VARIABILITY IN THE CHEMICAL COMPOSITION OF YAMS GROWN IN CAMEROON.(1)

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A B S T R A C T

98 cultivars belonging to eight yam species were analysed for mineral, protein, lipid, sugar and cell wall constituent content,

For most of the studied nutrients, intraspecific variability appears to be as high as interspecific • Nevertheless, significant differences in the average values per specie were found between D. alata, D. dumetorum and D. cayenensis - D. rotundata complex.

R E S U M E

Les teneurs en minéraux, protéines brutes, lipides, glucides digestibles et constituants membranaires de 98 cultivars appartenant à 8 espèces d'Ignames différentes sont déterminées.

Pour la plupart des nutriments considérés, la variabilité intraspécifique apparaît être au moins aussi importante que la variabilité interspécifique. Néanmoins, des différences significatives sont mises en évidence entre les moyennes par espèce obtenues sur D. alata, D. dumetorum et le complexe D. cayenensis - D.rotundata.

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I N T R O D U C T I O N

Several workers have shown the great variability that can exist between yams of different species. BUSSON (1965) has compared the chemical composition of eight species of yam collected in different parts of West Africa. He observed important differences in the contents of various nutrients expressed as gram per 100 gram on dry weight basis : crude protein (5.3 to 11.9), total carbohydrates (53.3 to 91.0) undigestible carbohydrates (4.9 to 51.7) and calcium (0.014 to 0.024). MARTIN and THOMPSON (1971) have insisted on the differences in crude protein content.

Other workers have been interested not only on the interspecific but also in the intraspecific variability in the chemical composition of yams. BAQUAR and OKE (1976 ; 1977) have determined crude protein and mineral (P, Ca, Mg, K, Na, Zn, Cu, Mn, Fe) contents of about 60 samples belonging to 6 different yam species ; the samples were collected from markets of various nigerian localities but were not well classified into differents cultivars. Results show that important variations though not statistically tested probably exist between species and, in addition, that variations between samples within a specie are also high. Using principal component analysis based on amino acid composition of 46 cultivars belonging to 5 yam species, SPLITTSTOESSER et al. (1973) have demonstrated a similar intra and interspecific diversity in amino-acid composition.

Earlier studies in our laboratory (TRECHE and GUION, 1980) have been dedicated to the differences in nutritional potentialities of the main yam species grown in Cameroon. This paper contains part

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of the results of a study that has been carried on 98 cultivars agronomicaly classified (LYONGA and AYUK-TAKEM, 1982) belonging to eight species. The objectives of this study are to compare intra and interspecific variability in chemical composition, to assess nutritional value of studied cultivars and to give references for clonal selection.

M A T E R I A L S A N D M E T H O D S

Collection of the yam samples

Each samples was collected, 1977 to 1982, from multiplication plots of the Institute of Agronomic Research in various stations in Cameroon. Samples were made of several tubers from different yam stands.

The 98 analysed samples do correspond to the yam types defined by LYONGA and AYUK-TAKEM (1982) who grouped some of these types as the same cultivars. In reference to this classification the following types were analysed :

- D. alata : A169, A269, A369, A669, A771, A871, A972, A1072, A1272, A1372, A1572, A1772, A1872, A2072, A2173, A2473, A2974, A3077, A3277, A3678, A3778, A3880, A3980
- D. bulbifera : B169, B269, B369, B469, B569, B669, B769, B869, B972, B1072, B1172
- D. cayenensis : C169, C269, C369, C469, C569, C669, C769, C870, C970, C1070, C1170, C1270, C1370, C1570, C1670, C1770, C1970, C2070

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- D. dumetorum : D169, D269, D369, D469, D569, D669, D769, D869, D969, D1069, D1170, D1370, D1472, D1572, D1672, D1772, D1872, D1975, D2075, D2175, cv. Asol Centre Sud, cv. smooth ex Bakundu, cv. Hairy ex Muyuka.
- D. esculenta : E171, E272, E373, E480, E580, E680
- D. liebrechtsiana : L170, L270
- D. rotundata : R169, R569, R670, R770, R871, R971, cv. Kendang ex Gamba, cv. ex Centre Sud, cv. ex Mankoon.
- D. schimperiana : S169, S269, S370, S470, S571, S671.

For each sample, less than a week stored, tubers were weighed, peeled, washed, colour noted, dried in vacuo at a temperature less than 60°C and ground in a whiley mill to pass through a 0.5 mm sieve.

Chemical analysis

The following contents were determined

- Dry matter, ash and crude protein by the conventional methods;
- 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);
- Undigestible carbohydrates by the formic acid technique of GUILLEMET and JACQUOT (1943) ;

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- Acid Detergent Fibre (lignocellulose) and Neutral Detergent Fibre (lignocellulose + hemicelluloses) by the procedures of VAN SOEST (1963) and VAN SOEST and WINE (1967) ;
- Pentosans by the aniline acetate colorimetric method of CERNING and GUILBOT (1978) ;
- Phosphorous, colorimetrically by the phosphovanadomolybdate ammonium method ;
- Iron by the orthophenantrolin colorimetric method (FORTUNE and MELLOW, 1938) ;
- Calcium, Potassium, Sodium by using EPPENDORF flame photometer (GUEGUEN and ROMBAUTS, 1961) ;
- Magnesium, Zinc and Copper by using VARIAN atomic absorption spectrometer.

R E S U L T S A N D D I S C U S S I O N

General characteristics and water content of the tubers (Table 1)

Average weight of the eight yam specie tubers are very different. In fact we can distinguish species having 1 or 2 tubers by plant (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) per plant.

Average peeling losses varies between 17.1 and 33.3 % depending on the specie. Within a specie, variations can be very high (11.8 to 51.3 for D. dumetorum yam samples)

The most prominent yam flesh colours are white and yellow while some cultivars of D. alata are distinctly violet and D. schimperiana orange.

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Concerning the dry matter content, yam species can be divided into two main groups : low dry matter content (D. alata, D. dumetorum and D. schimperiana) and high dry matter content (D. cayenensis, D. liebrechtsiana, D. rotundata). The small tubers or bulbils of D. esculenta and D. bulbifera have intermediary values. It should be noted that within D. cayenensis specie, cultivar C169 that has been selected on agronomic basis as "elite" (LYONGA and AYUK-TAKEM, 1982), is the only one with a low dry matter content. Variations within D. alata specie are more important than within the other species.

Mineral contents of the yam tubers (Table 2)

Ratios between the inferior average value by specie and the superior one for each mineral content vary between 1:2 and 1:3 except for Na with a ratio of 1:8 found between several species.

Within a specie, ratios between lower and higher values did not exceed 1:4 for most of the minerals. Intraspecific variability for P is lower than for other minerals while Na and mostly Fe do have a higher variability. It could be suggested that the highest Fe values were due to contamination of the samples during the drying in a vacuum oven.

In comparing our results on the most represented species (D. alata, D. dumetorum and D. rotundata) to those of BAQUAR and OKE (1977) one can note that for K and Zn the values are very similar. On the other hand, they have systematically higher P values, lower Mg and Fe while for Ca, Na and Cu they have, depending on specie, higher or lower values than us.

Carbohydrate contents of the yam tubers (Table 3 and 4)

Starch content of all the studied yam species are within the range 70.4 to 72.9 except for D. cayenensis, D. liebrechtsiana and D. rotundata that do have values more than 80.0. The intraspecific variability in the low starch content species is higher than in the others.

Concerning soluble sugars we can note that D. esculenta and D. liebrechtsiana do have comparatively high values. The other species do not differ markedly but we observe a high intraspecific variability mostly within D. alata specie and the non existence of free glucose in several cultivars.

For all the cell wall constituents studied, highest average values are found in D. dumetorum, then in D. alata and D. schimperiana tubers while the lowest are peculiar to D. rotundata and D. liebrechtsiana. The high cell wall constituent content in some D. dumetorum cultivars is probably due to hardening phenomenon (TRECHE and DELPEUCH, 1982) which can occur in the hours following harvest.

As it has been shown (BRILLOUET et al, 1981), the proportions of the different cell wall constituents, especially Lignocellulose and hemicellulose, are not the same in all the yam species. Average hemicellulose content (N.D.F minus A.D.F) is unnoticeable for D. dumetorum tubers while it reaches respectively 0.7 and 1.6 % for D. cayenensis and D. alata tubers.

Crude protein, Lipid and Energy content in the yam tubers (Table 5)

D. dumetorum and D. alata have the highest average crude protein content while D. liebrechtsiana and D. esculenta have the lowest.

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High crude protein content seems to be a genetical characteristic of D. dumetorum tubers since the average value of 24 new varieties bred in Cameroon attained 10.2 % (PFEIFFER and TRECHE, 1983). Nevertheless, as it has been noticed for other nutrients, intraspecific variability of crude protein content seems to be at least as high as interspecific variability.

Average values are partially in accordance to those of other workers. Our results are higher than those of BAQUAR and OKE (1976) for D. alata and D. dumetorum, lower for D. rotundata ; in reference to those of SPLITTSTOESSER et al (1973) they are lower for D. esculenta and D. bulbifera but very similar for D. alata and D. rotundata.

If expressed on a fresh weight basis, crude protein content leads to a different classification of the yam species : D. rotundata, D. dumetorum, D. alata and D. cayenensis are distinct from the others by having a content more than or equal to 2.0 %.

Lipid content is low except for D. liebrechtsiana and some cultivars of D. dumetorum. The range of ash content is not very wide.

If based on dry weight basis, the energy content of yam tubers does not vary due to the small absolute variation in Lipid and ash content. But considering equal quantity of edible tubers, the energy content has the same variation as water content : D. rotundata, D. cayenensis and D. liebrechtsiana have the highest calorific value.

C O N C L U S I O N

All along the study it has been remarked that D. cayenensis and

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D. rotundata are closely related. In fact certain researchers (MARTIN and RHODES, 1978 ; MIEGE, 1982) have grouped cultivars belonging to these species into a D. cayenensis - D. rotundata complex. We have verified using STUDENT-t test for each nutrient if the differences between average value for 18 D. cayenensis cultivars and 9 D. rotundata cultivars are significant : except for total soluble sugars, undigestible carbohydrate, Fe and Mg, the nutrient contents are not different.

The most interesting species with regards to the protein content on fresh weight basis are those with the highest number of cultivars in Cameroon : D. alata, D. dumetorum and D. cayenensis - D. rotundata complex. Using analysis of variance and FISCHER-F determination, we have tested the significance of the differences observed for each nutrient (Table 6). For 17 out of 20 studied nutrients, significant differences exist- The D. cayenensis - D. rotundata complex distinguishes itself mainly by its high dry matter, starch and low crude protein content on dry weight basis while D. dumetorum has higher crude protein, cell wall constituent and almost all mineral content.

Taking into account the characteristics in the chemical composition of the different species, especially the dry matter content, two important uses could be made of cameroonian yams. Cultivars of D. cayenensis - D. rotundata complex are best for consumption as fresh harvested or moderately stored tubers while D. dumetorum and perhaps D. alata could be used for yam flour production.

Due to important intraspecific variability, it is recommandable to determine chemical composition of each yam cultivar so as to know their nutritional value before an elaborate selection and propagation program.

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R E F E R E N C E S

BAQUAR, S.R. and OKE, O.L., 1976 - Protein in nigerian yams (Dioscorea spp). Nutr. Rpts. Int., 14, 237-248.

BAQUAR, S.R. and OKE, O.L., 1977 - Mineral constituents of nigerian yams - Nutr. Rpts. Int., 15, 265-272.

BRILLOUET, J.M., TRECHE, S. and SEALY, L., 1981 - Alterations in cell wall constituents of yams. Dioscorea dumetorum and D. rotundata with maturation and storage conditions. Relation with post-harvest hardening of D. dumetorum yam tubers. J. Food Sci., 46, 1964-1965 and 1967.

BUSSON, F., 1965 - Plantes alimentaires de l'Ouest africain - ed. LECONTE - Marseille.

CERNING, J. and GUILBOT, A., 1973 - A specific method for the determination of pentosans in cereals and cereal products. Cereal Chem., 50, 176-184.

FORTUNE, W.B. and MELLOW, M.C., 1938 - Ind. Engng Chem. Analyt. Edn., 10, 60.

GUEGUEN, L. and ROMBAUTS, P., 1961 - Dosage du sodium, du potassium, du calcium et du magnesium par spectrophotomètrie de flamme dans les aliments, le lait et les excreta - Ann. Biol. Anim. Bioch. Biophy., 1, 80-97.

GUILLEMET, R. and JACQUOT, R., 1943 - Essai de détermination de l'indigestible glucidique. C.R. Ac. Sci. Paris, 216, 508-510.

JOHNSON, G., LAMBERT, C., JOHNSON, D.K. and SUNDERWIRTH, S.G., 1964 - Colorimetric determination of glucose, fructose and sucrose in plant material using a combination of enzymatic and Chemical methods. J. Agr. Food Chem., 12, 216-219.

.../...

LOEWUS, F.A., 1952 - Improvement in anthrone method for the determination of carbohydrates - Anal. Chem., 24, 219.

LYONGA, S.N. and AYUK-TAKEM, J.A., 1982 - Investigations on selection and production of edible yams (Dioscorea spp) in the western highlands of the United Republic of Cameroon- in : yams. Ignames - ed. by J. MIEGE and S.N. LYONGA. Clarendon Press Oxford- 161-172.

MARTIN, F.W. and RHODES, A.M., 1978 - The relationship of Dioscorea cayenensis and D. rotundata - Trop. Agric. (Trinidad), 55, 193-206.

MARTIN, F.W. and THOMPSON, A.E., 1971 - Crude protein content of yams - Hortscience, 6, 545-546.

MERRIL, A.L. and WATT, B.K., 1955 - Energie value of food - Basis and derivation - Agric. Handbook N° 74 - U.S.D.A.

MIEGE, J., 1982 - Etude chimiotaxonomique de dix cultivars de Côte-d'Ivoire relevant du complexe Dioscorea cayenensis - D. rotundata. in : yams. Ignames - ed. by J. MIEGE and S.N. LYONGA. Clarendon Press Oxford, 197-231.

PFEIFFER, H. and TRECHE, S., 1983 - Unpublished results-

SPLITTSTOESSER, W.E., MARTIN, F.W. and RHODES, A.M., 1973 - The nutritional value of some tropical root crops- Proc. Trop. Reg. Am. Soc. Hort. Sci., 17, 290-294.

SPLITTSTOESSER, W.E., MARTIN, F.W. and RHODES, A.M., 1973 - The amino acid composition of five species of yams (Dioscorea) J. Amer. Soc. Hort. Sci., 98, 563-567.

.../...

THIVEND, P., MERCIER, C. and GUILBOT, A., 1965 - Dosage de l'amidon dans les milieux complexes - Ann. Biol. Anim. Bioch. Biophys., 5, 513-526.

TRECHE, S. and DELPEUCH, F.. 1982 - Le durcissement de Dioscorea dumetorum au Cameroun. in : yams - Ignames - ed. by J. MIEGE and S.N. LYONGA. Clarendon Press Oxford. 294-311.

TRECHE, S. and GUION, P., 1980 - Etude des potentialités nutritionnelles de quelques tubercules tropicaux cultivés au Cameroun - Revue Science et Technique, 1, 55-101.

VAN SOEST, P.S., 1963 - Use of detergents in the analysis of fibrous feeds. J. of Assoc. Offic. Anal. Chem., 46, 829-835.

VAN SOEST, P.S. and WINE, R.H., 1967 - Use of detergents in the analysis of fibrous feeds. 4. determination of plant cell - wall constituents. J. of Assoc. Offic. Anal. Chem., 50, 50-55.

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YAM SPECIES	Number of samples	Average (1) Weight of each analysed tuber in grams	Peeling (2) Losses as per cent of initial weight	Colour of the flesh	Dry matter (2) content as per cent of peeled fresh tuber
Dioscorea alata	23	792 228 - 2962	23.9 ± 1.4 15.8 - 39.6	White Cream yellow Violet	24.4 ± 1.2 14.1 - 35.1
Dioscorea bulbifera	11	77 26 - 110	26.0 ± 0.9 21.8 - 29.9	Yellow	28.8 ± 0.9 24.8 - 35.1
Dioscorea cayenensis	18	817 182 - 2510	28.5 ± 2.0 17.4 - 49.8	Yellow White	32.6 ± 1.0 23.5 - 40.2
Dioscorea dumetorum	23	582 98 - 1575	31.8 ± 2.0 11.8 - 51.3	Yellow White	23.2 ± 0.6 19.0 - 28.3
Dioscorea esculenta	6	122 49 - 298	27.0 ± 3.2 13.4 - 33.9	White	29.7 ± 1.2 24.5 - 30.8
Dioscorea liebrechtsiana	2	246 119 - 374	33.3 29.1 - 37.6	Cream	36.1 35.9 - 36.3
Dioscorea rotundata	9	1144 370 - 1643	25.8 ± 4.6 7.4 - 43.5	White	33.4 ± 1.5 26.3 - 39.5
Dioscorea schimperiana	6	906 745 - 1215	17.1 ± 2.1 8.7 - 21.8	Yellow Orange	23.0 ± 0.9 19.4 - 25.6
AVERAGE	98	586	26.7		28.90

(1) Average - Extreme Values
(2) Average ± Standard error - Extreme values

TABLE 1. Average weight, peeling losses, colour and dry matter content of the tubers of eight yam species

YAM SPECIES	Phosphorous g/100g	Calcium g/100g	Potassium g/100g	Magnesium mg/100g	Iron mg/100g	Zinc mg/100g	Copper mg/100g	Sodium mg/100g
oscorea alata	0,116 ± 0,005	0,029 ± 0,005	1,35 ± 0,06	27,2 ± 0,9	4,30 ± 0,78	1,48 ± 0,12	0,87 ± 0,04	8,8 ± 1.0
	0,068 - 0,183	0,014 - 0,049	0,85 - 1,91	19,5 - 35.5	0,94 - 17,6	0,68 - 2,47	0,53 - 1,28	3,9 - 19,3
oscorea bulbifera	0,128 ± 0,006	0,023 ± 0,007	1,17 ± 0,03	29,5 ± 1,5	4,39 ± 0,48	1,76 ± 0,07	1,47 ± 0,05	13,9 ± 1,7
	0,100 - 0,154	0,020 - 0,028	0,99 - 1,36	22,4 ± 25,8	2,01 - 7,53	1,40 - 2,12	1,25 - 1,79	11,6 - 21,6
oscorea cayenensis	0,093 ± 0,004	0,015 ± 0,001	0,87 ± 0,05	23,4 ± 0,7	2,92 ± 0,32	1,39 ± 0,08	0,94 ± 0,06	13,0 ± 0,9
	0,065 - 0,125	0,008 - 0,028	0,57 - 1,45	19,6 - 29,4	0,70 - 5,90	0,73 - 2,02	0,43 - 1,36	73 - 18,8
oscorea dumetorum	0,161 ± 0,005	0,042 ± 0,003	1,05 ± 0,07	57,1 ± 2,7	6,85 ± 0,85	1,88 ± 0,08	1,02 ± 0,10	15,9 ± 0,9
	0,118 - 0,201	0,023 - 0,073	0,49 - 2,03	30,9 - 114,5	2,18 - 18,7	0,89 - 2,98	0,61 - 2,18	8,1 - 23,4
oscorea esculenta	0,089 ± 0,008	0,025 ± 0,003	1,26 ± 0,05	37,4 ± 2,4	3,00 ± 0,34	2,11 ± 0,19	1,14 ± 0,06	3,9 ± 0,9
	0,063 - 0,114	0,019 - 0,032	1,15 - 1,48	28,9 - 44,6	1,69 - 3,83	1,63 - 2,65	0,88 - 1,30	3,8 - 4,0
oscorea liebrechtsiana	0,052	0,023	0,76	29,0	4,89	2,71	0,96	2,7
	0,050 - 0,053	0,020 - 0,026	0,70 - 0,82	27,9 - 30,1	3,83 - 5,94	2,59 - 2,83	0,96 - 0,96	2,4 - 2,9
oscorea rotundata	0,094 ± 0,005	0,018 ± 0,003	1,07 ± 0,10	52,8 ± 5,0	5,47 ± 0,82	1,30 ± 0,16	1,14 ± 0,17	12,9 ± 1,5
	0,067 - 0,114	0,011 - 0,036	0,73 - 1,74	26,7 - 72,5	2,46 - 10,27	0,78 - 2,16	0,73 - 2,16	11,0 - 16,7
oscorea schimperiana	0,112 ± 0,010	0,045 ± 0,010	1,28 ± 0,05	40,8 ± 4,6	3,42 ± 0,34	2,38 ± 0,32	1,65 ± 0,14	2,0 ± 0,2
	0,061 - 0,140	0,020 - 0,084	1,15 - 1,45	30,1 - 58,4	2,68 - 4,75	1,42 - 3,48	1,19 - 2,13	1,4 - 3,0
AVERAGE	0.106	0.028	1.10	37.2	4.41	1.88	1.15	9.14

Average ± standard error
Extreme values

TABLE 2. Mineral content of the eight yam species.

YAM SPECIES	Starch	Total soluble Sugars	Free Glucose	Fructose + Fructosans	Sucrose
Dioscorea alata	72,6 ± 1,4 60,2 - 82,1	4,25 ± 0,64 0,81 - 16,50	0,11 ± 0,04 0,00 - 0,68	2,19 ± 0,33 0,43 - 8,65	2,79 ± 0,60 0,06 - 14,68
Dioscorea bulbifera	72,9 ± 0,7 69,8 - 78,6	3,94 ± 0,52 2,57 - 6,82	0,02 ± 0,01 0,00 - 0,06	2,01 ± 0,27 1,19 - 3,67	2,77 ± 0,42 1,44 - 5,45
Dioscorea cayenensis	80,0 ± 0,7 76,9 - 85,3	3,66 ± 0,19 2,29 - 5,47	0,22 ± 0,05 0,00 - 0,60	1,74 ± 0,12 1,02 - 2,85	2,14 ± 0,24 0,58 - 4,31
Dioscorea dumetorum	70,5 ± 0,7 61,7 - 75,5	5,09 ± 0,51 0,60 - 12,34	0,35 ± 0,07 0,00 - 1,31	2,66 ± 0,28 0,33 - 6,69	3,42 ± 0,49 0,16 - 9,62
Dioscorea esculenta	70,4 ± 1,2 66,3 - 73,4	7,53 ± 1,41 3,20 - 11,75	0,80 ± 0,22 0,21 - 1,44	2,53 ± 0,38 0,97 - 3,82	3,28 ± 0,51 1,21 - 4,21
Dioscorea liebrechtsiana	80,4 79,7 - 81,1	8,44 8,39 - 8,48	2,19 2,09 - 2,28	4,66 4,41 - 4,91	3,57 3,39 - 3,74
Dioscorea rotundata	80,2 ± 0,9 77,4 - 84,1	2,94 ± 0,26 2,00 - 4,16	0,03 ± 0,02 0,00 - 0,15	1,43 ± 0,13 0,97 - 2,13	1,73 ± 0,32 0,54 - 2,37
Dioscorea schimperiana	71,1 ± 3,2 56,3 - 78,1	4,15 ± 0,42 2,59 - 5,41	0,54 ± 0,14 0,01 - 0,79	2,39 ± 0,26 1,47 - 3,03	1,64 ± 0,36 0,26 - 2,61
A V E R A G E	74,8	5,00	0,53	2,45	2,67

Average values ± Standard error
Extreme values

TABLE 3. Starch and soluble sugar content of the eight yam species (% on dry weight basis).

YAM SPECIES		Undigestible carbohydrate	Acid Detergent Fibre	Neutral Detergent Fibre	Pentosans
Dioscorea	alata	3,09 ± 0,95 1,86 - 4,62	3,4 ± 1,0 2,1 - 5,0	4,9 ± 1,5 2,8 - 8,8	1,08 ± 0,28 0,63 - 1,74
Dioscorea	bulbifera	2,78 ± 0,39 2,33 - 3,81	3,5 ± 0,6 3,0 - 5,0	3,5 ± 0,7 2,9 - 5,2	0,81 ± 0,13 0,57 - 1,03
Dioscorea	cayenensis	2,09 ± 0,52 1,10 - 2,79	2,6 ± 0,7 1,2 ± 4,1	3,3 ± 1,0 1,7 - 5,0	0,71 ± 0,12 0,54 - 0,97
Dioscorea	dumetorum	4,41 ± 0,23 2,78 - 7,17	5,5 ± 0,3 3,4 - 7,6	5,2 ± 0,4 3,0 - 8,4	1,61 ± 0,11 0,85 - 3,05
Dioscorea	esculenta	2,11 ± 0,11 1,89 - 2,44	2,7 ± 0,1 2,3 ± 3,1	2,6 ± 0,2 2,4 - 3,2	0,79 ± 0,04 0,68 - 0,90
Dioscorea	liebrechtsiana	1,65 1,63 - 1,66	2,0 1,9 - 2,1	2,4 2,4 - 2,5	0,64 0,55 - 0,72
Dioscorea	rotundata	1,70 ± 0,07 1,44 - 2,11	2,4 ± 0,1 2,1 - 2,7	2,6 ± 0,4 1,6 - 4,4	0,65 ± 0,04 0,44 - 0,84
Dioscorea	schimperiana	2,99 ± 0,48 1,95 - 4,72	3,5 + 0,6 2,4 - 5,8	4,6 ± 1,0 2,0 - 8,6	0,88 ± 0,07 0,67 - 1,07
AVERAGE		2,60	3,2	4,4	0,90

Average values ± Standard error
Extreme values

TABLE 4. Cell wall constituent content of the eight yam species (% on dry weight basis)

YAM SPECIES	Crude Protein (1)	Total lipids (1)	ASH at 550°C (1)	Total Sugars by difference % on dry weight basis	Energy (2) Content per 100g dry weight	Energy (2) content per 100g fresh weight	Protein fresh weight basis
Dioscorea alata	8,24 ± 0,66 4,72 - 15,84	0,24 ± 0,02 0,10 - 0,40	3,09 ± 0,15 2,06 - 4,47	88,4	383	94	2,01
Dioscorea bulbifera	6,17 ± 0,32 4,62 - 8,45	0,24 ± 0,02 0,14 - 0,36	3,35 ± 0,15 2,85 - 4,41	90,2	383	110	1,78
Dioscorea cayenensis	6,08 ± 0,33 3,55 - 8,35	0,21 ± 0,03 0,10 - 0,50	2,31 ± 0,09 1,92 - 3,59	91,4	387	126	1,98
Dioscorea dumetorum	9,64 ± 0,30 7,36 - 13,21	0,33 ± 0,03 0,07 - 0,63	2,82 ± 0,13 1,75 - 3,85	87,2	381	88	2,24
Dioscorea esculenta	5,10 ± 0,41 4,06 - 6,46	0,25 ± 0,06 0,11 - 0,46	2,30 ± 0,20 1,64 - 2,84	92,3	388	115	1,52
Dioscorea liebrechtsiana	3,17 3,12 - 3,22	0,82 0,72 - 0,92	1,74 1,70 - 1,78	94,2	396	143	1,14
Dioscorea rotundata	7,08 ± 0,54 4,31 - 8,88	0,17 ± 0,05 0,07 - 0,53	2,41 ± 0,25 1,35 - 3,85	90,4	385	128	2,35
Dioscorea schimperiana	7,66 ± 0,55 5,94 - 8,87	0,20 ± 0,02 0,15 - 0,26	2,93 ± 0,15 2,43 - 3,45	89,2	383	88	1,76
A V E R A G E	6,64	0,31	2,62	90,4	386	112	1,85

(1) Average values ± Standard error (% on dry weight basis)
Extreme values

(2) Calories calculated using specific energy factors given by MERRIL and WATT (1955).

TABLE 5. Protein, Lipid, ash and energy content of the eight yam species.

	D. alata	D. cayenensis - D. rotundata	D. dumetorum	Level of significance
Peeling losses (%)	23.9^{a}	27.6^{ab}	31.8^{b}	$P < 0.05$
Dry matter content (%)	24.4^{a}	32.9^{b}	23.2^{a}	$P < 0.01$
Starch (1)	72.6^{a}	80.1^{b}	70.5^{c}	$P < 0.01$
Total soluble sugars (1)	4.25^{ab}	3.41^{a}	5.09^{b}	$P < 0.05$
Fructose (1)	2;19	1.64	2.66	N. S.
Sucrose (1)	2.79	2.00	3.42	N. S.
Undigestible carbohydrate (1)	3.09^{a}	1.96^{b}	4.41^{c}	$P < 0.01$
N. D. F (1)	4.93^{a}	3.11^{b}	5.22^{b}	$P < 0.01$
A. D. F (1)	3.38^{a}	2.51^{b}	5.46^{c}	$P < 0.01$
Pentosans (1)	1.08^{a}	0.69^{b}	1.67^{c}	$P < 0.01$
Protein (1)	8.24^{a}	6.40^{b}	9.64^{c}	$P < 0.05$
Lipid (1)	0.24^{a}	0.21^{a}	0.32^{b}	$P < 0.05$
Ash (1)	3.09^{a}	2.35^{b}	2.82^{a}	$P < 0.05$
Phosphorous (2)	1.16^{a}	0.94^{b}	1.61^{c}	$P < 0.01$
Calcium (2)	0.29^{a}	0.16^{b}	0.42^{c}	$P < 0.01$
Magnesium (2)	0.27^{a}	9.33^{a}	0.57^{b}	$P < 0.01$
Potassium (2)	13.5^{a}	9.3^{b}	10.5^{b}	$P < 0.01$
Iron (3)	43.0^{a}	37.7^{a}	68.5^{b}	$P < 0.05$
Zinc (3)	14.8^{a}	13.6^{a}	18.8^{b}	$P < 0.01$
Copper (3)	8.6	10.1	10.2	N. S.
Sodium (2)	88^{a}	125^{b}	159^{c}	$P < 0.01$

(1) in g. per 100g. on dry weight basis

(2) in g. per 1000g. on dry weight basis

(3) in mg. per 1000g. on dry weight basis

In a given line values with no common superscript are significantly different.

TABLE 6. Comparison in the chemical composition of three main yam species grown in Cameroon.