

Evaluation of the Chemical Composition of Cameroonian Yam Germplasm

T. AGBOR-EGBE¹ AND S. TRECHE²

Food and Quality Control Laboratory, Centre for Food and Nutrition Research, I.M.P.M.,
P.O. Box 6163, Yaounde, Cameroon

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The chemical composition of 98 cultivars belonging to eight yam species extensively grown and consumed in Cameroon was evaluated. Due to the fact that statistical analysis showed no significant differences between the means obtained for the variables estimated for *Dioscorea cayenensis* and *D. rotundata* cultivars, these two yam species have been treated in this study as a single species termed *D. cayenensis/rotundata* complex. On the basis of dry matter content, the yam species could be divided into three groups, low (23–25 g 100 g⁻¹, *D. alata*, *D. dumetorum*, and *D. schimperiana*), intermediate (28–30 g 100 g⁻¹, *D. esculenta* and *D. bulbifera*), and high (32–37 g 100 g⁻¹, *D. cayenensis/rotundata* complex and *D. liebrechtsiana*). There was a great variability in protein levels among the yam species, which makes possible the selection of protein-rich cultivars. Mean fat levels were very low (0.1–0.9 g 100 g⁻¹). Starch contents ranged from a mean value of 70.4 to 72.9 g 100 g⁻¹, except for *D. cayenensis/rotundata* complex and *D. liebrechtsiana*, which had levels higher than 80 g 100 g⁻¹. *D. dumetorum* tubers had the highest levels of plant cell wall carbohydrates and almost all the minerals analyzed. Multivariate analysis has shown that some of the variables estimated and chosen in a stepwise manner could be used with a low probability error to differentiate among cultivars within a yam species.

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INTRODUCTION

Yams (*Dioscorea* spp.) are herbaceous plants with a twining stem belonging to the *Dioscoreaceae* family which consists of about 20 edible genera (Kay, 1987; Hladik *et al.*, 1984). They produce edible starchy storage tubers which are of cultural, economic, and nutritional importance in the tropical and subtropical regions of the world (Coursey, 1967). There are eight major yam species extensively grown and consumed in Cameroon (Lyonga and Ayuk-Takem, 1982). Generally, yam tubers are either boiled, roasted, baked, or fried. However, in some regions of Cameroon and in particular West Africa, the tubers are boiled and then pounded to a rather glutinous dough called "fufu." Cooked yam tubers or their products are usually eaten in association with protein-rich sauces.

In spite of their importance as a food source, there have been only a few studies reported on the chemical composition of a wide range of yam species, and little information is available for distinguishing cultivars within a species which are similar morphologically (Splittstoesser *et al.*, 1973; Martin, 1979). In the studies undertaken, the yam species and cultivars are often not differentiated from each other.

¹ To whom correspondence should be addressed. Fax: (237) 30 28 65.

² Current address: Centre ORSTOM, 911 Avenue Agropolis, B P 5045, 34032 Montpellier Cedex 1, France. Fax: (33) 67 54 78 00.



The chemical composition of *D. rotundata* tubers grown in Nigeria has, however, been widely reported (Ologhobo, 1985; Omole *et al.*, 1978). The available results on the chemical composition of yams indicate that the physiological stage (maturity) at harvest is not always clearly defined as some of the yam materials for analyses are often bought from local markets. It has been reported that the maturity of yam tubers at harvest affects their chemical composition (Gomez and Valdivieso, 1983; Bradbury and Holloway, 1988; Brillouet *et al.*, 1981). In addition, earlier studies reported in the literature for differentiating cultivars within a yam species were based on multivariate analysis performed on morpho-botanical characteristics obtained from only three yam species (Rhodes and Martin, 1972; Martin and Rhodes, 1978; Onyilgha, 1986).

The object of this work was to evaluate the chemical composition of a range of yams belonging to different genera found in a germplasm collection in order to differentiate among cultivars within a species and select nutritionally superior species.

MATERIALS AND METHODS

Germplasm Collection

Samples of 98 cultivars belonging to eight yam species [*Dioscorea alata* (23), *D. bulbifera* (11), *D. cayenensis* (18), *D. dumetorum* (23), *D. esculenta* (6), *D. liebrechtsiana* (2), *D. rotundata* (9), and *D. schimperiana* (6)] were collected from the multiplication plots of the Institute of Agronomic Research germplasm (Ekona, Cameroon). Although all the cultivars had been planted over a 3- to 4-week period in January/February 1991, the optimum time to harvest at maturity varies with cultivar from 9 to 12 months. In this study, the yam tubers were harvested, mature, at different periods as defined for each cultivar by Ngong-Nassah *et al.* (1980).

Samples for chemical analyses were prepared from at least 10 tubers per cultivar or 20 bulbils for *D. bulbifera* obtained from different plants. Within a day of harvest, the samples were peeled, washed, sliced into cubes, deep-frozen, and freeze-dried using a Chemlab bench drier (Chemlab Instruments Ltd, Hornchurch, Essex). Prior to chemical analyses, the freeze-dried samples were ground in a Wiley mill (Christison Scientific Equipment Ltd., Gateshead, Tyne and Wear), sieved (250 μm), and stored in polyethylene screw-capped bottles.

Chemical Analyses

Ground samples were analyzed in triplicate for moisture, crude protein, ash, and fat content using AOAC (1990) methods. Minerals were determined by atomic absorption spectrophotometry, phosphorus levels were evaluated by the vanado-molybdate colorimetric method (Stuffins, 1967), and iron content was estimated by the Saywell and Cunningham (1937) method. The extraction of alcohol-soluble sugars was achieved by refluxing ground samples (5 g) with 800-ml liter⁻¹ ethanol for 120 min. Starch was determined by the enzymic hydrolytic procedure of Thivend *et al.* (1972). Estimation of total alcohol-soluble sugars was by the Loewus (1952) method and individual sugars were determined by the method of Johnson *et al.* (1964), as modified by Cerning-Beroard (1975). Unavailable carbohydrate content was estimated following the Guillemet and Jacquot (1943) technique and pentosans by the Cerning and Guilbot (1973) method. Acid and neutral detergent fibers were gravimetrically estimated using the procedures of Van Soest (1963) and Van Soest and Wine (1967), respectively.

The percentage of soluble nitrogen in total nitrogen was estimated using the trichloroacetic acid method as described by Trèche (1983). Energy values were calculated using the factors given by Merrill and Watt (1955).

Statistical Analyses

D. liebrechtsiana was not included in the statistical analyses due to the small number of cultivars. Data obtained from the chemical analyses were statistically analyzed using BMDP (University of California, Los Angeles, CA) computer software. Due to differences in the sample population, significant differences between the yam species were evaluated using Student *t* test only on data that were normally distributed or adjusted to normality. When the variables estimated were nonnormally distributed, they were analyzed using the Mann–Whitney rank-sum nonparametric test. Significant differences, where applicable, were assessed at the 1% level. Stepwise discriminant analysis was also performed on the data following the procedures as described by Dixon (1990).

RESULTS AND DISCUSSION

Comparison of Yam Species Chemical Compositions

Statistical analysis showed no significant differences between the means for the variables estimated of *D. cayenensis* and *D. rotundata* cultivars. Hence, these two yam species have been treated in this study as a single species termed *D. cayenensis/rotundata* complex. Results obtained from earlier morpho-botanical and chemio-taxonomic studies have also grouped these same yam species into a complex with a similar name (Martin and Rhodes, 1978; Miège, 1982).

On the basis of dry matter content, as reported in Table 1, the yam species studied could be divided into three groups; low (23–25 g 100 g⁻¹, *D. alata*, *D. dumetorum*, and *D. schimperiana*), intermediate (28–30 g 100 g⁻¹, *D. esculenta* and *D. bulbifera*), and high (32–37 g 100 g⁻¹, *D. cayenensis/rotundata* complex and *D. liebrechtsiana*). Within the yam species studied, *D. alata* had the largest range in dry matter content found in the yam species.

D. alata and *D. dumetorum* showed fairly high crude protein levels and those obtained for *D. liebrechtsiana* were the lowest (3.2 g 100 g⁻¹). The yam species studied in these experiments have a comparable crude protein content with the mean values reported for sweet potato (5.6 g 100 g⁻¹; Bradbury and Holloway, 1988) and edible aroids (5.6–6.8 g 100 g⁻¹; Agbor-Egbe and Rickard, 1990) but considerably higher than those reported for cassava roots (1.7 g 100 g⁻¹; Gomez and Valdivieso, 1983). The results obtained in this investigation show a great variability in protein levels among cultivars within each yam species, which makes possible the selection of protein-rich cultivars. This is particularly evident in *D. dumetorum* and *D. alata*, where comparatively high levels in crude protein were found. Francis *et al.* (1975) reported considerable variability in crude protein content of several yam cultivars of *D. alata*, *D. cayenensis*, *D. rotundata*, and *D. trifida*. The protein levels obtained in this study indicate that yams need not invariably be considered protein-poor.

The mean fat levels were similar in all the cultivars studied. These were very low and are comparable to values often found in other root and tuber crops, potato (0.4

TABLE 1

DRY MATTER, CRUDE PROTEIN, AND FAT CONTENTS OF THE YAM SPECIES*

YAM SPECIES	NUMBER OF CULTIVARS	DRY MATTER	CRUDE PROTEIN (N x 6.25)	TOTAL FAT
<i>D. liebrechtsiana</i>	2	36.1 (35.9-36.3)	3.2 (3.1-3.2)	0.8 (0.7-0.9)
<i>D. alata</i>	23	24.4 ± 1.2 ^c (14.1-35.1)	8.3 ± 0.7 ^b (4.7-15.6)	0.2 ^b (0.1-0.4)
<i>D. bulbifera</i>	11	28.8 ± 0.9 ^b (24.8-35.1)	6.3 ± 0.3 ^{cd} (4.6-8.5)	0.2 ^{ab} (0.1-0.4)
<i>D. cayenensis/rotundata</i> Complex	27	33.0 ± 0.8 ^a (25.2-39.5)	6.4 ± 0.3 ^d (3.7-8.9)	0.2 ^{cd} (0.1-0.5)
<i>D. dumetorum</i>	23	23.2 ± 0.6 ^c (19.0-28.3)	9.6 ± 0.3 ^a (7.4-13.2)	0.3 ^a (0.1-0.6)
<i>D. esculenta</i>	6	29.6 ± 1.2 ^b (24.5-30.8)	5.2 ± 0.4 ^d (4.1-6.5)	0.3 ± 0.1 ^{bc} (0.1-0.5)
<i>D. schimperiana</i>	6	23.0 ± 0.9 ^c (19.4-25.6)	7.7 ± 0.6 ^{bc} (5.9-8.9)	0.2 ^{bd} (0.1-0.3)

*Mean values (g 100 g⁻¹, on dry weight basis) ± standard deviation.

Note. Dry matter, on fresh weight basis. Figures within parentheses are the ranges of the mean values. Figures with the same letter within a column are not significantly different at the 1% level.

g 100⁻¹; Bradbury and Holloway, 1988), edible aroids (0.2 g 100⁻¹; Agbor-Egbe and Rickard, 1990), and cassava (0.3 g 100⁻¹; Rickard and Coursey, 1981).

The starch contents of the yam species studied ranged from a mean value of 70.4 to 73.4 g 100 g⁻¹, except for *D. cayenensis/rotundata* complex and *D. liebrechtsiana*, which had levels higher than 80 g 100 g⁻¹ (Table 2). It was found that *D. liebrechtsiana* had comparatively high levels of the individual sugars analyzed and sucrose was found to be the most abundant sugar in all the yam species studied. A great variability exists within *D. alata* sugar contents. Hladik *et al.* (1984) also observed an intra- and interspecific variability in the carbohydrate content of several yam species cultivated in Central Africa.

In this study, it was found that *D. dumetorum* tubers had the highest levels of plant cell wall carbohydrate and *D. cayenensis/rotundata* complex and *D. liebrechtsiana* tubers had the lowest levels (Table 3). Very high plant cell wall carbohydrate levels have previously been found in certain *D. dumetorum* cultivars (Trèche and Delpuech, 1982; Brillouet *et al.*, 1981). In these studies, the very high plant cell wall carbohydrate levels were attributed to tuber "hardening phenomenon" (thickening of cell wall parenchyma, extended cooking time, impaired cooked tuber texture and taste), which occurs a few hours after harvest. Earlier studies on the determination of cell wall carbohydrate, using the Van Soest detergent method, have shown that neutral detergent fiber levels are often higher than those of acid detergent fiber (Marlett and Chester, 1985; Prosky *et al.*, 1985; Barry *et al.*, 1990). However, some yam cultivars were found in this investigation to have neutral detergent fiber (NDF) contents lower than those of acid detergent fiber (ADF). This finding is similar to that reported for dietary fiber contents of some tropical fruits and vegetables (Lund and Smoot, 1982; Lund

TABLE 2
CARBOHYDRATE COMPOSITION OF THE YAM SPECIES

YAM SPECIES	NUMBER OF CULTIVARS	STARCH	TOTAL ALCOHOL-SOLUBLE SUGARS	FRUCTOSE	GLUCOSE	SUCROSE
<i>D. liebrechtsiana</i>	2	80.4 (79.7-81.1)	8.4 (8.4-8.5)	2.8 (2.6-2.9)	2.2 (2.1-2.3)	3.6 (3.4-3.7)
<i>D. alata</i>	23	73.4 ± 1.3 ^b (60.2-82.1)	4.4 ± 0.7 ^{bc} (0.8-18.1)	0.8 ± 0.1 ^a (0.1-2.4)	0.1 (0-0.7)	2.8 ± 0.6 (0.1-14.7)
<i>D. bulbifera</i>	11	72.9 ± 0.8 ^{bc} (69.8-78.6)	3.9 ± 0.5 ^{abc} (2.5-7.2)	0.6 ± 0.1 ^a (0.1-1.1)	trace	2.8 ± 0.4 (1.4-5.5)
<i>D. cayenensis/rotundata</i> Complex	27	80.1 ± 0.6 ^a (73.5-85.3)	3.5 ± 0.2 ^c (2.0-5.5)	0.6 ± 0.1 ^a (0.2-1.5)	0.2 (0-0.6)	2.0 ± 0.2 (0.7-4.3)
<i>D. dumetorum</i>	23	70.5 ± 0.8 ^{cd} (61.7-75.5)	5.1 ± 0.5 ^{ab} (0.6-12.3)	0.9 ± 0.1 ^a (0.2-2.0)	0.4 ± 0.1 (0-1.3)	3.4 ± 0.5 (0.1-9.6)
<i>D. esculenta</i>	6	70.4 ± 1.2 ^{bd} (66.3-73.4)	7.5 ± 1.4 ^a (3.2-11.6)	0.8 ± 0.2 ^a (0.3-1.5)	0.8 ± 0.2 (0.2-1.4)	3.3 ± 0.5 (1.2-4.3)
<i>D. schimperiana</i>	6	71.1 ± 3.3 ^{cd} (56.3-78.1)	4.2 ± 0.4 ^{abc} (2.6-5.4)	1.5 ± 0.3 ^b (0.7-1.7)	0.5 ± 0.1 (0-0.8)	1.6 ± 0.4 (0.3-2.6)

Note. Refer to Table 1 footnotes.

et al., 1983). It has been suggested that the NDF levels lower than those of ADF obtained using the Van Soest gravimetric techniques may be due to the formation of insoluble complexes with condensed tannins or pectins and the presence of residual proteins in the yam samples; these contaminants are known to interfere with the assay of dietary fibers (Morrison, 1980; Robertson and Van Soest, 1978). It has also been reported that the estimation of dietary fiber levels depends on the analytical method used (Mongeau and Brassard, 1986; Englyst and Hudson, 1987).

TABLE 3
PLANT CELL WALL CARBOHYDRATE CONTENTS OF THE YAM SPECIES

YAM SPECIES	NUMBER OF CULTIVARS	UNAVAILABLE CARBOHYDRATES	NEUTRAL DETERGENT FIBRE	ACID DETERGENT FIBRE	PENOSANS
<i>D. liebrechtsiana</i>	2	1.7 (1.6-1.7)	2.4 (2.4-2.5)	2.0 (1.9-2.1)	0.6 (0.6-0.7)
<i>D. alata</i>	23	3.1 ± 0.2 ^b (1.9-4.6)	4.9 ± 0.2 ^a (2.8-8.1)	3.4 ± 0.2 ^{bc} (2.1-4.9)	1.1 ± 0.1 ^b (0.6-1.7)
<i>D. bulbifera</i>	11	2.8 ± 0.1 ^b (2.3-3.8)	3.5 ± 0.2 ^{bc} (2.9-4.2)	3.5 ± 0.2 ^b (3.0-5.0)	0.8 ± 0.1 ^c (0.6-1.0)
<i>D. cayenensis/rotundata</i> Complex	27	1.9 ± 0.1 ^d (1.1-2.9)	3.1 ± 0.2 ^c (1.6-5.0)	2.5 ± 0.1 ^c (1.2-2.7)	0.7 ± 0.1 ^c (0.4-1.0)
<i>D. dumetorum</i>	23	4.4 ± 0.2 ^a (2.8-7.2)	5.2 ± 0.3 ^a (3.0-8.4)	5.5 ± 0.3 ^a (3.4-7.6)	1.6 ± 0.1 ^a (0.9-3.1)
<i>D. esculenta</i>	6	2.1 ± 0.1 ^{cd} (1.9-2.5)	2.6 ± 0.1 ^c (2.4-3.2)	2.7 ± 0.1 ^c (2.3-3.1)	0.8 ^{bc} (0.7-0.9)
<i>D. schimperiana</i>	6	3.0 ± 0.5 ^{bc} (2.0-4.7)	4.6 ± 1.0 ^{ab} (2.0-8.6)	3.5 ± 0.5 ^{bc} (2.4-5.8)	0.9 ± 0.1 ^{bc} (0.7-1.1)

Note. Refer to Table 1 footnotes.

TABLE 4

ASH AND MACRO-ELEMENTS COMPOSITION OF THE YAM SPECIES

YAM SPECIES	NUMBER OF CULTIVARS	mg 100 g ⁻¹				
		ASH	P	Ca	K	Mg
<i>D. liebrechtsiana</i>	2	17 (17-18)	52 (50-53)	23 (20-26)	760 (700-820)	29 (27.9-30.1)
<i>D. alata</i>	23	31 ± 2 ^{ab} (21-44)	116 ± 5 ^b (68-163)	24.1 ± 2 ^b (14-49)	1350 ± 60 ^a (850-1820)	27.2 ± 1 ^b (19.5-35.5)
<i>D. bulbifera</i>	11	34 ± 2 ^a (29-44)	127 ± 6 ^b (100-154)	23.2 ± 1 ^b (20-49)	1170 ± 40 ^{ab} (990-1360)	29.5 ± 2 ^b (22.4-35.8)
<i>D. cayenensis/rotundata</i> Complex	27	24 ± 1 ^d (14-39)	93 ± 4 ^d (65-125)	15.6 ± 1 ^c (8-36)	940 ± 60 ^c (590-1740)	33.2 ± 3 ^{bc} (19.6-72.5)
<i>D. dumetorum</i>	23	28 ± 1 ^{bc} (18-39)	161 ± 5 ^a (118-201)	41.8 ± 3 ^a (23-73)	1050 ± 80 ^{bc} (490-2030)	57.1 ± 3 ^a (30.9-82.1)
<i>D. esculenta</i>	6	23 ± 2 ^{cd} (16-28)	89 ± 9 ^{cd} (63-114)	25.2 ± 2 ^b (19-32)	1260 ± 60 ^{ac} (1150-1480)	37.4 ± 2 ^c (28.9-44.6)
<i>D. schimperiana</i>	6	29 ± 2 ^{abc} (24-35)	112 ± 13 ^{bc} (61-140)	44.8 ± 11 ^a (20-84)	1280 ± 50 ^{ac} (1150-1350)	40.8 ± 5 ^{bc} (30.1-58.4)

Note. Refer to Table 1 footnotes.

The pentosan contents found in this study are similar to those reported for yams studied in Ghana (Sefa-Dedeh and Rasper, 1977).

Mineral levels are given in Tables 4 and 5. *D. dumetorum* cultivars had the highest levels for almost all the minerals analyzed and potassium was the most abundant

TABLE 5

OLIGO-ELEMENTS COMPOSITION OF THE YAM SPECIES

YAM SPECIES	NUMBER OF CULTIVARS	mg 100 g ⁻¹			
		Fe	Na	Cu	Zn
<i>D. liebrechtsiana</i>	2	4.9 (3.8-5.9)	2.7 (2.4-2.9)	1.0 (1.0)	2.7 (2.6-2.8)
<i>D. alata</i>	23	4.3 ± 0.8 ^{ab} (0.9-17.6)	8.8 ± 1.0 ^b (3.7-19.3)	0.9 ± 0.1 ^c (0.5-1.3)	1.5 ± 0.1 ^{bc} (0.8-2.5)
<i>D. bulbifera</i>	11	4.4 ± 0.5 ^{ab} (2.0-7.5)	15.2 ± 1.0 ^{ac} (11.6-21.6)	1.5 ± 0.1 ^a (1.3-1.8)	1.8 ± 0.1 ^{ab} (1.4-2.1)
<i>D. cayenensis/rotundata</i> Complex	27	3.8 ± 0.4 ^b (0.7-10.3)	13.0 ± 0.6 ^c (7.3-18.8)	1.0 ± 0.1 ^{bc} (0.4-2.2)	1.3 ± 0.1 ^c (0.7-2.2)
<i>D. dumetorum</i>	23	6.7 ± 0.9 ^a (2.2-18.7)	15.9 ± 0.9 ^a (8.1-23.4)	1.0 ± 0.1 ^{bc} (0.6-2.2)	1.9 ± 0.1 ^a (0.9-3.0)
<i>D. esculenta</i>	6	3.0 ± 0.3 ^{ab} (1.7-3.8)	3.9 ± 0.4 ^d (3.8-4.0)	1.1 ± 0.1 ^b (0.9-1.3)	2.1 ± 0.2 ^a (1.6-2.7)
<i>D. schimperiana</i>	6	3.4 ± 0.3 ^{ab} (2.7-4.7)	2.0 ± 0.3 ^e (1.4-3.0)	1.7 ± 0.2 ^a (1.2-2.1)	2.4 ± 0.3 ^a (1.4-3.5)

Note. Refer to Table 1 footnotes.

mineral ranging from a mean value of 760 to 1350 mg 100 g⁻¹. These levels are similar to those reported for Nigerian yams (Ologhobo, 1985), but lower than those found in food composition tables (FAO, 1968). In FAO tables, the yam species and cultivars are not differentiated from each other and the physiological state of the tubers at harvest is not clearly defined. Comparison of mean values per species for each mineral estimated showed that a significant difference exists between the yam species studied and a marked intraspecific variability exists mostly within *D. alata* and *D. schimperiana* cultivars. The variation in the chemical composition of the yam species studied in these experiments compares relatively well with those obtained by Agbor-Egbe and Rickard (1990) for edible aroids found in Cameroonian germplasm collection.

Stepwise Discriminant Analysis of Yam Cultivars Chemical Composition

A stepwise discriminant analysis was performed between six yam species (*D. alata*, *D. bulbifera*, *D. cayenensis/rotundata* complex, *D. dumetorum*, *D. esculenta*, and *D. schimperiana*) so as to identify the linear combinations of the 22 variables estimated which best allow differentiation of cultivars within a species and the degree of overlap between the yam species studied. The results of the statistical analysis showed that 10 variables (crude protein, pentosans, phosphorus, potassium, magnesium, sodium, copper, undetermined (100 - {starch + total alcohol-soluble sugars + fat + crude protein + ash + NDF}), % soluble nitrogen in total nitrogen, and energy levels), chosen in a stepwise manner were enough to best predict the yam species to which a cultivar belonged. As shown in Fig. 1, the canonical variables 1 and 2 accounted for 45 and 35% of the total dispersion, respectively. The plot of cultivars on the plan defined by these canonical variables showed a definite separation between the yam species, except for *D. alata* whose projections overlap with those of *D. cayenensis/rotundata* complex, *D. dumetorum*, *D. esculenta*, and *D. schimperiana*. A jackknifed classification matrix indicated that among the yam species studied, nine cultivars were not assigned by calculation to the right group corresponding to their true species. These misclassified cultivars are three in *D. alata*, four in *D. cayenensis/rotundata* complex, and two in *D. dumetorum*.

The results obtained from the stepwise discriminant analysis indicate that there exists a classification function which is a combination of predictor variables that can be used with a low probability error to differentiate among cultivars within a yam species. In view of the fact that some yam species are similar morphologically, the results have also shown that chemical analyses could be used to identify the taxonomic classification of a cultivar found in a yam germplasm collection.

CONCLUSION

The results obtained in this study show that the potential exists for selecting nutritionally superior cultivars of *Dioscorea* spp. and that there also exists a marked significant variability between all the yam species studied. The variability in the chemical composition of yam species is clearly useful for the plant breeder who may select/breed cultivars with certain desired agronomic and nutritional characteristics. On the basis of high crude protein and starch levels, *D. cayenensis/rotundata* complex and *D. dumetorum* cultivars could be selected for intensive cultivation in Cameroon and in other yam-growing regions. Following the results reported by Bradbury *et al.*

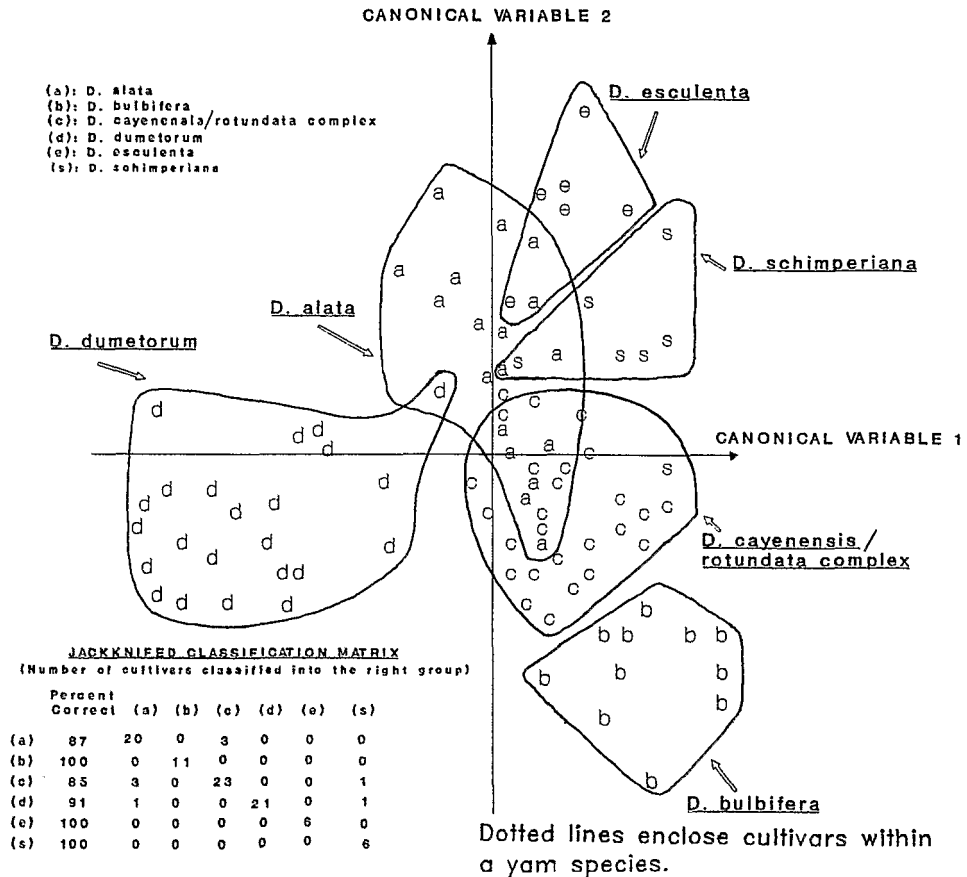


FIG. 1. Stepwise discriminant analysis: Plot of yam cultivars on the canonical variables 1 and 2.

(1988) that cooking does not significantly affect the nutrient content of yams, some of the yam cultivars studied could provide the dietary requirements for human nutrition.

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