protein and fat contents were determined by the method of AOAC (1975). The energy content was estimated by the method described by Onyeike *et al.* (2000). Vitamin C was determined by indophenols titration method (AOAC, 1984).

The methods described by James (1985) method were used to determine vitamin C, calcium, magnesium and phosphorus. Sodium and potassium were determined by flame photometric method (AOAC, 1984).

Functional properties: Water and oil absorption capacities were determined by the method of Abey and Ibeh (1988). The method of Coffman and Gracia (1977)

Table 1: Proximate composition of *D. alata* varieties

	Moisture Content%	Ash%	Ether extract%	Crude protein%	Crude fibre%	Carbohy-drate%	Energy Kcal/100g
TDa 98/01166	6.52[b]	3.08[a]	1.10[a]	6.78[bc]	1.13[a]	87.64[a]	385.33[a]
TDa 98/01168	6.00[bc]	2.25[b]	0.90[b]	6.34[cd]	1.05[ab]	83.46[a]	367.30[a]
TDa 98/01176	7.50[a]	2.30[b]	0.78[c]	7.00[b]	0.80[bc]	81.62[a]	361.58[a]
TDa 99/00169	5.77[cd]	2.38[b]	0.75[c]	7.18[b]	0.88[bc]	83.04[a]	367.63[a]
TDa 99/00240	5.26[d]	3.15[a]	0.85[c]	8.31[a]	0.90[bc]	81.53[a]	367.01[a]
TDa 297	7.57[a]	2.65[ab]	1.03[ab]	5.69[ef]	0.75[c]	82.31[a]	361.27[a]
Local best	6.05[bc]	2.25[b]	0.75[c]	5.78[de]	0.83[bc]	84.34[a]	367.23[a]

Means with the same superscripts in the same column are not significantly different (P < 0.05)

Table 2: Mineral contents of *D. alata* varieties (mg/100g)

	K	Na	P	Ca	Mg	Vitamin C
TDA98/01168	400.00[a]	200.00[b]	120.00[d]	60.12[b]	85.08[b]	18.48[cd]
TDA98/01178	380.00[a]	380.00[a]	140.00[cd]	60.12[b]	85.08[b]	20.22[cd]
TDA99/00240	380.00[a]	250.00[b]	340.00[a]	80.16[a]	24.31[d]	17.60[d]
TDA 98/01166	240.00[b]	190.00[b]	180.00[c]	40.08[c]	97.24[a]	16.72[d]
TDA 99/00169	320.00[ab]	200.00[b]	300.00[ab]	20.16[d]	60.77[c]	35.20[a]
TDA297	310.00[ab]	220.00[b]	260.00[b]	40.08[c]	97.24[a]	28.45[b]
Local best (LC)	260.00[b]	360.00[a]	100.00[d]	20.04[d]	60.77[c]	22.88[c]

Means with the same superscripts in the same column are not significantly different (P < 0.05)

was used for the determination of gelation-capacity. The method of Okaka and Potter (1979) was used to determine the bulk density, while the method described by Armstrong *et al.* (1979) was used for the determination of wettability.

Results and Discussion

Chemical composition: The chemical compositions of *D. alata* studied are presented in Table 1. Statistical analysis showed significant differences (P<0.05) between the means of the variables estimated except for carbohydrate and energy content.

D. alata variety, TDa 99/00240 had the highest protein content of 8.31%. Generally the *D. alata* varieties investigated had comparable crude protein contents with the mean values reported for sweet potato: 5.6-6.8g100g^{-1}, (Agbor - Egbo and Richard, 1990) but higher than those reported for cassava roots, 1.7g 100g^{-1}, (Gomez and Valdivieso, 1983).

The variability in protein levels among the varieties makes possible the selection of protein rich variety. This is particularly evident in TDa 99/00240, TDa 99/00169 and TDa 98/011776 (Table 1), where comparatively high levels in crude protein were found. The protein levels obtained in this study indicate that *D. alata* need not be considered protein-poor.

The mean fat levels ranged from 0.75-1.10% with significant difference (P<0.05) between some of the varieties. The fat values of all the varieties were very low and are comparable to the values found in other root and tuber crops like potato (0.4g100^{-1}, Bradbury and Holloway, 1988) and cassava (0.3g/100g^{-1}, Richard and Coursey, 1981).

The carbohydrate content ranged from a mean value of 81.53-87.64% with no significant difference (P>0.05) in their mean values. *D. alata* generally contains high carbohydrate content and this accounts for the high energy calorie observed in all the varieties.

The mineral levels of the *D. alata* varieties are shown in Table 2. The high levels for almost all the minerals analyzed in all the varieties indicate their importance as good sources of nutrition for the consumers of *D. alata.* Comparism of the mean values per variety for each mineral estimated showed that a significant difference (P < 0.05) exists between the *D. alata* varieties studied.

Functional properties: The functional properties of the *D. alata* varieties are presented in Table 3.

Bulk density: The mean values obtained for bulk density (Table 3) in all the varieties did not show any significant difference (P > 0.05). However, the levels of bulk density ranging from 0.64-0.76g/cm^3 were similar to the values reported for *D. rotundata* (Udensi and Okaka, 2000). High bulk density increases the rate of dispersion (Brennan *et al.*, 1976), which is important in the reconstitution of yam flours in hot water to produce yam fufu dough.

Water absorption capacity (WAC): The water absorption capacity for the different varieties was significantly different (P < 0.05). The values obtained are similar to values reported for *D. rotundata*. (Udensi and Okaka, 2000). WAC is an important functional property required in food formulations especially those involving dough handling such as yam fufu.

Wettability: The mean values of wettability for the different varieties were significantly different (P < 0.05) except for Tda 98/01176 and Tda 99/00169. The

Table 3: Functional properties of *D. alata* varieties

	Water absorption capacity	Bulk density g/cm^3	Wett-ability (secs)	Gelation % w/v
TDA98/01166	3.35^{bc}	0.66^{a}	27.00^{d}	50
TDA99/00240	3.80^{a}	0.70^{a}	29.00^{bc}	40
TDA98/01176	3.20^{cd}	0.70^{a}	35.00^{a}	50
TDA 99/00169	3.30^{bc}	0.76^{a}	35.00^{a}	50
TDA 98/01168	2.90^{d}	0.69^{a}	30.00^{b}	30
TDA297	3.65^{ab}	0.64^{a}	28.00^{cd}	55
Local best (LC)	3.25^{cd}	0.67^{a}	30.00^{b}	50

Means with the same superscripts in the same column are not significantly different ($P < 0.05$).

wettability values ranging from 27-35 (secs) were lower than the value 42.5 (secs) reported for *D. rotundata* (Udensi and Okaka, 2000). Wettability provides a useful indication of the degree to which dried flour such as *D. alata* flour is likely to possess instant characteristics.

Gelation capacity (% w/v): The gelation capacity of the *D. alata* varieties ranged from 30-55% w/v with TDa/297 having the highest value of 55% w/v. The mean values for the gelation capacity of the different *D. alata* varieties were lower than the mean value (22% w/v) reported for cassava flour (Udensi *et al*., 2005). The high values of gelation capacity obtained for some of the varieties reveal that *D. alata* is not quite suitable for the formation of fufu dough.

Conclusion: The results obtained in this study show that the potential exists for selecting nutritionally superior varieties of *D. alata*. The variability in the chemical composition and functional properties of *D. alata* varieties are clearly useful for the Plant Breeders that may select varieties with certain nutritional characteristics. On the basis of high crude protein level, TDa 98/01168, TDa 99/00169 and TDa 98/01176 could be selected for intensive cultivation in Nigeria and other *D. alata* growing regions.

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