EVALUATION OF SELECTED FOOD PROPERTIES OF WHITE YAM (*DIOSCOREA ROTUNDATA*) IN PAPUA NEW GUINEA

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ABSTRACT

White yam, Dioscorea rotundata *Poir., has recently been introduced for cultivation in Papua New Guinea to increase yam production and provide varieties for yam consumers and potential processors. Physical, chemical, functional, and sensory properties of the introduced yam species,* TDr-90-1-1 *cultivar, were assessed in relation to popular cultivars,* Takua Yavu *and* Glame, *respectively of* D. alata *and* D. esculenta. D. rotundata *was the most difficult to peel (manually and mechanically) and gave the highest dry matter. The pH of its water-extract was slightly acidic as were for others (5.7 – 6.7) but the extract had the lowest solids content.* D. rotundata *slices (6 mm) absorbed less water but slightly more oil. It exhibited the slowest rehydration behaviour and its 4% slurry was the most viscous at 20 revmin^{-1} in a rotational viscometer as a cold (35°C, 1.56 Nsm^{-2}) or hot (75°C, 0.83 Nsm^{-2}) paste. Sensory evaluation revealed that it was essentially as acceptable as* D. esculenta *when cooked or fried as chips but better than* D. alata. *The perceived bitter after-taste and irritation upon chewing and swallowing products from* D. rotundata *suggested that its content of anti-nutritional (oxalates, tannins and phytic acid) components may be higher than normal and should be quantified for complete acceptability of the yam as a food material. The potential of* D. rotundata *for food production in PNG is good and ought to be pursued.*

Keywords: *Physio-chemical, functional, viscosity, sensory evaluation, water absorption, Dioscorea alata, Dioscorea esculenta.*

INTRODUCTION

Yams (*Dioscorea* spp.) are herbaceous plants with a twining stem belonging to the *Dioscoreaceae* family, which is reported by Kay (1987) to consist of about 60 edible species. Of all, four are widely cultivated and consumed (Kay 1987; Bradbury and Holloway 1988; Udoessien and Ifon 1992). These are *Dioscorea alata* L., water yam; *D. esculenta* (Lour.) Burk., Asiatic yam (often but incorrectly referred to as Chinese yam); *D. cayenensis* Lam., yellow yam; and *D. rotundata* Poir. Increasing taxonomy and composition evidence, however, points to *D. rotundata* and *D. cayenensis* as being the same species (Agbor-Egbe and Treche 1995).

FAO (1993) gives the area and production of yams in PNG as 13,000 hectares and 220,000 tonnes respectively. Yams produce edible starch storage tubers, which are of socio-cultural and economic importance in tropical and subtropical countries (Onwueme and Charles 1994). Nutritionally (Bradbury and Holloway 1988; Ezeh 1992; Udoessien and Ifon 1992), yams are:

- A source of energy.
- Low in protein but contribute to some essential amino acids requirements of the consumers.
- Important sources of pharmaceutical compounds such as saponins and sapogenins, which are precursors of cortisone and steroidal homones.
- Generally low in phytic acid, tannin and cyanide.

Also, yams contribute towards the dietary needs of mineral elements such as calcium, phosphorus and iron, and their soluble oxalates are not high enough to pose a serious threat to calcium (and divalent minerals) availability.

In Papua New Guinea, yam is reportedly the third root crop behind sweet potato and taro but interestingly, PNG is considered to be one of the centres of origin of *D. esculenta* (Kay 1987). While about 1100 accessions of *D. alata* and *D. esculenta* have been recorded in Vanuatu, PNG and Solomon Island, *D. rotundata* is of minor importance generally in the Pacific (Bradbury and Hol-

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loway 1988) in spite of its relatively superior characteristics and dominance of the global yam production. Probably, because of its food uses (Kay 1987; Onwueme and Charles 1994), the cultivation of *D. rotundata* is gradually being encouraged in PNG and it is expected to fit into the farming practice of the target farmers, who are experienced yam producers.

As with any introduced (new or modified) food, the acceptability and hence, sustainability of the food is dependent on many factors, the most important of which are the food properties such as physical, chemical, functional, and sensory. If the introduced food is to withstand the test of time, it must be comparable in properties to or better than existing competitive foods. By instinct, consumers tend to compare foods and modify their patronage accordingly. Hence, the objective of this paper, as a first step in our evaluation of the introduced yam species, was to obtain experimental data on the selected food properties and examine how they compare with the ones for *D. alata* and *D. esculenta*, which are already eaten in PNG.

MATERIALS AND METHODS

Materials

The yam samples were obtained from the storage barn of the National Agricultural Research Institute research station at Bubia and analyses on them started in October, 1998. Several tubers of a promising variety, one each from the three species, were obtained. They were identified as: *D. alata, Takua Yavu; D. esculenta, Glame; D. rotundata, TDr 90-1-1*. *Takua Yavu* was planted in October 1997 and harvested in June 1998. *Glame* was planted in November 1997 and harvested in September 1998 while *TDr 90-1-1* was planted in November 1997 and harvested in August 1998. These crops were planted at Bubia, where the soil is a sandy clay-loam. Fertiliser (Urea) was applied as a basal dressing to the yam plants at about 50 kg nitrogen ha^{-1} at one month after planting. The initial land preparation was done using tractor-mounted implements but all husbandry practices including planting, staking, weeding, and harvesting were carried out manually.

Chemical Property

Moisture content of the fresh tubers were determined by standard procedures – Method 930.15 (AOAC, 1990). The fresh tubers were peeled in an abrasive peeler (Crypto Peerless Ltd., Birmingham B9 4UA, UK; model CC 14) and dried (APV Mitchell (Dryers) Ltd., Carlie CA2 5OU, UK) at 40°C and 2.6 ms^{-1} air flow for about 45 hr after being sliced (AB Halde Maskiner, Sweden) to about 6 mm thickness. Part of the dried slices was ground using a domestic mill and analysed for moisture, crude protein by Kjeldahl procedures (Method 921.32B), crude fat using petroleum either (Method 920.39B) and ash (Method 942.05) following the procedures in AOAC (1990). Carbohydrate was obtained by difference while the procedures in Martin (1979) were used in determining the starch content (acid hydrolysis technique) and the acidity of the yam flours. The pH of the water extract from the acidity determination was measured with a pH meter (TOA Electronics, Japan; model HM-7E). The energy content was calculated using the Atwater factors (kJg^{-1}) on calculated composition of the fresh tubers: protein, 17 and fat, 38 (Bradbury and Holloway 1988) but for the carbohydrate, 16.5 was used being the average of the factors for starch and sugar (Sopade and Koyama 1999).

Physical Property

The ease of and losses from peeling were assessed by peeling about 1.0 kg of each cultivar for up to 4 min. with water in the abrasive peeler. Manual peeling was also done.

Water absorption was measured by incubating 18 g of the yam flour in 2000 ml water at 40°C for 1 hr. The slurry was centrifuged (Kokusan Corp. Tokyo, Japan; model H-103N; radius = 9.5 cm) at 1500 $revmin^{-1}$ for 10 min. The gel was weighed and water absorption index, WAI, was defined as:

$$\frac{W_2 - W_1}{W_1\{1-[M/100]\}} \times 100 \qquad (1)$$

where, W_1 = weight of the flour; W_2 = weight of the gel; M = moisture content of the flour.

The solids content of the decanted solution was determined by evaporating the solution to dryness at 100°C in an oven. Water solubility index, WSI, was defined as:

$$\frac{\text{Total solids in solution}}{W_1\{1-[M/100]\}} \times 100 \qquad (2)$$

The oil absorption index (OAI) was determined an defined as WAI except that copra oil replaced the water.

A 4% solution of the yam flour was brought to boil and simmered for 5 min. before cooling. The evaporated water (110 – 130 g) was added back to the slurry and its viscosity determined at 75°C and 35°C using a rotational viscometer (Brook field Engineering Laboratories, Inc., Stoughton, MA; model RVDV-1+ Version 4.1) at 20 $revmin^{-1}$. Viscosity values were recorded after 3 min. of rotation and no sample rested for less than 3 min. prior to measurement.

Rehydration characteristics of the yam cultivars were assessed at about 22°C by soaking about 5 g dried slices in 60 mL of water for up to 5.5 hr. Periodically, the water was drained and the slices were gently blotted before weighing them. From material balance principles, the moisture content during the soaking was calculated and related to the soaking time.

Sensory Property

Fresh tubers were peeled and divided into two. One lot was thickly (approximately 15 mm x 20 mm x 25 mm) sliced, boiled and simmered in excess water till completely cooked (11 – 20 min.) as judged by the ease of penetration by a cutlery. The cooking water was drained and the cooked slices immediately served for sensory evaluation.

The other lot was thinly (= 1 mm) sliced and deep fried for 3 – 5 min. Frying was stopped when the hot oil stopped bubbling and a golden brown colour was approached. The chips were drained off oil and immediately served for sensory evaluation.

A nine-point hedonic scale was used with 9 representing extremely like and 1 was for an extreme dislike. Ten panellists, four females and six males, who were final year (1998) Food Technology students, conducted the evaluation. Having attended lectures in the principles and procedures of sensory evaluation, and conducted numerous hedonic tests, the panellists were considered trained enough to evaluate the sensory properties of the two yam products. Parameters evaluated included colour, taste, texture, and overall acceptability. Results were subjected to analysis of variance (ANOVA) and Duncan t-test as described elsewhere (Kramer and Twigg 1980).

RESULTS AND DISCUSSION

Table 1 summarises the physico-chemical property of the three yam species. The proximate composition of some popular PNG cultivars of these yam species as reported by Bradbury and Holloway (1988) is included. *D rotundata* was the driest (lowest moisture content) of the fresh tubers despite being in storage for the shortest period. Agbor-Egbe and Treche (1995) noted that, in dry matter, *D. alata* is low (23 – 25%), *D. esculenta* is intermediate (28 – 30%) and *D. rotundata* is high (32 – 37%). Our results follow this trend. Our results also indicate the generally low fat, intermediate protein and high carbohydrate (starch) contents of the yam species. However, the values we obtained for the fat and starch contents are slightly high but close to the range reported by various workers for these species (Table 2).

The chemical compositions of yam (and other root crops) have engaged the attention of many workers, and as shown in Table 2, reported values vary substantially. The following reasons have been advanced (Ekpenyong 1984; Ologhobo 1985; Bradbury and Holloway 1988; Onayemi and Idowu 1988; Faboya and Asagbra 1990) for the differences:

- Environmental conditions.
- Cultural and farming practices.
- Soil fertility.
- Varietal differences.
- Length of storage.
- Degree of maturity

For the *Glame* cultivar of *D. esculenta* planted in different areas of the East Sepik Province of PNG, Bradbury and Holloway (1988) obtained (%) 71.0 – 77.6, moisiture; 1.98 – 2.24, protein; 15.8 – 23.1, starch; 0.07 – 0.09, fat; and 0.66 – 0.83, ash. Storing *D. rotundata* for 150 days, Onayemi and Idowu (1988) recorded (%) 71 – 77, moisture; 0.16 – 0.20, fat; 0.6 – 1.2, protein; 17.0 – 21.8, starch but no change in the ash content. We have only recently initiated this evaluation study and it is planned that as the *D. rotundata* becomes more important in PNG, more cultivars and samples of the yam species in relation to the other two would be evaluated.

The peeling studies revealed that *D. rotundata* was the most resistant to abrasive peeling. Between 1 and 3 min. of peeling, *D. rotundata* lost 16 – 47% weight (63% at 4 min.) while the other two lost more than 60% after only 2 min. of peeling. Manual peeling showed that the peel was between 9 and 16% and *D. alata* was the easiest to peel. However, with mechanical peeling, a higher percent loss can be tolerated but any weight loss greater than 45% could be regarded as indicating excessive loss of yam solids after the peels had been removed. It is, therefore, recommended for potential processors to peel *D. rotundata* for a longer time than normally used for *D. alata* and *D. esculenta*. In the type of the abrasive peeler used in this study, *D. rotundata* may be peeled (1-2 kg) for 3 min. while 1 min is enough for the same weight of *D. alata* and *D. esculenta*. The longer peeling time for *D. rotun-*

Table 1. **Physico-chemical properties of the yam species[a]**

Parameter	D. alata	D. esculenta	D. rotundata
Moisture content[b]	73.4 ± 1.58 (9.0 ± 0.04)[c] [75.2 – 83.8][d]	72.2 ± 0.05 (8.8 ± 0.17) [71.0 – 81.2]	68.5 ± 0.32 (8.6 ± 0.04)
Crude fat	1.3 ± 0.00 [0.3 – 0.5]	1.2 ± 0.05 [0.2 – 0.4]	1.1 ± 0.01
Ash	1.8 ± 0.06 (3.1 – 4.5)	3.1 ± 0.01 (2.0 – 4.2)	2.2 ± 0.06
Protein (N x 6.25)	6.2 ± 0.03 [5.2 – 8.1]	8.2 ± 0.01 [63.1 – 80.9]	5.8 ± 0.06
Carbohydrate by Difference	90.8	87.5	90.9
Starch	90.1 ± 5.21 [74.6 – 87.8]	73.0 ± 3.72 [63.1 – 80.9]	77.8 ± 1.81
Energy (MJkg^{-1})	4.4	4.5	5.2
Energy ratios (%) contributed by: protein	6.3	8.6	6.0
fat	2.9	2.7	2.5
carbohydrate	90.7	88.7	91.5
Acidity (% lactic)	0.4 ± 0.05	0.7 ± 0.05	0.7 ± 0.06
pH	6.7	6.2	5.7
Ease of peeling	Easiest	Easier	Easy
Peeling losses	High	Medium	Low
% Peel (manual)	9	14	16

a: Dried samples were used and values expressed on % dry basis as means ± standard deviations.
b: Values for fresh samples and expressed on % wet basis.
c: The moisture content of the dried samples and expressed on % wet basis.
d: Values in [ ] brackets are for the popular cultivars (including Glame for *D. esculenta*) grown in the East Sepik Province analysed by Bradbury and Holloway (1988).

Table 2. **Chemical composition of the yam species from various references**

Yam species	Parameter	Reference[a]				
		I[b]	II[c]	III[d]	IV[e]	V[f]
D. alata	Moisture	65.73	86.65	69.80	76.79	77.3
	Fat	0.03-0.27	0.1-0.4	0.62-0.93	0.06-0.10	0.08
	Ash	0.67-2.06	0.021-0.044	3.60-4.36	0.75-0.88	
	Protein	1.12-2.78	4.7-15.6	5.61-6.55	1.35-3.05	2.15
	Carbohydrate	22-29		87.00-88.87		17.72
	Starch		60.2-82.1		15.9-17.5	
	Sugars		0.8-18.1		0.77-1.39	
	Crude fibre	0.65-1.40		0.70-1.10	1.19-2.36	1.88
D. esculenta	Moisture	67-81	76-.69	70-82	71-76	74.2
	Fat	0.04-0.29	0.1-0.5	0.42-0.52	0.04-0.07	0.06
	Ash	0.5-1.24	0.016-0.028	2.60-3.18	0.74-0.90	
	Protein	1.29-1.87	4.1-6.5	6.66-8.00	1.77-2.30	2.06
	Carbohydrate	17-25		88.33-88.69		19.85
	Starch		66.3-73.4		17.7-22.2	
	Sugars		3.2-11.6		0.32-0.78	
	Crude fibre	0.18-1.51		0.65-1.15	0.94-1.40	1.15
D. rotundata	Moisture	58-	75.61	67.76	65.7±1.0	65.7
	Fat	0.05-0.12	0.1-0.5	0.30-0.46	0.09±0.01	0.09
	Ash	0.53-2.56	0.014-0.039	2.70-4.00	0.73±0.01	
	Protein	1.02-1.99	3.7-8.9	4.33-4.80	1.42±0.03	1.42
	Carbohydrate	15-23		89.82-90.72		30.52
	Starch		73.5-85.3		30.2±0.7	
	Sugars		2.0-5.5		0.32±0.08	
	Crude fibre	0.35-0.79		1.00-1.45	0.63± 0.10	0.63

a: A blank cell indicates data not available. Reference I = Kay (1987), II = Agbor-Egbe and Treche (1995), III = Ologhobo (1985), IV = Bradbury and Holloway (1988), V = SPC (1995).

b: The upper range for the moisture content of *D. rotundata* was wrongly (typographical) quoted as 33% and, therefore, not included in the table.

c: Apart from the moisture content, other values are on % dry basis.

d: Values are for the head, middle and tail sections of the tuber. Apart from the moisture content, other values are on % dry basis.

e: Values are for the dietary fibre and for *D. rotundata*, figures are means ± standard deviations.

f: Values are for the dietary fibre.

data has an economic implication for potential processors as more energy is used and production cost is increased relative to the cost for the other two yam species.

It has been observed (Kay 1987) that while *D. esculenta* is thin-skinned, *D. alata* and *D. rotundata* are thick-skinned. The higher moisture content of *D. alata*, however, reduces its resistance to peeling when compared to *D. rotundata*. Soaking legumes, which increases their moisture content, have been reported by Sopade *et al.*, 1994 to aid the removal of their hulls, a form of peeling. Apart from this factor, ease of mechanical peeling is dependent on how regular the shape of the tuber is as the tuber surface needs to contact the abrasive surface of the peeler. The *D. rotundata* was the most irregular and heavily distorted while the *D. alata* was essential cylindrical and the *D. esculenta* was basically round or spherical.

Fig. 1 shows the water absorption (WAI), water solubility (WSI) and oil absorption (OAI) indices of the yam species. The absorption indices are related to the ability of the macro-nutrients (starch and protein) to bind a liquid and they have implications for food uses of the materials. A food material with a high WAI is valuable as a food thickener and Ruales *et al.* (1993) observed that the water absorption capacity of an infant food and the amount of water-soluble substances present will affect its palatability in the form of a porridge or a beverage. The whipping ability is related to OAI and it is probably more important in protein-rich foods because OAI increases with an increase in protein content (del Rosario and Flores 1981). It should be noted also that the possibility of a complex between amylose (a starch fraction) and lipids or fats makes the starch content an important parameter in OAI (Deshpande *et al.* 1982). However, the ability to bind fats is important since fats act as flavour retainers and they improve the mouth feel of foods (Rahma and Mostafa 1988). WSI, on the other hand, shows the amount of water-leachable components. For starchy materials, solubility in water increases with polymer degradation through, for example, heat treatment by generating components of low molecular weights (Ruales *et al.* 1993).

Although a high water absorption tends to be accompanied by a low WSI as with *D. esculenta* and *D. rotundata*, the trend with *D. alata* is the opposite (Fig. 1). During peeling, it was observed that *D. alata* was the most slimy implying that it exuded more mucilages, which have been linked to glycoproteins (Onwueme and Charles 1994), than the other two. It was observed that the mucilages accumulated on the surfaces of the yam slices and after drying became solid deposits. This resulted in the high WSI of *D. alata* dispite its intermediate WAI. *D. rotundata* absorbed the most oil (non-polar), the least water (polar) and had the smallest water-soluble components.

An important requirement of any dried food is its reconstituability or rehydration behaviour (Okaka *et al.* 1991). Although root crops are not usually dried as traditional foods in PNG, it seems that the benefits of dehydration or drying have not been properly evaluated in PNG. The lessons from the major drought in 1997 (due to the El-Nino phenomenon) call for an urgent review and modification of the post-harvest strategy for root crops in the country. Food surveys (Harvey and Heywood 1983), for example, have revealed that root crops respectively contribute more than 50% and 30% of the total energy and protein intake in the country, and making these foods available all the year round is a key agro-food task.

The rehydration behaviour of the dried (40°C) yam slices (6 mm) shows (Fig. 2) the normal sorption pattern (Peleg 1988); a sudden increase in absorbed water during the first 50 min. followed by a gradual zone and terminating in a slow phase after 200 min. *D. rotundata* showed a gentle rehydration pattern and absorbed the least irrespective of the duration of soaking.

Sorption patterns are better analysed using sorption equations and the non-exponential Peleg's equation has proved quite useful (Sopade and Kiamur 1999). The equation is:

$$M_t = M_o + \frac{t}{K_1 + K_2 t} \quad \ldots\ldots 3$$

where, M_t = moisture content at time t, M_o = initial moisture content, and K_1 and K_2 = constants. While K_1 defines the temperature dependence of the rehydration behaviour, K_2 is independent of temperature (Sopade and Obekpa 1990) and defines the maximum absorbed water (equilibrium moisture content, M_E) by the food (Peleg 1988):

$$M_E = M_o + \frac{1}{K_2} \quad \ldots\ldots 4$$

Equation [4] is useful in predicting the closeness of the rehydrated dried food to the fresh state and possibly in examining modification of the water binding sites. An application of Eqn. [3] to the rehydration data of the yam species gave a correlation coefficient that ranges from 0.9525 – 0.9780, which shows a good fit. The M_E values (%) for the yams are : *D. alata*, 65.8; *D. esculenta*, 63.8 and *D. rotundata*, 54.1. The differ-

Figure 1. Absorption and solubility indices of the three yams species

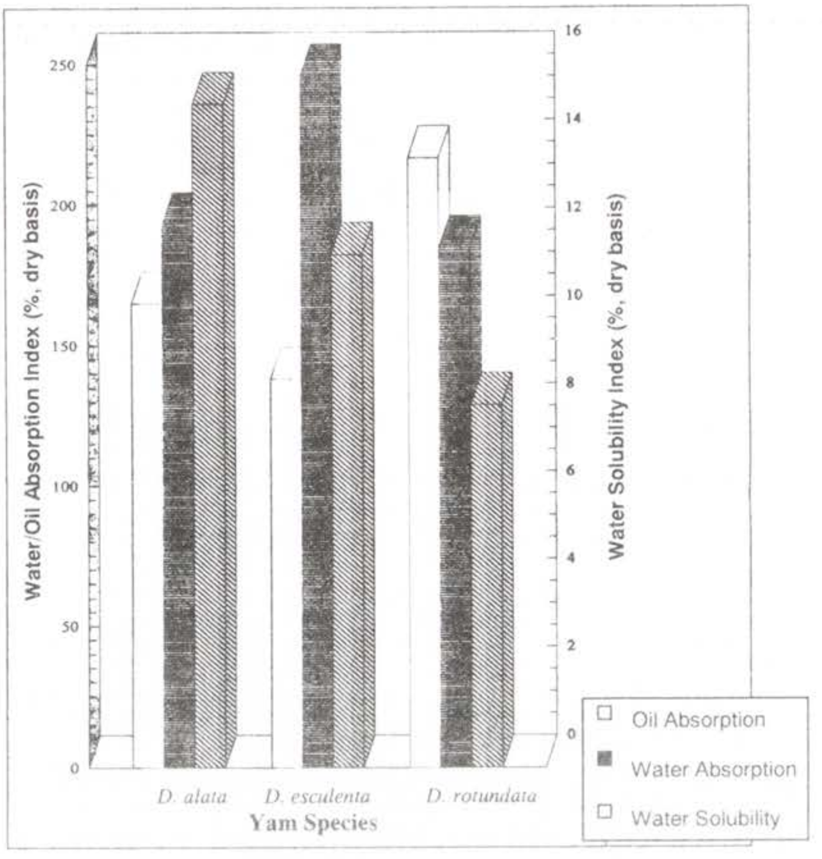
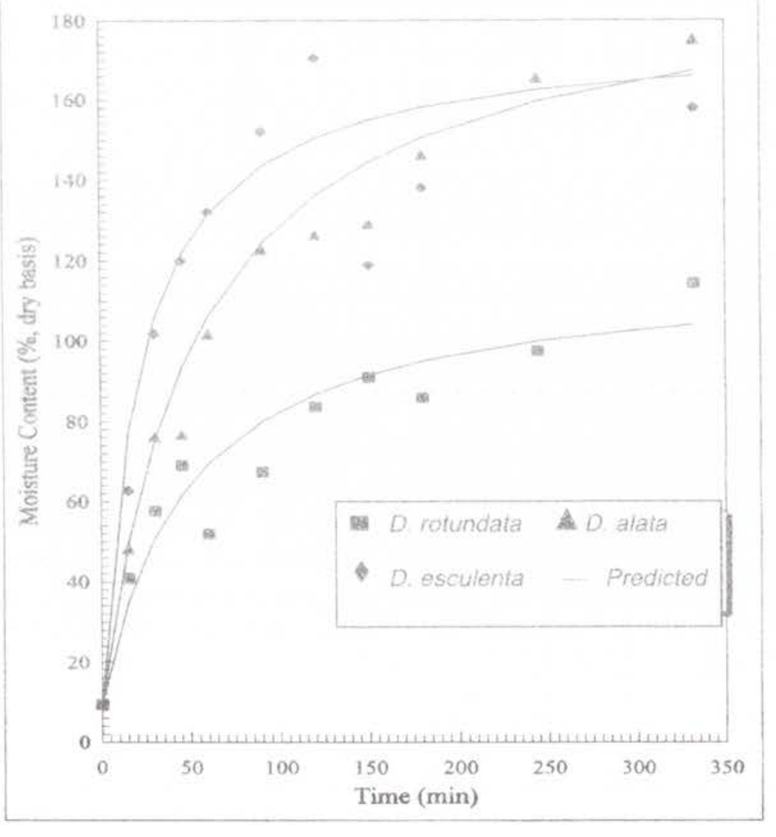


Figure 2. Rehydration behaviour of the three yam species



ences from the fresh state moisture contents (%) are from 7.6 to 14.4 with *D. rotundata* exhibiting the biggest difference. It could be that the drying conditions (40°C, 2.6 ms^{-1}, 45 hr) damaged the water binding sites more in the cultivar but this was not assessed separately; the moisture content of the dried *D. rotundata* slices was the lowest (Table 1). From these observations, it could be that the drying characteristics of *D. rotundata* differ, which is expected, from those of the other species and a study in this direction would be worthwhile.

However, if the cultivars studied here could be subjected to the same treatments as reported in this study, the following equations would predict their water uptake ability on %, dry basis:

D. alata: $$M_t = M_o + \frac{t}{0.29 + 5.47 \times 10^{-3}t} \quad \ldots\ldots 5$$

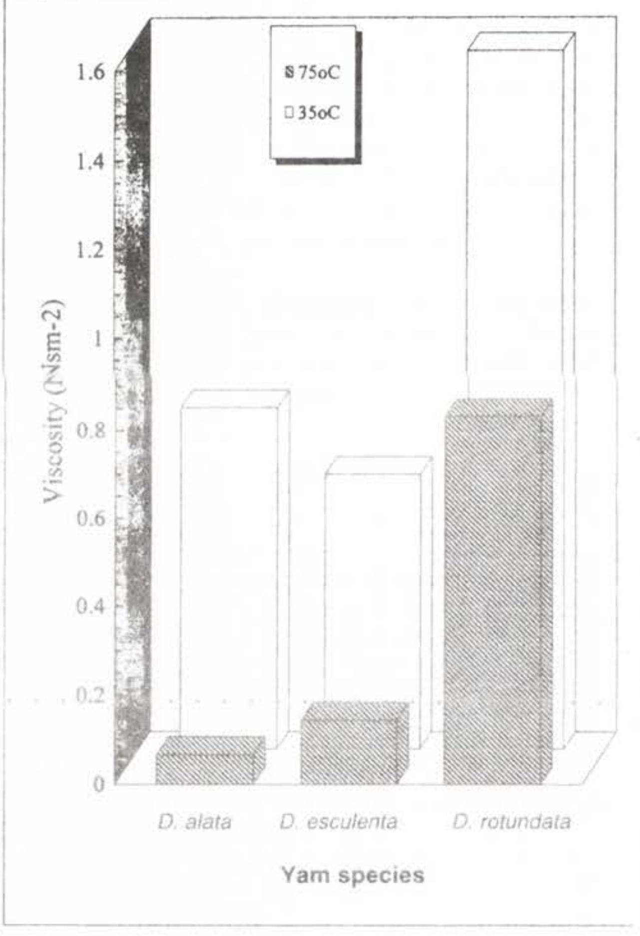
D. esculenta; $$M_t = M_o + \frac{t}{0.13 + 6.00 \times 10^{-3}t} \quad \ldots\ldots 6$$

D. rotundata: $$M_t = M_o + \frac{t}{0.44 + 9.22 \times 10^{-3}t} \quad \ldots\ldots 7$$

These equations [5 – 7] will allow the moisture content to be estimated for a known soaking period as against guessing the time. This is important to the food processor, who is concerned with the economics of the processing package. The equations will also assist in providing the consumers with the knowledge of an appropriate time to obtain defined rehydration levels for various functional uses.

Another functional property is the viscosity of the cultivars. Faboya and Asagbra (1990) have studied, using a Brabender amylograph, the viscous property of five Nigerian cultivars of *D. cayenensis/rotundata* complex and concluded that the starch of *D. rotundata* is a highly viscous one. In the absence of an amylograph, we used a rotational viscometer and the viscosity values at hot and cool temperatures are shown in Fig. 3. All the samples gave higher viscosity values at 35°C than at 75°C, an observation that agrees with the general temperature-viscosity trend (Sopade and Filibus 1995). At either temperature, *D. rotundata* was the most viscous and was 2 – 4 times more viscous than the others. With a starch content lower than that for *D. alata* and comparable to that for *D. esculenta*, the starch of *D. rotundata* must indeed be a highly viscous one for these unique characteristics. Kay (1987) reported that the starch granules of *D. alata* are of sizes 5 – 50 µm, *D. esculenta*, 1 – 15µm and *D. rotundata* 10 – 70 µm and viscosity of *D. alata* starch was quoted as 100 – 200 Brabender units (BU) while Faboya and Asagbra (1990) obtained 360 – 980 BU for that of *D. rotundata* starch. The high viscosity of *D. rotundata* makes it the main raw material for pounded yam in West Africa (Onwueme and Charles 1994). However, it does not seem that there is an identical traditional product in PNG. Rather, the high viscosity of *D. rotundata* can be explored to make a porridge (more watery than pounded yam) that can fall in the same category as cooked sago (*Metroxyln sagu*) starch porridge, which is available in the PNG food system. But sago starch is more viscous (Sopade and Koyama 1999) and more solids of *D. rotundata* have to be used to obtain a close product because viscosity increases with solids content

Figure 3. **Viscous property of the three yam**



(Sopade and Filibus 1995). Since *D. rotundata* is nutritionally superior to sago starch, consumption of more *D. rotundata* solids brings nutritional benefits.

An increase consumption will be dependent on the sensory quality of *D. rotundata* in relation to what the consumers are used to. Since ANOVA what the consumers are used to. Since ANOVA showed no significant difference ($p>0.05$) amongst the panellists, a significant difference ($p<0.05$) amongst the samples was accepted to be entirely due to the inherent differences amongst the samples. Table 3 is a summary of the organoleptic evaluation of the yam cultivars. With respect to the cooked samples, there was no difference ($p>0.05$) in the colour and taste but *D. alata* was the least preferred in terms of the texture (hardness and chewiness) while *D. rotundata* and *D. esculenta* were better preferred in the overall quality (a compound of all sensory parameters). For the fried chips, the samples were found to be significantly different ($p<0.05$) only in the texture (crispiness) with *D. rotundata* being rated essentially the best. Generally, *D. rotundata* was rated the best for the products assessed and this was considered as a positive development for *D. rotundata* as a new yam species in Papua New Guinea.

Table 4 shows the comments of the panellists. Remarkably, the panellists detected a bitter aftertaste in the *D. rotundata* samples and thought that it contained a component that is irritating to the throat. During peeling and washing, we detected that the wash water from *D. rotundata* irritates the skin. Onayemi and Idowu (1988) have reported bitterness in *D. cayenensis/rotundata* complex due to the residual polyphenols and glycoalkaloids. The amount of bitterness compounds increases with the length of storage and are mostly concentrated at the head section. The head section is that part of the tuber to which the vine is attached while the tail is the distal portion with the growing point (Ologhobo 1985). Both sections are watery and are frequently discarded or dried and milled into yam flour. With respect to the effect of storage, Onayemi and Idowu (1988) reported that the yam tubers need not be stored for more than 120 days and that storage for a longer period would yield tubers that are too bitter. The *D. rotundata* tubers that we studied were stored for about 60 days before our analyses started. Irrespective, farmers in PNG, who are being introduced to *D. rotundata*, should be advised accordingly.

Irritants in root crops particularly in taro (*Colocasia, Xathosoma* and *Alocasia* spp.) are due to oxalates (Bradbury and Holloway 1988), which are generally considered low in yam (Udoessien and Ifon 1992). It is unknown if the levels of oxalates in the *D. rotundata* cultivar evaluated were higher than normal and consequently, uncomfortable to the panellists. There is a need to analyse the anti-nutritional constituents. The low oxalates in yams grown elsewhere may not be the situation with the *D. rotundata* grown in PNG as environmental and soil factors affect the composition of root crops.

Table 3. **Summary of the organoleptic evaluation of the yam products**

Product	Parameter	D. alata	D. esculenta	D. rotundata
Cooked	Colour	6.4a	7.3a	7.1a
	Taste	5.8a	6.7a	7.6a
	Texture	4.5a	6.4ab	7.8b
	Overall acceptability	5.2a	6.2ab	7.8b
Fried chips	Colour	7.1a	7.0a	7.1a
	Taste	7.0a	7.5a	7.1a
	Texture	6.2a	6.4ab	8.2b
	Overall Acceptability	7.0a	7.1a	7.2a

a: Values within a row followed by a different letter are significantly different at $p<0.05$

Table 4. **Comments from the sensory evaluation of the yam products**

D. alata	*D. esculenta*	*D. rotundata*
Cooked		
Remarkable taste. Tastes sweet with good after-taste. Sticky in the mouth, a bit raw but fair. Tastes better. Sticky when eaten. Texture is hard. Sweeter than the others. No irritating substance but sweet. Colour not quite attractive.	Tastes nice. Soft and powdery feeling. Least white in colour and a bit sweet in the mouth. Feels raw and uncooked. Appealing colour. Produced crunchy sound when chewed. Preferred texture for starchy foods. Tasted nice and acceptable colour. White colour.	Appealing colour but taste is not too good. Good texture. Reasonable chewing texture. Right in taste and colour. Colour not really appealing. Sticky and too soft in texture. Most acceptable. Texture is the most acceptable. Natural yam colour. Nice texture but sticky in the mouth. Seemed to contain an irritating substance. Quite firmer texture. Colour and taste are good but quite bitter when swallowed. Met all the quality attributes. Taste much better. Far more acceptable.
Fried chips		
Appealing colour and remarkable taste. Reasonable flavour. A bit golden brown, soft but tastes nice. Soft and a bit crispy. Have a better light brownish colour. More like stale chips. Texture too soft. Crisp texture for chip making. Best taste. Distinct yam taste still detected. Right texture for chips. Potential as a commercial product	Golden brown in colour. Best taste of all. A bit crispy but feels like unleavened bread. Texture too soft. Crisp texture for chip making. Best sample. Colour needs improvement. A bit too brown. Texture too loose.	Has crispy texture although no pronounced flavour of taste. Has a bitter after-taste upon swallowing. White in colour. Hard and most crispy. Crispier than others. Colour is attractive. A bit crunchy. The best texture, desirable colour and taste. Seems to contain an irritating substance when swallowed. Very hard crispiness. Taste nice but colour not attractive. Has acceptable white colour. A bit too crunchy.

CONCLUSION

Papua New Guinea locally-grown *Dioscorea rotundata* exhibited certain properties that are in line with similar properties of the yam species available elsewhere. It has a high dry matter and produces a porridge that is more viscous than ones from D. alata *and D. esculenta*. When cooked or fried, it was better accepted but left a bitter after-taste and was more irritating to the throat. However, the *D. rotundata* cultivar *TDr 90-1-1* evaluated has not been adversely affected by the environmental and farming practices in the location where it was harvested. This suggests that it can be assimilated into the national agricultural systems. Nevertheless, farmers into its cultivation ought not to store the tubers for more than 120 days. The extent of agricultural extension strategy on *D. rotundata* will depend on the current post-harvest handling practices of *D. alata* and *D. esculenta*, which are the existing popular yam species.

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