Variability in the Chemical Composition of Yams Grown in Cameroon

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We analyzed 98 cultivars belonging to eight yam species for mineral, protein, lipid, sugar, and cell-wall constituents. For most of the nutrients, intraspecific variability was as high as interspecific variability, but significant differences in the average values per species were found between *Dioscorea alata*, *D. dumetorum*, and the *D. cayenensis–D. rotundata* complex.

Several workers have shown the great variability that can exist between yams of different species. Busson (1965) compared the chemical composition of eight species of yam collected in different parts of West Africa. He observed important differences in the contents of crude protein (5.3–11.9 g/100 g), total carbohydrates (53.3–91.0 g/100 g), nondigestible carbohydrates (4.9–51.7 g/100 g), and calcium (0.014–0.024 g/100 g). Martin and Thompson (1971) insisted on the differences in crude protein content.

Other workers have been interested not only in the interspecific but also in the intraspecific variability in the chemical composition of yams. Baquar and Oke (1976, 1977) determined crude protein and mineral contents of about 60 samples belonging to 6 different yam species; the samples were collected from markets in Nigeria but were not well classified into different cultivars. Results showed that important variations, though not statistically tested, probably exist between species, and, in addition, that variations between samples within a species are also high. Similarly, using principal-component analysis based on amino-acid composition of 46 cultivars belonging to 5 yam species, Splittstoesser et al. (1973a) demonstrated wide intra- and interspecific diversity in amino-acid composition.

Earlier studies in our laboratory (Treche and Guion 1980) were dedicated to the differences in nutritional potentialities of the main yam species grown in Cameroon. This paper contains part of the results of a study on 98 cultivars agronomically classified (Lyonga and Ayuk-Takem 1982) belonging to 8 species. The objectives of our study were to compare intra- and interspecific variability in chemical composition, to assess nutritional value of cultivars, and to give references for clonal selection.

Materials and Methods

From 1977 to 1982, we collected 98 samples from multiplication plots of the Institute of Agronomic Research throughout Cameroon. The samples corresponded to the descriptions by Lyonga and Ayuk-Takem (1982): *D. alata*, 23 samples; *D. bulbifera*, 11; *D. cayenensis*, 18; *D. dumetorum*, 23; *D. esculenta*, 6; *D. liebrechtsiana*, 2; *D. rotundata*, 9; and *D. schimperiana*, 6. For each sample, stored less than a week, tubers were weighed, peeled, washed, dried *in vacuo* at < 60°C, and ground in a "whiley" mill to pass through a 0.5-mm sieve.

We noted flesh colour and conducted chemical analyses to determine the contents of dry matter, ash, and crude protein; lipid by soxhlet extraction with petroleum ether; starch by the glucoamylase method (Thivend et al. 1965); total soluble sugars colorimetrically by the anthron method (Loewus 1952) after two hot extractions and one cold extraction by 80% ethanol; free glucose, fructose, and sucrose in 80% ethanol extract as proposed by Johnson et al. (1964); nondigestible carbohydrates by the formic-acid technique of Guillemet and Jacquot (1943); acid detergent fibre (lignocellulose) and neutral detergent fibre (lignocellulose and hemicellulose) by the procedures of van Soest (1963) and van Soest and Wine (1967); pentosans by the aniline–acetate colorimetric method of

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Table 1. Dry matter, starch, cell-wall constituents, minerals, protein, lipids, and energy content of eight yam species.

	D. alata	*D. bulbifera*	*D. cayenensis*	*D. dumetorum*	*D. esculenta*	*D. liebrechtsiana*	*D. rotundata*	*D. schimperiana*
Samples	23	11	18	23	6	2	9	6
Dry matter (% of fresh peeled tuber)								
Average ± SE	24.4 ± 1.2	28.8 ± 0.9	32.6 ± 1.0	23.2 ± 0.6	29.7 ± 1.2	36.1	33.4 ± 1.5	23.0 ± 0.9
Range	14.1 – 35.1	24.8 – 35.1	23.5 – 40.2	19.0 – 28.3	24.5 – 30.8	35.9 – 36.3	26.3 – 39.5	19.4 – 25.6
Starch (%, dry weight basis)								
Average ± SE	72.6 ± 1.4	72.9 ± 0.7	80.0 ± 0.7	70.5 ± 0.7	70.4 ± 1.2	80.4	80.2 ± 0.9	71.1 ± 3.2
Range	60.2 – 82.1	69.8 – 78.6	76.9 –85.3	61.7 – 75.5	66.3 – 73.4	79.7 – 81.1	77.4 – 84.1	56.3 – 78.1
Acid-detergent fibre (%, dry weight)								
Average ± SE	3.4 ± 1.0	3.5 ± 0.6	2.6 ± 0.7	5.5 ± 0.3	2.7 ± 0.1	2.0	2.4 ± 0.1	3.5 ± 0.5
Range	2.1 – 5.0	3.0 – 5.0	1.2 – 4.1	3.4 – 7.6	2.3 – 3.1	1.9 – 2.1	2.1 – 2.7	2.4 – 5.8
Neutral detergent fibre (%, dry weight)								
Average ± SE	4.9 ± 1.5	3.5 ± 0.7	3.3 ± 1.0	5.2 ± 0.4	2.6 ± 0.2	2.4	2.6 ± 0.4	4.6 ± 1.0
Range	2.8 – 8.8	2.9 – 5.2	1.7 – 5.0	3.0 – 8.4	2.4 – 3.2	2.4 – 2.5	1.6 – 4.4	2.0 – 8.6
Phosphorus (g/100 g)								
Average ± SE	0.116 ± 0.005	0.128 ± 0.006	0.093 ± 0.004	0.161 ± 0.005	0.089 ± 0.008	0.052	0.094 ± 0.005	0.112 ± 0.010
Range	0.068 – 0.183	0.100 – 0.154	0.065 – 0.125	0.118 – 0.201	0.063 – 0.114	0.050 – 0.053	0.067 – 0.114	0.061 – 0.140
Calcium (g/100 g)								
Average ± SE	0.029 ± 0.005	0.023 ± 0.007	0.015 ± 0.001	0.042 ± 0.003	0.025 ± 0.003	0.023	0.018 ± 0.003	0.045 ± 0.010
Range	0.014 – 0.049	0.020 – 0.028	0.008 – 0.028	0.023 – 0.073	0.019 – 0.032	0.020 – 0.026	0.011 – 0.036	0.020 – 0.084
Potassium (g/100 g)								
Average ± SE	1.35 ± 0.06	1.17 ± 0.03	0.087 ± 0.05	1.05 ± 0.07	1.26 ± 0.05	0.76	1.07 ± 0.10	1.28 ± 0.05
Range	0.85 – 1.91	0.99 – 1.36	0.57 – 1.45	0.49 – 2.03	1.15 – 1.48	0.70 – 0.82	0.73 – 1.74	1.15 – 1.45
Magnesium (g/100 g)								
Average ± SE	27.2 ± 0.9	24.5 ± 1.5	23.4 ± 0.7	57.1 ± 2.7	37.4 ± 2.4	29.0	52.8 ± 5.0	40.8 ± 4.6
Range	19.5 – 35.5	22.4 – 25.8	19.6 – 29.4	30.9 – 114.5	28.9 – 44.6	27.9 – 30.1	26.7 – 72.5	30.1 – 58.4
Iron (g/100 g)								
Average ± SE	4.30 ± 0.78	4.39 ± 0.48	2.92 ± 0.32	6.85 ± 0.85	3.00 ± 0.34	4.89	5.47 ± 0.82	3.42 ± 0.34
Range	0.94 – 17.6	2.01 – 7.53	0.70 – 5.90	2.18 – 18.7	1.69 – 3.83	3.83 – 5.94	2.46 – 10.27	2.68 – 4.75
Zinc (g/100 g)								
Average ± SE	1.48 ± 0.12	1.76 ± 0.07	1.39 ± 0.08	1.88 ± 0.08	2.11 ± 0.19	2.71	1.30 ± 0.16	2.38 ± 0.32
Range	0.68 – 2.47	1.40 – 2.12	0.73 – 2.02	0.89 – 2.98	1.63 – 2.65	2.59 – 2.83	0.78 – 2.16	1.42 – 3.48
Copper (g/100 g)								
Average ± SE	0.87 ± 0.04	1.47 ± 0.05	0.94 ± 0.06	1.02 ± 0.10	1.14 ± 0.06	0.96	1.14 ± 0.17	1.65 ± 0.14
Range	0.53 – 1.28	1.25 – 1.79	0.43 – 1.36	0.61 – 2.18	0.88 – 1.30	0.96 – 0.96	0.73 – 2.16	1.19 – 2.13
Sodium (g/100 g)								
Average ± SE	8.8 ± 1.0	13.9 ± 1.7	13.0 ± 0.9	15.9 ± 0.9	3.9 ± 0.9	2.7	12.9 ± 1.5	2.0 ± 0.2
Range	3.9 – 19.3	11.6 – 21.6	7.3 – 18.8	8.1 – 23.4	3.8 – 4.0	2.4 – 2.9	11.0 – 16.7	1.4 – 3.0
Crude protein (%, dry weight)								
Average ± SE	8.24 ± 0.66	6.17 ± 0.32	6.08 ± 0.33	9.64 ± 0.30	5.10 ± 0.41	3.17	7.02 ± 0.54	7.66 ± 0.55
Range	4.72 – 15.84	4.62 – 8.45	3.55 – 8.35	7.36 – 13.21	4.06 – 6.46	3.12 – 3.22	4.31 – 8.88	5.94 – 8.87
Total lipids (%, dry weight)								
Average ± SE	0.24 ± 0.02	0.24 ± 0.02	0.21 ± 0.03	0.33 ± 0.05	0.25 ± 0.06	0.82	0.17 ± 0.05	0.20 ± 0.02
Range	0.10 – 0.40	0.14 – 0.36	0.10 – 0.50	0.07 – 0.63	0.11 – 0.46	0.72 – 0.92	0.07 – 0.53	0.15 – 0.26
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a calulated from specific energy factors given by MERRIL and WATT (1955)

Average ± SE	[illegible]	[illegible]	[illegible] ± 0.06	1.02 ± 0.10	1.14 ± 0.06	0.96	1.14 ± 0.17	1.65 ± 0.14
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Energy (cal/100 g)	383	383	387	381	388	396	[illegible]	[illegible]

Cerning and Giulbot (1973); phosphorus colorimetrically by the phosphovanadomolybdate ammonium method; iron by the orthophenanthrolene colorimetric method; calcium, potassium, sodium by Eppendorf flame photometer (Gueguen and Rombauts 1961); magnesium, zinc, and copper by Varian atomic absorption spectrometer.

Results and Discussion

Average weight of tubers from the eight species differed markedly. In fact, we could distinguish species by the number of tubers per plant — one or two: *D. alata, D. cayenensis, D. liebrechtsiana, D. rotundata, D. schimperiana*; several tubers jointly attached per plant: *D. dumetorum*; and distinct small tubers: *D. esculenta*; or bulbils: *D. bulbifera*.

Average peeling losses varied between 17.1% and 33.3%, depending on the species. Within one species, variations were very high (11.8–51.3% for *D. dumetorum* yam samples).

The flesh was most commonly white or yellow, but some cultivars of *D. alata* were distinctly violet and those of *D. schimperiana* orange.

The species could be divided into those with low (23–25%) dry-matter content (*D. alata, D. dumetorum, D. schimperiana*) and high (32–37%) dry-matter content (*D. cayenensis, D. liebrechtsiana, D. rotundata*), with *D. esculenta* and *D. bulbifera* having intermediate values (Table 1). Within *D. cayenensis*, cultivar C169, which has been selected as agronomically elite (Lyonga and Ayuk-Takem 1982), was the only one with low dry-matter content. Variations within *D. alata* were more important than those within the other species.

In mineral contents, ratios between the lowest and highest average by species varied between 1 : 2 and 1 : 3 except for sodium with a ratio of 1 : 8 found between several species (Table 1). Within one species, the ratio did not exceed 1 : 4 for most of the minerals. Intraspecific variability for P was lower than for other minerals, whereas Na and Fe had higher variability. The highest Fe values were probably caused by contamination of the samples during drying. Our results on K and Zn contents in *D. alata, D. dumetorum*, and *D. rotundata* were similar to those of Baquar and Oke (1977), but other values differed systematically.

Starch contents were within the range 70.4–72.9% except for *D. cayenensis, D. liebrechtsiana*, and *D. rotundata*, which had values greater than 80.0% (Table 1). The intraspecific variability in the low-starch species was higher than in the others.

Dioscorea esculenta and *D. liebrechtsiana* had comparatively high soluble sugars. The other species did not differ markedly from one another, but there was a high intraspecific variability, mostly within *D. alata* species.

For all the cell-wall constituents studied (Table 1), *D. dumetorum* had the highest average values, then *D. alata* and *D. schimperiana*. The lowest were peculiar to *D. rotundata* and *D. liebrechtsiana*. The high values for some *D. dumetorum* cultivars probably reflected the hardening phenomenon (Treche and Delpeuche 1982), which can occur just hours after harvest. As has been shown by Brillouet et al. (1981), the proportions of different cell-wall constituents, especially lignocellulose and hemicellulose, were not the same in all the yam species. Average hemicellulose content was unnoticeable for *D. dumetorum* tubers, whereas it reached 0.7% and 1.6% for *D. cayenensis* and *D. alata*, respectively.

Dioscorea dumetorum and *D. alata* had the highest average crude protein (Table 1); *D. liebrechtsiana* and *D. esculenta*, the lowest. High crude-protein content seems to be characteristic of *D. dumetorum* tubers, as the average value of 24 new varieties bred in Cameroon attained 10.2% (Pfeiffer and Treche, unpublished data). Nevertheless, intraspecific variability of crude protein seems to be at least as high as interspecific variability. On a fresh-weight basis, *D. rotundata, D. dumetorum, D. alata*, and *D. cayenensis* were distinct from the others by having a protein content more than or equal to 2.0%.

Lipid content was low except in *D. liebrechtsiana* and some cultivars of *D. dumetorum*. The range of ash content was not wide.

The energy content (Table 1) did not vary much because of the small absolute variation in lipid and ash, with *D. rotundata, D. cayenensis*, and *D. liebrechtsiana* having the highest calorific value.

Conclusion

Dioscorea cayenensis and *D. rotundata* were shown to be closely related. In fact, certain researchers (Martin and Rhodes 1978; Miege 1982) have grouped cultivars of these species into a *D. cayenensis–D. rotundata* complex. Using the Student's t-test for each nutrient, we found no significant differences between the two species except for total soluble sugars, nondigestible carbohydrates, Fe, and Mg.

Taking into account the characteristics in the chemical composition of the different species, especially the dry-matter content, we believe that cultivars of the *D. cayenensis–D. rotundata* complex are best for consumption fresh, whereas *D. dumetorum* and perhaps *D. alata* could be used in yam flour.

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TROPICAL ROOT CROPS:
PRODUCTION AND USES IN AFRICA

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PROCEEDINGS OF THE SECOND TRIENNIAL SYMPOSIUM OF THE INTERNATIONAL SOCIETY FOR TROPICAL ROOT CROPS — AFRICA BRANCH HELD IN DOUALA, CAMEROON, 14 – 19 AUGUST 1983