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Physico-chemical characterisation of yam (*Dioscorea alata* L.) tubers from Vanuatu

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Abstract

The objectives of this study were: (1) to analyse the physico-chemical characteristics of 48 *Dioscorea alata* varieties representing a core sample of the Vanuatu national germplasm collection; (2) to relate those characteristics with the varieties eating quality; and (3) to assess the possibility of selecting varieties according to their chemotype. Overall, 331 accessions were collected from 15 different islands of Vanuatu, planted in an *ex situ* germplasm collection and described during 3 years. The 48 varieties included in the core sample were selected according to their island of origin, eating quality, tuber shape, tuber flesh colour and morphotype. Analyses of their tubers were made for percentage dry matter, starch, amylose, lipids, minerals, proteins, sugars and gelatinisation temperature range. Significant variation exists for each of these characteristics except for gelatinisation temperature. Varieties with good eating quality are characterised with high dry matter, starch and amylose contents. Chemotypes appear to be genetically controlled and further screening of germplasm and/or breeding will have to take into consideration these characteristics, important for farmers' adoption.

Introduction

The greater yam (*Dioscorea alata* L.) is the most widely distributed species of the genus in the humid and semi-humid tropics. It is an important food in Africa, the Caribbean, and especially Melanesia where it has considerable social and cultural importance (Coursey 1976). Methods of cultivation are consistent with maintaining the fragile ecosystems of the lowland areas. Yam is also a crop with potential for increased commercial exploitation.

From comparison of 235 varieties collected world wide in the 1970s, it was concluded that the centre of variation of *D. alata* is first Papua New Guinea and second Indonesia (Martin and Rhodes 1977). More than 1000 varieties are currently grown in Melanesia although there are signs of genetic erosion in farmers fields (Jackson 1994). Traditionally, farmers maintain a wide range of diversity, including varieties with tubers irregular in shape, and therefore hard to peel and others with smooth skin and regular shape which are more convenient to use. Harvesting alone can account for 20% of the total production costs and is also largely dependent on tuber shape (Onwueme and Charles 1994). The possibility exists of identifying varieties with compact tubers, easy to harvest that comply to modern-day requirements and those for commercial exploitation, in particular. Selection could overcome the difficulty of producing new varieties in a crop where flowering is sporadic and hand pollination complex.

Lucrative urban markets require the smaller, round or oval varieties with white tuber flesh, free of oxidation (Brown 1995). Few studies have been conducted on the physico-chemical variation of *D. alata* tubers. Martin (1974) observed in Puerto Rico that high dry weights are associated with fine structure, dense feel, high quality, and concluded that high density is a varietal character that is not changed much by environmental influences. In the Pacific, although some preliminary work has been done at the inter-specific level (Bradbury and Holloway 1988), the lack of information on the variation within *D. alata* hinders its prospective utilisation as a high quality exportable vegetable. Egesi et al. (2003) studied the extent of genetic diversity existing for organoleptic properties in 40 water yam varieties cultivated in Nigeria. Two thirds of their accessions were identified as being suitable for boiled yam, while more than half of these accessions were good for pounded yam. Their results were, however, based on the respective quality attributes evaluated but the physico-chemical characteristics of the tubers were not quantified, Furthermore, *D. alata* is thought to have been introduced clonally in Africa and its genetic base is narrow as demonstrated by the limited isozyme variation detected between African cultivars (Lebot et al. 1998).

In Vanuatu, indigenous knowledge claims that there is tremendous variation between the culinary and palatability properties of *D. alata* varieties, some being suitable for certain types of preparation, while others are not, and some being cooked much faster than others. When the tuber of some varieties is cut open, the colour of the surface begins to change rapidly with the oxidation of polyphenolic compounds and become yellowish or brown. Polyphenolic oxidation is also associated with off-flavours, bitterness and deserves in some cases, special preparations. In most islands of Vanuatu, only certain varieties are suitable for the preparation of the national dish, *laplap*, a pudding made from freshly and finely grounded tubers steam cooked in *Heliconia indica* leaves. Others have to be boiled or roasted in order to be palatable (Bourrieau 2000).

The present study aims at providing information on the chemical composition variation of *D. alata* tubers from selected varieties collected in Vanuatu, an area where significant genetic diversity has previously been detected with molecular markers (Malapa et al. 2005). The objectives of our study were: (1) to analyse the physico-chemical characteristics of a core sample of 48 *D. alata* varieties; (2) to relate those characteristics with their eating quality, and (3) to assess the possibility of selecting varieties according to their chemotypes.

Materials and methods

Selection of a core sample

Overall, between 1997 and 1998, 331 accessions of *D. alata* were collected from the 15 most populated islands of the Vanuatu archipelago (Table 1), These accessions were planted during the first week of August every year during three growing seasons, from 1999 to 2002, at VARTC (Vanuatu Agricultural Research and Technical Centre) on the Island of Espiritu Santo (Figure 1), which receives 2800 mm of rainfall per year, Each accession was represented by four plants, established 1×1 m^{2}square, with four individual stakes 1.50 m high tied together at their top. Each year, the harvest began in April for early maturing types and lasted until June for late maturing types, Each year these accessions were described using 32 internationally standardised morpho-agronomical

Table 1. Geographical origin of *Dioscorea alata* accessions collected in Vanuatu (see Figure 1).

Island	Accessions	%
Malekula	99	29.9
Santo	70	21.1
Efaté	35	10.6
Tanna	32	9.7
Pentecost	24	7.3
Erromango	20	6.0
Maewo	11	3.3
Aneitum	11	3.3
Ambrym	8	2.4
Futuna	6	1.8
Malo	6	1.8
Vanua Lava	4	1.2
Gaua	3	0.9
Ambae	1	0.3
Tongoariki	1	0.3
Total	331	100

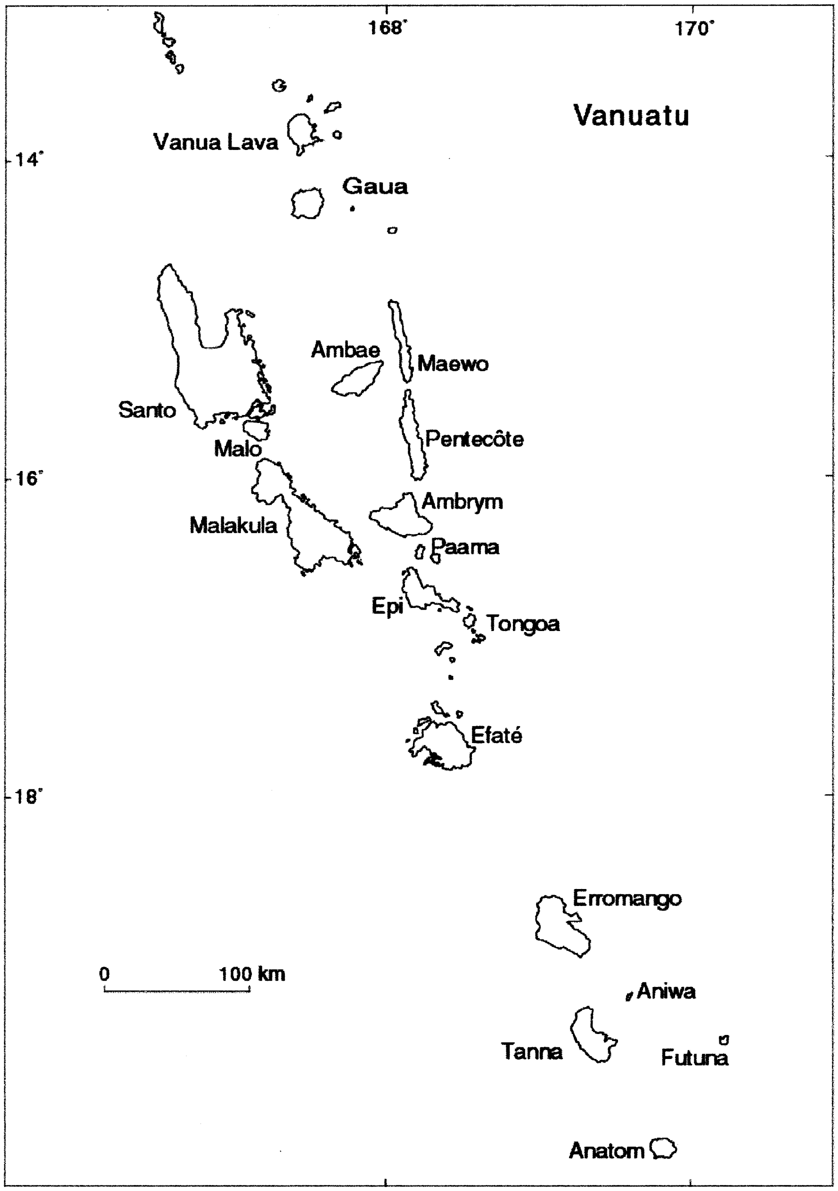

Figure 1. Map of Vanuatu indicating islands where *Dioscorea alata* germplasm was collected.

descriptors (IPGRI 1997). The results were compiled in a database in Excel™ format, corrected or updated every year, and duplicates were identified. The Vanuatu germplasm collection was finally found to present at least 240 distinct morphotypes (SPYN 2003).

It was then decided to assemble a core sample including 20% of these morphotypes and representing the extent of variation observed for the tubers. A branching method (Van Hintum 1995), based on morphological and passport data, combined with knowledge about the structure of the germplasm, was used to stratify the collection, Overall, 48 varieties were finally selected based on their: (a) island of origin; (b) eating quality; (c) tuber shape; (d) tuber flesh colour; and (e) oxidation of the tuber flesh. Particular attention was also given to some particular morphotypes so that the maximum variation could be included in the core sample.

Eating quality (poor, average, good) was determined (1) according to traditional knowledge recorded with passport data while collecting accessions and (2) by regular assessments made by the staff of the root crops programme at VARTC (five persons) following the three annual harvests of the germplasm collection. Fresh tubers were manually peeled, sliced and boiled and tasted each time they were harvested. Good varieties appeared to have characteristics that are well accepted by almost all persons (Bourrieau 2000). Oxidation of the flesh (present or absent) was assessed visually 5 min after cutting the central portion of the fresh tuber,

Physico-chemical characteristics of dried tubers

During the third growing season (August 2001–June 2002), the 48 varieties belonging to the core sample were each represented by four plants which were clones of the same mother plant harvested during the previous campaign. These four plants were planted and harvested the same day, when that variety was mature. No visual variation was ever observed between the four replicate clones. Fresh tubers were cut for each of the four plants and bulked into one sample per variety. Central transverse sections (approx. 10 cm thick) of the tubers were cut for each of the four plants and bulked into one sample per variety. Approximately 2 kg of fresh weight were manually sliced into chips by hands and oven dried at 70 °C for 48 h. After drying, dried chips were ground first in a stainless steel mill to pass through a 1-mm screen and then with a laboratory mill Perten 3100 (Perten instruments, France) using a screen of fine aperture (0.5 mm).

Dry matter samples (flours) produced at the Food Processing Laboratory of the Department of Agriculture in Port-Vila, Vanuatu, were sent to CIRAD, Montpellier, France, and all analyses were conducted according to AFNOR (*Association Francaise*) and/or EEC methods. Dry matter (D.M., % fresh weight), starch (% dry weight), amylose, minerals, lipids, proteins, total sugars contents and minimum and maximum gelatinisation temperatures were determined. Moisture content, ash and free lipid contents were determined by oven-drying for 2 h at 130 °C, incineration for 2 h 30 min at 900 °C, and diethyl ether extraction followed by evaporation and drying at 100 °C for 15 min, respectively. Crude protein contents were calculated from nitrogen contents ($N \times 6.25$) obtained using the Kjeldahl method. All analyses were performed in duplicate. Amylose content was measured in duplicate from the energy of amylose/lyso-phospholipid complex formation using differential scanning calorimetry according to Mestres et al. (1996). The onset and the end temperatures of the gelatinisation transition of starch were calculated with a linear base line between 55 and 90 °C.

Data analysis

The computations were expedited by the computer programme NTSYS (Exeter Publishing Ltd., Setauket, N.Y.). The physico-chemical data matrix composed of all variables, excluding amylose/starch ratio and gelatinisation temperatures, was subjected to multivariate analysis (UPGMA using Euclidean distance).

Results

Selection of the core sample

Variation and frequencies of the most significant tuber traits are presented in Table 2. Tuber shapes and tuber flesh colours are very variable. Cylindrical tubers (148 accessions) are fragile and tend to break when they are transported. Deformed tubers (136 acc.), triangular (7 acc.) and flat tubers (4 acc.) are not attractive to consumers but oval (26 acc.) and/or round (10 acc,) tubers are compact, easy to handle and to peel. All 331 accessions present in the germplasm collection were scored for their eating quality and 42 accessions were found to present tubers with poor eating quality (12.7%), while 168 acc, were rated as average (51%) and 121 acc. were rated as good (36.5%).

The list of the 48 varieties included in the core sample is presented in Table 3. Accessions originating from 10 different islands, out of the 15 islands surveyed, were included. Varieties with different eating qualities (20 good accessions, 10 average and 18 poor ones) were selected in order to be able to compare their physico-chemical characteristics. Finally, morphotypes which were well differentiated were also selected. It is assumed that this sample, assembling 20% of the total number

Table 2. Variation and frequencies of the most significant tuber traits measured on 331 accessions (representing approx. 240 distinct morphotypes).

Descriptors	Traits	% Acc.
Tuber shape	Round	3.0
	Oval	7.9
	Cylindrical	44.7
	Flattened	1.2
	Triangular	2.1
	Deformed	41.1
Tubers per plant	Very few (0–2)	74.3
	Few (3–5)	22.1
	Many (> 6)	3.6
Skin colour at tuber head	White	9.8
	Yellow	33.3
	Orange	1.0
	Pink	22.8
	Purple	33.1
Flesh colour of central part	White	71.6
	Yellow	4.6
	Light purple	2.8
	Purple	6.3
	White and purple	14.3
	Outer purple, inner yellow	0.4
Oxidation	Present	17.8
	Absent	82.2
Eating quality	Poor	12.7
	Average	51.0
	Good	36.5

of morphotypes existing in the germplasm collection, gives a fair representation of the diversity found in Vanuatu within the cultivated species *D. alata*.

Varieties with good eating quality appear to present all types of tuber shapes (round, oval, cylindrical, flat, triangular, deformed), they originate from different islands and can have coloured or white flesh. All varieties that present oval tubers (i.e., acc. 578, 402, 597, 415, 459, 475) have white tuber flesh and are of good eating quality (10.9% of total number of accessions). Oxidation occur mostly in varieties with poor eating quality but two varieties (acc. 453 and 704) with good eating quality were also found to oxidise (Table 3).

A detailed study conducted using 32 descriptors (IPGRI 1997) scored on the 331 accessions revealed tremendous variation in colours and forms of vegetative and underground organs characteristics (SPYN 2003). However, when the resulting qualitative data matrix was subjected to multivariate analyses (PCA and UPGMA), a continuum of morphological variation was revealed and it was not possible to distinguish clear subgroups (Malapa 2000), These analyses confirmed the results obtained by previous attempts to classify the intra specific variation of *D. alata* (Martin and Rhodes 1977; Lebot et al. 1998) indicating (a) that morphological descriptors have limited informative value and (b) that it is not possible to find a clear structure of the morphological variation.

Physico-chemical characteristics variation

The results of the physico-chemical characteristics analyses are presented in Table 4. The most variable characteristics are the total sugars (coefficient of variation, CV = 91.3%), lipids (CV 33.3%), and proteins (CV 17.8%). Dry matter (CV 17.2%), starch (CV 11.6%) and amylose (CV 9.1%) contents are also significantly variable.

Minimum and maximum gelatinisation temperatures present very low CV% and were not included in the data matrix (48 OTUs $\times$ 7 variables: dry matter, starch, amylose, minerals, lipids, proteins and sugars) extracted from Table 4 and subjected to UPGMA (Euclidean distance). The resulting dendrogram is presented in Figure 2 and three groups of chemotypes are revealed. These groups are not related to the geographical origin of the varieties or with some peculiar morphological traits. Although chemotypes are controlled genetically, they do not appear to correspond to some particular morphotypes. However, most of the 20 varieties presenting good eating quality are clustering in the upper part of the dendrogram (except acc no. 415), while most the 18 varieties presenting a poor eating quality of their tubers (except acc. nos, 049 and 577) are clustering in the bottom part of the dendrogram.

Good varieties appear to be characterised with a high amylose/starch ratio (A/S ratio > 0.17 in Table 4). All varieties presenting tubers with poor eating quality are characterised by low A/S ratio < 0.16, high mineral and high protein contents, except one (acc. 643) which has a high A/S ratio (0.21) but very low total sugars content. This characteristic appears somewhat important and a variety such as *Maligni* (acc. 633) is famous and appreciated throughout Vanuatu because of its very 'sweet' taste, which is confirmed by the

Table 3. List of varieties analysed.

Island of origin	Quality	Tuber shape	Flesh colour	Oxidation	Local name	Acc. no.
Malekula	Good	Oval	White	Absent	Letslets maser	578
Malekula	Good	Cylindrical	White	Absent	Romb soso	536
Malekula	Good	Cylindrical	White	Absent	Mombri	551
Malekula	Good	Triangular	Coloured	Absent	n.a.	009
Malekula	Average	Deformed	White	Present	Nabulalas	265
Malekula	Average	Deformed	Coloured	Absent	Navilu	008
Malekula	Average	Deformed	Coloured	Absent	n.a.	602
Malekula	Poor	Cylindrical	White	Absent	Nivikilmlak	286
Malekula	Poor	Cylindrical	White	Absent	Nikelpo woman	533
Malekula	Poor	Cylindrical	White	Absent	Tapa	589
Malekula	Poor	Deformed	White	Absent	Pirai	016
Malekula	Poor	Deformed	White	Absent	Visn	531
Malekula	Poor	Deformed	White	Absent	Tumas	562
Malekula	Poor	Deformed	White	Absent	Baksan	577
Malekula	Poor	Deformed	White	Present	Homb	567
Malekula	Poor	Deformed	Coloured	Present	Letslefs nambas	579
Santo	Good	Oval	White	Absent	Raranaeolo	402
Santo	Good	Oval	White	Absent	n.a.	597
Santo	Good	Cylindrical	White	Absent	n.a.	592
Santo	Good	Cylindrical	White	Absent	n.a.	596
Santo	Good	Cylindrical	White	Present	Livusivari	453
Santo	Good	Flattened	White	Absent	Uratavue	452
Santo	Good	Deformed	White	Absent	Riprip	491
Santo	Average	Cylindrical	White	Absent	n.a.	247
Santo	Average	Cylindrical	White	Absent	Rave	400
Santo	Average	Cylindrical	Coloured	Absent	n.a.	404
Santo	Poor	Deformed	White	Present	Aga	510
Santo	Poor	Deformed	Coloured	Absent	Tageu	514
Pentecost	Good	Round	White	Absent	Shulniu	645
Pentecost	Good	Oval	White	Absent	Obal	415
Pentecost	Good	Oval	White	Absent	Maligni	633
Pentecost	Average	Cylindrical	White	Absent	Tahirao	418
Pentecost	Average	Deformed	White	Absent	Kilman	419
Pentecost	Poor	Deformed	White	Absent	Bwalanvara	639
Pentecost	Poor	Deformed	Coloured	Absent	Vorobwagi	643
Tanna	Good	Deformed	Coloured	Present	Nawanurunkimanga	704
Tanna	Average	Deformed	White	Absent	Tumas	700
Tanna	Average	Deformed	White	Absent	Wasu	701
Tanna	Poor	Deformed	White	Absent	Rosapin	706
Maewo	Poor	Deformed	White	Absent	Sovwa	657
Maewo	Poor	Deformed	White	Absent	Ririho	661
Maewo	Poor	Cylindrical	White	Present	Malabong hivo	049
Malo	Good	Oval	White	Absent	Basa	459
Malo	Poor	Deformed	White	Present	Balabalavuvuha	463
Vanua Lava	Good	Cylindrical	White	Absent	Turea	655
Ambrym	Good	Deformed	White	Absent	Masinruburo	623
Ambae	Good	Deformed	Coloured	Absent	Bughi toa	373
Efate	Good	Oval	White	Absent	Salemanu tetea	475

highest sugars content (5.71%). However, several varieties rated as 'good' also have low total sugars content, and therefore sugars content alone cannot determine quality.

Simple linear correlations between seven physico-chemical characteristics were computed and the results are presented in Table 5. Starch, amylose and total sugars contents are positively correlated with dry matter. Minerals, lipids and proteins contents are positively correlated between them, but negatively correlated with dry matter, starch and amylose. Total sugars content are negatively

Table 4. Physico-chemical characteristics of 48 *D. alata* accessions from Vanuatu (acc. are listed in the order given by the dendrogram in Figure 2).

Acc. no.[a]	D.M. %	Starch %	Amylose %	Ratio A/S	Minerals %	Lipids %	Proteins %	Sugars %	T. gel °C	T. gel °C
645 G	22.00	74.9	19.0	0.19	2.9	0.3	10.3	2.96	79.8	88.0
475 G	22.44	75.2	20.0	0.20	3.6	0.3	10.8	1.07	78.9	87.9
452 G	23.21	74.8	20.4	0.20	2.8	0.3	9.2	1.9	79.2	86.9
459 G	20.37	74.8	17.7	0.18	2.5	0.2	9.1	2.6	80.2	88.5
536 G	20.68	75.5	16.7	0.17	3.3	0.3	10.6	1.92	78.8	88.6
592 G	20.00	72.6	17.4	0.17	3.1	0.3	9.2	3.78	80.7	91.2
633 G	22.22	75.9	17.2	0.17	3.2	0.3	10.4	5.71	78.7	87.4
597 G	19.64	78.2	19.2	0.19	3.1	0.3	11.5	2.11	79.1	86.7
655 G	20.00	76.2	17.7	0.18	3.4	0.3	12.8	2.05	76.8	87.4
402 G	24.07	75.7	17.8	0.18	3.0	0.3	12.4	0.81	78.3	87.1
373 G	22.91	76.1	17.7	0.18	2.8	0.3	11.7	0.72	79.4	88.6
009 G	25.71	74.8	16.4	0.16	3.3	0.2	10.4	0.29	81.3	90.7
596 G	24.00	73.4	20.7	0.21	3.0	0.2	13.3	1.17	74.8	87.1
623 G	25.00	77.4	17.8	0.18	3.9	0.3	15.7	1.23	77.1	85.5
578 G	24.21	78.2	19.9	0.20	3.0	0.3	9.5	0.64	78.9	86.7
453 G	28.00	78.2	17.8	0.18	2.8	0.2	9.3	0.87	80.4	89.1
551 G	26.31	78.6	18.2	0.18	3.0	0.3	11.2	0.83	79.7	87.8
049 P	29.26	76.3	16.5	0.17	3.0	0.2	11.0	1.12	79.3	87.4
602 A	29.98	75.7	17.7	0.18	3.3	0.2	12.1	0.76	79.3	88.7
491 G	29.41	76.4	18.0	0.18	3.1	0.3	9.9	1.62	78.8	86.2
008 A	31.42	75.5	17.4	0.17	2.9	0.2	9.9	0.86	77.6	85.8
404 A	27.74	75.8	18.9	0.19	2.5	0.2	11.5	1.44	77.2	89.4
704 G	28.23	75.6	19.8	0.20	2.6	0.3	12.1	0.28	78.6	86.0
419 A	27.77	75.0	13.8	0.14	3.2	0.3	11.7	0.67	79.5	88.0
577 P	28.57	75.6	15.5	0.16	3.1	0.3	11.6	2.45	79.1	88.5
247 A	27.27	71.3	19.2	0.19	2.5	0.3	9.8	0.83	80.0	91.6
701 A	27.94	73.8	19.4	0.19	2.8	0.2	8.8	2.39	77.8	89.2
418 A	28.16	73.2	15.6	0.16	3.2	0.2	15.1	1.45	78.2	86.2
400 A	27.58	73.6	15.8	0.16	3.2	0.2	14.6	0.76	78.2	86.3
700 A	26.51	71.1	15.0	0.15	4.0	0.3	14.8	0.6	78.6	86.9
265 A	23.53	73.1	13.4	0.13	3.8	0.3	12.4	0.36	81.5	90.3
415 G	22.91	70.1	18.4	0.18	3.8	0.3	11.6	3.22	77.8	86.7
562 P	22.60	71.5	19.0	0.19	3.4	0.3	10.6	1.32	78.8	88.1
661 P	23.40	71.8	15.9	0.16	3.2	0.3	10.7	2.12	80.4	89.7
533 P	21.95	69.0	17.8	0.18	3.8	0.3	12.1	0.25	79.2	87.3
286 P	25.00	68.0	15.2	0.15	3.2	0.3	13.2	3.0	78.5	88.3
657 P	23.68	67.1	17.2	0.17	3.3	0.3	10.9	2.62	77.4	85.2
643 P	21.42	67.0	20.5	0.21	3.0	0.3	10.7	0.58	78.8	87.2
589 P	18.75	72.1	15.1	0.15	4.3	0.4	15.6	2.4	78.9	88.0
531 P	20.23	72.1	16.8	0.17	3.9	0.3	14.2	0.8	78.6	86.1
639 P	21.21	68.8	15.4	0.15	3.7	0.3	15.0	1.04	75.7	84.2
016 P	19.04	71.4	17.1	0.17	3.5	0.3	11.5	4.51	78.1	85.6
706 P	19.69	69.4	17.0	0.17	3.2	0.4	12.1	5.2	77.5	88.4
567 P	18.60	69.8	13.7	0.14	3.2	0.4	11.2	3.97	80.7	88.4
579 P	21.42	68.3	15.1	0.15	3.1	0.3	10.2	4.91	80.3	87.9
463 P	14.81	64.9	14.4	0.14	3.8	0.4	15.8	3.28	77.6	85.2
514 P	16.21	63.6	14.1	0.14	4.9	0.5	16.4	2.12	79.6	88.2
510 P	13.68	66.9	14.2	0.14	4.2	0.4	17.0	1.26	78.9	86.5
Max	31.42	78.6	20.7	0.21	4.9	0.5	17.0	5.71	81.5	91.6
Min	13.68	63.6	13.4	0.13	2.5	0.2	8.8	0.6	78.8	87.6
Mean	23.44	73.1	17.2	0.17	3.3	0.3	11.95	1.85	74.9	84.2
Std	4.02	3.67	2	0.02	0.5	0.1	2.13	1.37		
CV%	17.2	9.1	11.6	11.6	15.2	33.3	17.8	91.3		

[a]Bold are the accessions rated "good" (G) and in italics are the accessions rated "poor" (P).

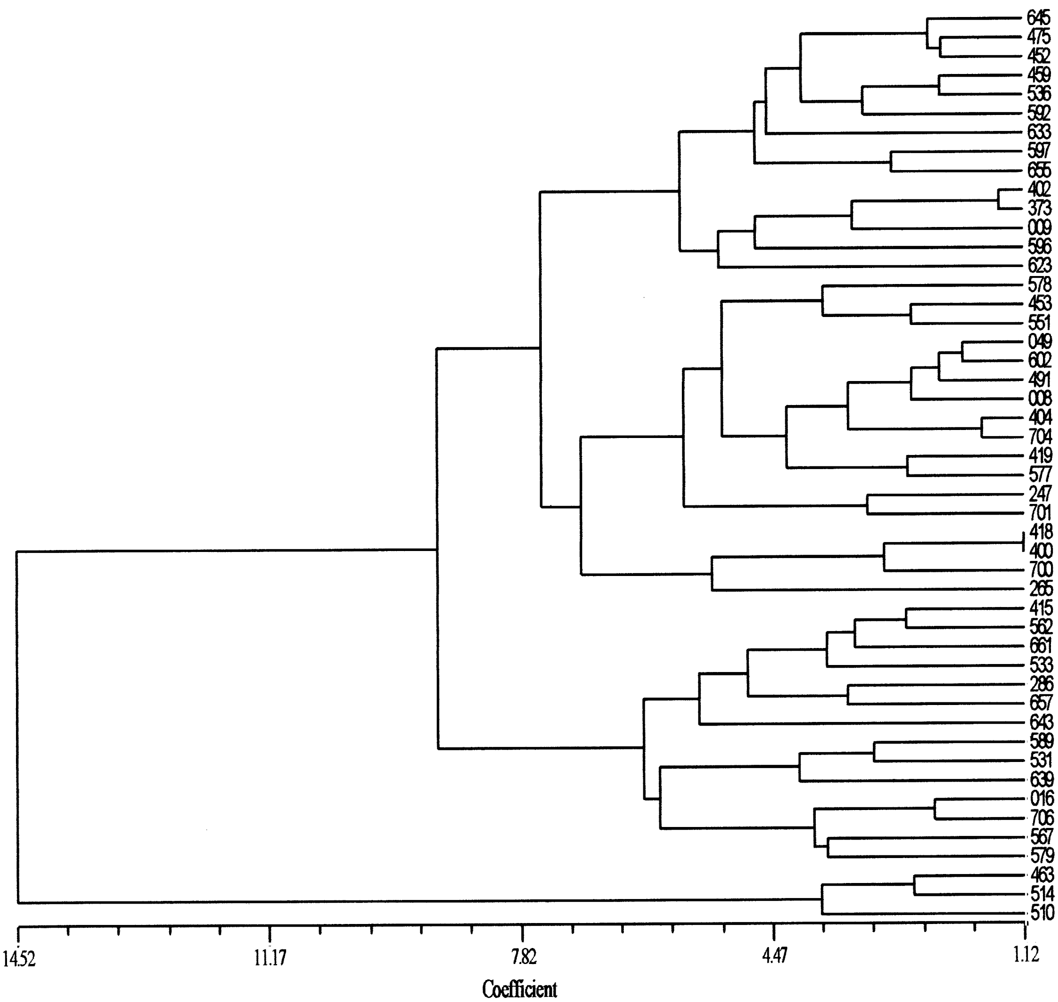

Figure 2. UPGMA (Euclidean distance) conducted on the data matrix 48 varieties × 7 variables.

Table 5. Simple linear correlation coefficients between six physico-chemical characteristics of 48 selected varieties.

	D.M.	Starch	Amylose	Minerals	Lipids	Proteins
Starch	+0.3559**					
Amylose	+0.6031**	+0.1808				
Minerals	−0.6196**	−0.2225	−0.4838**			
Lipids	−0.7189**	−0.4185**	−0.5576**	+0.6752**		
Proteins	−0.7360**	−0.2544	−0.5360**	+0.8627**	+0.5716**	
Sugars	+0.0384**	+0.1332	−0.2185	−0.3817**	+0.0090	−0.4617**

Value of r at 1% = 0.354 (**).

correlated with minerals and proteins contents. Some of these correlation coefficients confirm previous results obtained by Lebot et al. (1998) with cultivars grown in New Caledonia.

Discussion

Previous work conducted on the physico-chemical characteristics variation of yam tubers focussed mostly on differences existing between species measured on samples collected in different growing environment (Bradburry and Holloway 1988; Treche 1998). Lebot et al. (1998) analysed 131 cultivars of *D. alata* from New Caledonia for dry matter, starch, proteins and minerals but amylose and total sugars were not measured and oxidation and eating quality ratings were not available, Overall, less variation (expressed in CV%) was found in New Caledonia (i.e.,11.8 vs. 17.2% for dry matter, 5.6 vs. 9.1 for starch, 11.4 vs. 15.2 for minerals and 16.8 vs. 17.8 for proteins) which is consistent with the greater genetic diversity found in Vanuatu (Malapa et al. 2005). Egesi et al. (2003) evaluated 40 accessions for the suitability of their tubers for the preparation of boiled and pounded yams. Ratings were based on hedonic scales and the mean scores for general preference were regressed on individual attribute scores. Mealiness, colour and taste were found to be important for boiled yam, while consistency, colour and stickiness determined the general preference for pounded yam. Quantification of the major physico-chemical characteristics, however, was not available.

Our study attempted to compare different varieties, planted the same day in the same plot with the same experimental conditions, so that comparison of their physico-chemical characteristics would be possible. As far as the quality is concerned, it appears that the significant variation of the most important physico-chemical characteristics of the tubers confirms traditional knowledge. For example, appreciated varieties present a high A/S ratio (>0.17) which appears to be necessary to produce a good *laplap*, with the required firmness and elasticity of the pudding (Bourrieau 2000). These varieties are also characterised with high dry matter and total sugars contents and low proteins and minerals contents. High dry matter has already been shown to be associated with fine structure, dense feel in the mouth and quality (Martin 1974; Bourrieau 2000). This is often, but not always, combined with a white flesh which is not susceptible to oxidation when exposed to air. Tuber shape is not related to good taste and good cooking quality, Selection on external characteristics alone cannot guarantee the quality of the organoleptic properties. When accessions with suitable chemotypes are combined with an attractive tuber shape, the final number of varieties presenting these desired traits is quite low and, in Vanuatu for example, they represent less than 10% of the total number of accessions (SPYN 2003).

Chemotypes appear to be genetically controlled. Breeding *D. alata* for improved chemical composition of the tubers is dependent on the knowledge that one cultivar presents a chemotype better than another when they are grown in the same environment. Further screening of germplasm and/or breeding will have to take into consideration these physico-chemical characteristics, important for consumers and farmers' adoption. The accurate measurement of these traits is, however, expensive and time consuming in the absence of visual tools which would allow rapid screening. However, important physico-chemical characteristics are significantly correlated with dry matter content (starch, amylose, sugars). This indicates, although it does not prove, that screening numerous accessions for this trait alone (i.e., specific gravity) could contribute to the selection of suitable chemotypes. The range of values found for a particular trait reveals that there is scope for improvement in the long term by breeding and by clonal selection in the short term. Nothing is known of the genetic basis of such traits. However, the fact that *D. alata* genotypes are heterozygous will probably generate remarkable segregation of the physico-chemical characteristics of the tubers in progenies.

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