Journal of Research in Forestry, Wildlife & Environment Vol. 12(2) June, 2020
E-mail: jrfwe2019@gmail.com; jfewr@yahoo.com
http://www.ajol.info/index.php/jrfwe

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ISBN: 2141 – 1778
Nwachukwu and Dan, 2020

STUDIES ON NUTRITIVE CHARACTERISTICS OF SOME ACCESSIONS OF *Dacryodes edulis* FROM SELECTED STATES OF SOUTHEASTERN NIGERIA

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ABSTRACT

This study was conducted to evaluate the nutrient content among some accessions of Dacryodes edulis. Six accessions of Dacryodes edulis seeds were collected from two States in Nigeria and analyzed for proximate, mineral, vitamin and phytochemical compositions. Ten fruits were collected from each accession to evaluate the variation in their fruit length, width, weight pulp and seed weight of D.edulis. The result showed that all the proximate, mineral, vitamin and phytochemical compositions of the seeds were highly significant (P<0.001). The result further showed that there is significantly (P<0.001) difference between the length, width, weight pulp and seed weight. This study established that greater variability in fruit characteristics of D edulis are significantly affected by fruit size.

Key words: Nutrient content, Phytochemical compositions , Fruit characteristics and variations.

INTRODUCTION

African pear (*Dacryodes edulis*) (G. Don) H.J Lam belongs to the family Burseraceae, and is also known as *Safou* (French), *ube* (Ibo), *elemi* (Yoruba), *eben* (Efik) and *orumu*(Benin) (Kengue *et al.*,2002).It grows in a wide range of soil types and are widely distributed in Africa. It is found in Cameroon,Congo(Brazzaville),Congo(Kinshasa) , Gabon, Ghana, Equitorial Guinea, Nigeria and Sao Tome,(Onana , 2008). In south-east Nigeria, the trees are grown around homesteads and flowering takes place from January to April. The major fruiting season is between May and October (Emebiri and Nwufo, 1990; Kengue and Nyagatchou, 1990). In both rural and urban areas of Cameroon, the fruits are boiled or roasted and then eaten with cassava or maize (Tchatat, 1996).

Fruits of *D edulis* are ellipsoidal and their size varies approximately from 4 to 9cm long and from 2 to 5cm wide (Omoti and Okiy, 1987). As a percentage of dry matter, the pulp contains 31.9% oil, 25.9% proteins and 17.9% fibre (Omoti and Okiy, 1987; Ajiwe *et al*., 1997). It can be an important source of pulp oil, seed oil and even whole fruit oil (Awono *et al*., 2002).The African pear oil should take their place in the food industry, the pharmaceutical and the cosmetics industry (soap, perfume, creams) as well as in other branches of industry where fat raw materials are needed. The cake remaining after the production of pulp oil may be use ful in the food industry, bakery and baby foods (Awono *et al*., 2002).

Dacryodes edulis trees are also important for the provision of shade. The tree is consequently commonly found in home gardens and in smallholder cocoa farms in Cameroun (Leakey and Tchoundjeu, 2001). The fruits, are harvested when they change colour from whitish-green to pink to dark blue – purple to black. The fruits have an attractive, oily, slightly sour taste when cooked, but have a relatively short shelf-life when raw, although this can be prolonged by drying using traditional knowledge. In Cameroon, the fruit is typically roasted, but in Nigeria, the fruits are usually soften in moderate hot water. It is usually eaten with freshly roasted or boiled maize, cassava or plantain.

Recent studies have examined opportunities to extend the shelf life of fruits (Kalenda *et al*., 2002), and to process the fruits into more durable products (Mbofung *et al.,* 2002). The socio-economic importance of *Dacryodes edulis* has recently been documented (Schreckenberg *et al.*, 2002a). Trees are predominantly planted as shade trees in association with cocoa or coffee, where they are also a source of income, as their fruits are widely traded locally , regionally and internationally (Ndoye *et al.,* 1997,Awono *et al.,* 2002), with exports from Cameroon estimated at US$2 million in 1999. At the farm level, the estimated value of *Dacryodes edulis* fruits is US$161 per tree per year and, on average, producers receive 75% of the consumer price, with weekly marketing margins up to double the minimum wage. This income is particularly important to women as it comes at a time of year when school fees and associated costs have to be paid (Schreckenberg *et al.,* 2002a). Interestingly, the retail trade is dominated by women, while the wholesale trade is dominated by men (Schreckenberg *et al.,* 2002a). The retail trade recognises the tree-to-tree variation in fruit characteristics (Leakey and Ladipo, 1996), while the wholesale trade does not (Leakey *et al.,* 2002). The potential of *D. edulis* to generate income to rural households and to promote food security is supported by work on fruit yield and household benefits (Okafor 1980; Tchoundjeu *et al*., 2002).

Although *Dacryodes edulis* is typically propagated by seed, it can be propagated by vegetative method by cuttings and by marcotting (air layering) (Mialoundama *et al.,* 2002). Matured marcotts are typically short and bushy in growth, and consequently are planted at 10m - 10m spacing. In the context of increasing social and economic pressure on forests and natural resources, it has been recognised that *Dacryodes edulis* plays an important role in alleviating the threats on food security caused by disturbances to the balance of nature arising from human activities (Mialoundama *et al.,* 2002).

In this context, it is clear from the number of recent publications and conferences that there is growing recognition of the importance of *Dacryodes edulis* (Okorie, 2001; Kengue, 2002; Kengue *et al*., 2002a; Schreckenberg *et al.,* 2002b) as an agroforestry tree which benefits the poor, malnourished and disadvantaged people of West and Central Africa. It is vital to determine the nutritive value of some of these products from tropical plants in Nigeria , since some of these products have been widely accepted as a dietary constituent among peasants in Nigeria. A high degree of morphological variability in tree species had been identified (Wuruhiu,1999) , but there is still insufficient fruit quality characterization to understand the selection of suitable individual trees that will meet the need of farmers, consumers and potential food processors and exporters (Leaky ,1999). This therefore gives the impetus for this study and hence the objectives of this study were to determine the genetic variability among the nutritional traits of the accessions of *Dacryodes edulis* so as to understand the variation in fruit characteristics among *Dacryodes edulis* accessions.

MATERIALS AND METHODS

Study Area

The study was carried out at the Eastern Research Station of Forestry Research Institute of Nigeria, Umuahia, Abia State. Umuahia is located on low land rainforest zone of Nigeria, It lies between longitude 7^0 33,E and Latitude 5^o 29, N, at 122 metres above sea level, with annual rainfall ranges of 180cm to 220cm. The air temperature varies from 22 ^{o}C to 32 ^{o}C,while the relative humidity varies from 51% to 86%.

Collection of Samples

Seeds of six accessions of *Dacryodes edulis* were collected from two States in Nigeria (Table1) and used for this study. The accessions were identified at Reliable Research Laboratory Services located at Orji Kalu Housing Estate Umuahia, Abia State. Proximate, minerals, vitamins and phytochemical compositions were carried out on the seeds.

Table 1: Accessions list showing place of collection, State, longitude and latitude

Accession number	Place of collection	State	Longitude	latitude
AC1	Ugwuana	Imo	5^{o} 22E	5^{o} 22E
AC2	Ahiaeke	Abia	7^{o} 32^{1}E	5^{o} 29^{1} N
AC3	Egbelubi	Imo	5^{o} 4^{1}N	5^{o} 22E
AC4	Orlu	Imo	5^{o} 7 ^{1}N	7^{o} 6^{1}E
AC5	Ngwa	Abia	5^{o} 25 E	6^{o} 14 N
AC6	Okpala	Imo	5^{o} 3^{1}N	5^{o} 22E

Proximate Analysis

Moisture content was determined by the method off Pearson (1976) and James (1995). Crude protein (Nx6.25) was determined by the Kjedahl method .The recommended method of Association of Official Analytical Chemist (AOAC, 1990) was used for the determination of ash, crude lipid and crude fiber. The carbohydrate content was obtained by difference as the nitrogen free extract. The energy value was determined using the Atwater formula. Energy value (Kcal/100g) = (4 X % carbohydrate) + (9 X % crude protein) + (4 X % crude protein).

EV **=** (4 x % C) + (9 x % CP) + (4 x % CP) ……. [1]

Where:
EV = Energy value (Kcal/100g)
C = Carbohydrate
CP = Crude Protein
% = Percent

Mineral Analysis

The mineral content of the sample was determined by dry ash extraction method described by James(1995) and Kirk and Sawyer (1998) .Calcium and magnesium were determined by the versanate EDTA complexionmetric titration method while phosphorus was determined by molybdovanadate colorimetric method (James ,1995). Iron in the samples was determined using atomic absorption spectrophotometer as described by Pearson (1976), Carpenter and Hendricks (2003).

Vitamin Analysis

Vitamin C was determined according to the method outlined by Krik and Sawyer (1998), while the B-vitamins were determined by the spectrophotometric method described by Okwu (2004).

Phytochemical Analysis

Alkaloid was determined by the alkaline precipitation gravimetric method as described by Harbourne (1973). Tannins and oxalate were determined using Folins –Deni spectrophoto- metric method as described by Hang and Lantzal (1983). Flavonoids was determine using acidification and ethyl acetate extraction method as described by AOAC(1990).All the determinant was done in triplicates.

Fruit Characteristics Studies for *Dacryodes edulis*

The Fruit length was obtained by measuring the length of the fruit with the aid of sowing thread and metric rule. The width of the fruit was obtained by measuring the diameter of the fruit with the aid of sowing threat and metric ruler. The fruit weight was determined with the aid of sensitive weighing balance. The pulp weight was obtained with the aid of sensitive weighing balance after separating the pulp from the seeds. The seed weight was determined with the aid of sensitive weighing balance after separating seeds from the pulp.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) , using the GenStat Discovery Edition 3 (GenStat, 2007) and mean separation was done using LSD.

RESULTS

Fruit Characteristics of *Dacryodes edulis*

Fruit length varied from 4.46cm – 7.22 cm. AC1 had the longest fruits, while AC2 had the lowest fruits (4.46cm), while fruit width varies from 6.54cm – 12.6cm. AC5 had the widest fruits, while AC2 had the narrower fruits (Table 2). Fruit weight, also varied from 15.78g – 45.2g/fruit with AC3

having the heaviest fruits (45.17g) ,while AC2 had the smallest fruit (15.78g). AC5 had the heaviest seeds (44.5 4g) and AC2 the least seed weight(15.78g) ,AC5 had the heaviest fruit pulp while and AC2 had the least pulp (8.87g). Bigger pulp and fruit weight is of interest to farmers and consumers alike and therefore will be an important trait for selection .

Table 2: Fruit Characteristics of some accessions of *Dacryodes edulis*

Accessions	Fruit width (cm)	Fruit length (cm)	Fruit weight (g)	Seed weight (g)	Pulp weight (g)
Ugwuana	8.00	5.82	18.30	7.87	10.45
Ahiaeke	6.54	4.46	15.78	6.91	8.87
Egbelubi	11.10	7.22	45.17	12.39	32.78
Orlu	9.28	6.36	34.19	9.74	24.45
Ngwa	12.27	6.35	44.54	15.04	29.50
Okpala	9.10	4.55	28.02	11.43	16.50
LSD0.05	0.7143***	0.3020***	2.331***	1.271***	2.044***

*ns = not significant; * = P<0.05; ** = P<0.01; *** = P <0.001*

Nutrient content of *Dacryodes edulis*

The proximate composition of the fruits of *Dacryodes edulis* are shown in Table 3 .Highly significant differences (P<0.001) was observed for all the traits. Moisture content is high and varied in all the accessions. It is ranged from 21.90% to 24.20% in AC3 and AC2 respectively. The high moisture content observed among the accession showed *that Dacryodes edulis* is not resistant to microbial spoilage .The ash and crude fibre content of *Dacryodes edulis* accessions varied from 2.47% t0 3.06% and 5.74% to 6.2% respectively.

Crude protein content of the accessions was high and also varied in all the accessions, with AC4 having the highest crude protein at 13.71% while AC3 has the lowest crude protein at 12.45% . Crude fat content of the accessions were high and varied in all the accession ,with AC5 having the highest fat content at 31.45% while AC2 has the lowest at 29.04%.

Table 3: Proximate composition of some accessions of *Dacryodes edulis* fruits.

Accessions	Proximate composition (%)					
	Moisture content	Ash	Crude fibre	Crude protein	Fat	Carbohydrate
Ugwuana	23.78	2.74	2.82	12.82	29.65	28.19
Ahiaeke	21.91	2.74	2.60	13.78	29.04	30.20
Egbelubi	24.17	2.83	2.83	12.45	27.87	30.75
Orlu	23.87	2.94	2.88	13.71	29.60	30.05
Ngwa	23.83	2.92	2.81	12.90	31.45	26.09
Okpala	25.03	3.06	2.94	12.63	27.56	28.78
LSD0.05	1.30ns	0.06**›	0.39ns	0.08***	0.81**›	0.09**

*ns = not significant; * = P<0.05; ** = P<0.01; *** = P <0.001*

The mineral composition of the seeds of *Dacryodes edulis* are shown in Table 4. Highly significant differences (P<0.001) were observed for all the traits. Calcium content of the accessions was high with AC3 having highest at 181.66 mg/100g while AC2 and AC6 had the lowest at 175.20mg/100g . Magnesium content of the accession was moderate and ranged from 32.67mg/100g to 36.77mg/100g in AC1 and AC2 while AC3 is having the lowest magnesium content at 32.67/100g.

The result also showed that zinc concentration of the accession was moderate having its highest as 5.89mg/100g in AC4 while having its highest its lowest as 4.68mg/100g in AC2 . Iron concentration of the accession was also moderate having its highest as 3.80mg/100g in AC1 while AC6 had the lowest at 2.90mg/100g. Potassium concentration of the accession was high with AC1 having the highest potassium content of 146.80mg/100g while AC6 had the lowest concentration as 143.88mg/100g.

Sodium concentration of the accession was moderate having its highest concentration of 83.60mg/100g in AC1 while the lowest was 76.38mg/100g in AC5 .

Table 4: Mineral Composition of some accessions of *Dacryodes edulis* fruits.

Accessions	Mineral composition (Mg/100g)					
	Calcium	Magnesium	Zinc	Iron	Potassium	Sodium
Ugwuana	178.53	36.77	5.79	3.80	146.77	83.60
Ahiaeke	175.82	36.77	4.68	3.79	146.88	79.56
Egbelubi	181.66	32.67	5.84	2.95	145.61	78.54
Orlu	180.39	35.92	5.89	3.67	14582	80.54
Ngwa	179.57	34.86	4.81	3.49	145.82	76.38
Okpala	175.82	35.87	5.74	2.90	143.88	81.68
LSD0.05	0.08***	0.15***	0.12***	0.13***	0.48***	0.36***

*ns = not significant; * = P<0.05; ** = P<0.01; *** = P <0.001*

The phytochemical composition of the seeds of *Dacryodes edulis* are shown in Table 5. Highly significant differences (P<0.001) were observed for all the trait. Saponin concentration was very low in all the accessions and ranged from 0.08% to 0.13 % in AC3 and AC2 respectively. Tannin concentration was also low and ranged from 0.42% to 0.60% in AC2 and AC4. Flavonoid concentration was also low in all the accessions and ranged from 0.16% to 0.23% in AC3andAC5 respectively. Alkaloid concentration was also low in all the accessions and ranged from 0.28% to 0.37% in AC3 , AC5 and AC6 respectively. Also the hydrogen cyanide concentration of the accessions was low ranging from 0.24 mg/kg to 0.2 8mg/kg in AC5 and AC6 respectively.

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Table 5: Phytochemical Composition of some accessions of *Dacryodes edulis* fruits.

Accessions	(%)			(mg/kg)	
	Saponin	Tannin	Flavonoid	Alkaloid	Hydrogen cyanide
Ugwuana	0.11	0.45	0.23	0.30	0.28
Ahiaeke	0.13	0.42	0.17	0.32	0.25
Egbelubi	0.08	0.49	0.16	0.28	0.28
Orlu	0.12	0.60	0.20	0.31	0.25
Ngwa	0.10	0.52	0.23	0.37	0.24
Okpala	0.12	0.47	0.17	0.37	0.28
LSD0.05	05 0.02**	0.03***	0.02***	0.02***	0.04***

*ns = not significant; * = P<0.05; ** = P<0.01; *** = P <0.001*

The vitamin composition of the fruits of *Dacryodes edulis* are shown in Table 6. Highly significant differences was observed for the vitamin determined (P<0.001) except the B -vitamins that were not significant among the accessions . The result showed that the vitamin C concentration was high and from ranged 58.68 mg/100g to 62.58 mg/100g among the accessions.

Thiamin (vitamin B1) appears to be the lowest while riboflavin vitamin B2 ranged from 0.02 mg/100g to 0.04 mg/100g among the accessions. Niacin (vitamin B3) also ranged from 0.05 mg/100g to 0.06 mg/100g. Vitamin A was also high and ranged from 6.85 mg/100g to 7.47 mg/100g in AC6 and AC2 respectively. Vitamin E Concentration of the accessions was moderate high having the highest concentration as 6.14 mg/100g in AC3 while its lowest concentration is 5.86mg/100g in AC5.

Table 6: Vitamin Composition of some accessions of *Dacryodes edulis* fruits.

Accessions	Vitamin Composition (Mg/100g)					
	Thiamin (BI)	Riboflavin (B2)	Niacin (B3)	Vitamin A	Vitamin C	Vitamin E
Ugwuana	0.01	0.02	0.06	6.88	58.82	5.87
Ahiaeke	0.02	0.03	0.06	7.46	58.68	5.78
Egbelubi	0.02	0.04	0.06	6.87	62.58	6.14
Orlu	0.02	0.03	0.06	7.18	59.58	6.11
Ngwa	0.20	0.03	0.06	6.94	61.87	5.86
Okpala	0.01	0.04	0.06	6.85	63.63	5.96
LSD0.05	0.05ns	0.01ns	0.39ns	0.06***	0.29***	0.05***

*ns = not significant; * = P<0.05; ** = P<0.01; *** = P <0.001*

DISCUSSIONS

This study was done to evaluate the proximate, vitamins minerals and anti-nutrient composition of *Plukenetia conophora* .This study showed that *D. edulis* are good source of essential nutrients like crude protein , fat , carbohydrate, and crude fibre , minerals such as calcium, magnesium, zinc, iron , potassium and sodium, vitamins like vitamin C ,vitamin A, vitamin E and anti- nutrients such as Alkaloids, saponin, tannins, flavonoid and hydrogen cyanide.

The moisture content observed among the accessions of *D.edulis* ranged from 21.91%-25.03% .This range is low and this observation agrees with earlier reports of (Aruah *el at.*,2012), that low moisture content can make food be resistant to microbial spoilage , leading to improved shelf life , as moisture content is an index of water activity of many food crops and is used as a measure of stability and susceptibility to microbial contamination (Darey,1989). This level of ash content observed among the accessions of *D. edulis* ranged from 2.47% -3.09% were lower than the report of Nwachukwu and Ijeh(2000).The level of crude protein observed among the accessions of *D. edulis* ranged from 12.44% - 13.78% , were higher, this observation disagrees with report of Nwachukwu and Ijeh (2000).

The level of fibre content observed among the accessions *D. edulis* ranged from 2.60% - 2.94% is low ,is line with the work of (Ensininger and Ensiningerb,1996). Fibre content of a plant is an important nutritional indicator as fibre adds bulk to food and prevent the excess intake of starchy food and may therefore guide against metabolic conditions such as hypercholesterolemia and diabetes, it also helps to keep the blood sugar under control and can bind to the colon (Ensininger and Ensiningerb, 1996).

Crude fat content among the accessions *D.edulis* were high and ranged from 27.56%-29.60%. Carbohydrate content among the accessions *D.edulis,* was high and ranged from 26.09%-30.75%, this observation agrees with the report of (Effiong *et al* .,2007). Carbohydrate provides energy to the cells in the body , Particularly the brain , which is the only carbohydrate dependent organ in the body (Effiong *et al* ., 2007). Carbohydrate is necessary for maintenance of plasma level, it spares the body protein from being easily digested and help to prevent the using of protein (Uyoh *et al.*, 2013*).*

Calcium content of the accessions *D.edulis,* was high and ranged from 175.20mg/100g -181.66 mg/100g. Calcium is a major factor sustaining strong bone and play a part in muscle contraction and relaxation, blood clothing, synaphic transmission and the absorption of vitamin b12 (Nwofia *et al*.,2013). Calcium plays significant role in photosynthesis, carbohydrate metabolism, nucleic acid and binding agent of cell wall. (Russel ,1973).

Magnesium content of the accessions of *D.edulis,* was high and ranged from 32.69mg/100g - 36.77mg/100g. Magnesium play a role in regulating the acid-alkaline in the body (Bouanga-kalou *el at* .,2011).

Potassium content of the accessions of *D.edulis* was high and ranged from 143.88mg/100g – 146.88mg/100g.Potassium function is to maintain the normal balance and distribution of fluid through the body. It also play an important role in the

synthesis of amino acids and protein (Malik and Srivastava, 1982). The electrolytes, including Potassium are involved in the maintenance of normal pH balance and also work in conjunction with calcium and magnesium in the maintenance of normal muscle contraction and relaxation, and nerve transmission (Akpabio and Akpakpan, 2012).This showed that *D edulis* contains the adequate amount of the minerals.

Sodium concentration of the accessions of *D.edulis* was high and ranged from 78.54mg/100g – 83.60mg/100g. Sodium is important for fluid distribution, blood pressure, cellular work and electrical activities (Mathew, 2013).

Zinc concentration of the accessions of *D.edulis* was moderate and ranged from 4.68mg/100g – 5.89 mg/100g. Zinc is an essential component of a large number of enzymes and stabilizes the molecular structure of cellular components and membranes and contributes in the maintenance of cell and organ integrity (Emebu and Anyika, 2001). Zinc provides natural protective mechanism against viruses, especially those causing respiratory tract infection (Sadler, 2004).

Iron concentration of the accessions of *D.edulis* was moderate and ranged from 2.90mg/100g – 3.80mg /100g. Iron is an essential trace metal and play numerous biochemical roles in the body , including binding oxygen to heamoglobin and acting as important catalytic center in many enzymes such as cytochrome (Geisssler and Power, 2005). Iron and zinc are required in small quantities for normal functioning of the body, excess of the mineral will result to clinical signs and symptoms.

The level of photochemical constituent among the accessions of *PD.edulis* accessions , showed that alkaloid ranged from 0.28-0.37, flavonoid 0.16-0.23,hydrogen cyanide0.24-0.37,tannin 0.42-0.60,saponin 0.08-0.13, these photochemicals were lower than the report of osuagwu and Nwachukwu, (2007) . These values are also considerable lower than those reported by (Gupta *el at*.,1989) indicating that these lower phytochemicals will provide a better bioavailability in minerals.

The level of vitamin A observed among the accessions of *D. edulis* are moderate and ranged from 6.85-7.46 this observation agrees with the report of (Zelman, 2011). Vitamin A is a fat soluble vitamin , it is vital for healthy bones ,teeth skin , mucous membrance and good sight.

This result showed that the vitamin C level of the accessions of *D .edulis* ranged from 58.68-63.63, it showed that *D.edulis* is a good source of vitamin C. Vitamin C is vital in protection against immune system deficiencies, cardiovascular disease, prenatal health problems, eye disease and even skin wrinkling.

The level of B –vitamin observed among the accessions of *D. edulis* is low . This observation agrees with reports of (Wright,2002). The B – Vitamins are water soluble vitamins and are needed in lower quantity to provide energy for the body and for metabolizing proteins and fats, B- vitamins have anti-infective properties, helps in wound healing ,and may improve the immune system and assist reducing infection (Wright,2002).

The level of vitamin E observed among the accessions of *D. edulis* were moderate . This finding is line with the result of (Anon, 2002). Vitamin E acts as antioxidants, fight against the negative effects of free radicals, which affects the tissue, hence minimizing stress and muscle injury from exercise. Vitamin E has the ability to assist in protecting body from free radical and products of oxygenation. It reacts together with other nutrients and antioxidants to put out free radicals. It equally hinders lipoxygenation , an enzyme responsible for formation of proinflammatory leukotrienes (Anon 2002).

CONCLUSION

This study showed that *Dacryodes edulis* is a good source of essential nutrients. This study equally provides quantitative data on the variability of *Dacryodes edulis* fruit traits. The high level of intraspecific variability is typical of an outbreeding tree species. The variability in the fruit characteristics is important for further domestication of the species, whose flesh is consumed as a nutritious staple food.

This study describes a methodology for describing and selecting superior phenotypes for cultivar development. The fruits of *Dacryodes edulis* have been found to have a wide range of variation in commercially important characteristics, which could be subjected to genetic selection.

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