Food Chemistry **44** (1992) 255–259

Variation in physical and chemical composition during maturation of umbu (*Spondias tuberosa*) fruits

Narendra Narain, Pushkar S. Bora, Heinz J. Holschuh & Margarida Angelica da S. Vasconcelos

Departamento de Tecnologia Quimica e de Alimentos, Universidade Federal da Paraiba, 58.059 — João Pessoa — PB., Brazil

(Received 2 August 1991; revised version received and accepted 4 October 1991)

The fruits of the umbu (*Spondias tuberosa* Arruda Camara), also known as 'imbu' in English, were analysed for some physical and chemical changes during various stages of maturity. The fruit was found to be round to ovoidal in shape, being, on average, 3·21 cm long and 2·86 cm in width. Half-ripe fruits contained the maximum (64·62%) pulp content. The pH of the fruits increased with the advance in maturity and ripe fruits were significantly less acidic than green mature and half-ripe fruits. Ripe and half-ripe fruits contained significantly higher reducing sugars (5·34 and 4·14%, respectively) than green mature (2·79%) fruits.

INTRODUCTION

Among several fruits belonging to the genus *Spondias*, which are grown in various parts of the tropics, the umbu (*Spondias tuberosa* Arruda Camara), although relatively little known in the Western Hemisphere, is considered perhaps the best in quality (Popenoe, 1920). Umbuzeiro, or imbuzeiro as the plant is traditionally known in Brazil, is native to the semi-arid region of the Borborema, in the state of Paraiba (Gomes, 1964). It is found in great abundance in dry areas known as 'caatingas' in North-eastern Brazil (Rizzini & Mors, 1976).

Although the annual production of umbu is reported to be about 19,000 metric tons (Fundação Instituto Brasileiro de Geografia e Estatística, 1989), its actual production is expected to be much higher as its accountability is subject to error, as a result of its natural habitat and the absence of any systematic plantations. The fruit is utilized principally in the form of 'umbuzada', prepared by mixing the filtered pulp with sugar and milk. The fruit is also used in the production of ice cream and in the manufacture of cordial, wine and sweet confections. Recently, the fruit-processing industries of the region have developed an interest in this fruit and are exporting the frozen pulp to several European countries.

The fruit, umbu, sometimes referred to in English as 'imbu', is a drupe that is 2–3·5 cm long and weighs 10–20 g; it is round, ovoid or oblong in shape and greenish yellow in colour when ripe, with a thin skin and a large seed (Gomes, 1985). The pulp, which is soft, juicy and has a bitter-sweet taste, is very much appreciated by the local people and comparable to sweet orange.

Scientific information, in general, on this fruit is scanty. Silva *et al.* (1987*a*) studied the phenological characteristics of umbu trees, relating this to the genetic variations existent in different municipalities of Taperoa and Teixeira in the state of Paraiba, Brazil. Silva *et al.* (1984) also reported the mineral composition of leaves, fruits, roots and tubers of umbuzeiro. Chaves *et al.* (1971) presented some physical and chemical analyses of ripe umbu fruit. However, no detailed study exists on the physical and chemical characteristics of umbu fruit at different stages of maturity.

The objective of the present study was to determine the physical, physico-chemical and chemical characteristics during the various stages of maturation of the fruit.

MATERIALS AND METHODS

The fruits of the umbuzeiro (*Spondias tuberosa* Arruda Camara) were obtained from the municipality of Pombal in the state of Paraiba, Brazil. After the harvest, the fruits were classified into three apparent maturities, based on the subjective evaluation of the texture of the fruit and colour of the skin:

(1) green mature — hard texture and green colour;
(2) half-ripe — firm texture and light green colour;
(3) ripe — soft texture and light green colour with yellowish tinge.

Food Chemistry 0308–8146/92/$05.00

Physical analysis

Thirty fruits of each maturity were individually analysed for physical characteristics. The length and diameter of the fruit were measured with a vernier calliper and the volume was measured by displacement of liquid. The measurement of length was made on the polar axis of fruit, i.e. between the apex and the stem. The maximum width of the fruit, measured in the direction perpendicular to the polar axis, is defined as the diameter.

Chemical analysis

The edible portion of the fruit was separated from the seed using a stainless steel knife, and triturated in a domestic mixer, at its maximum velocity, for 3 min. Moisture, titratable acidity, ash, crude fibre, sugars, starch, pectin, tannin, ascorbic acid, iron, calcium and phosphorus were determined according to the methods described by Ranganna (1977). The protein content was determined by the method of Lowry, modified by Schacterle & Pollack (1973). Five samples of each maturity were analysed in triplicate.

Statistical analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences (Nie *et al.*, 1975). Tukey's studentized range test (Steel & Torrie, 1980) was performed to compare all the mean differences.

RESULTS AND DISCUSSION

The dimensions of the umbu fruit and its components are shown in Table 1. The fruit is round to ovoidal in shape, being 3·21±1·14 cm (mean ± three times the standard deviation covering 99·97% of all determinations) long and 2·86±0·84 cm in diameter for all three maturities. Medeiros (1967) reported the fruit to be an oval drupe, 3·5–4·0 cm long. The ratio of length to diameter of the seed was about 1·5, because of its ellipsoidal-to-ovoidal form. The thickness of the pulp increased from 0·64 cm in green mature fruits to about 0·86 cm in half-ripe fruits, presenting a significant difference between them; however, no significant difference was observed between half-ripe and ripe fruits.

The distribution by weight of the various components of the fruit is presented in Table 2. Taking into consideration the fruits of all three maturities, it was observed that, on average, the pulp, seed and skin constituted 57·78, 21·27 and 20·95% of the weight of the whole fruit, respectively. Although no mention was made of the maturity of the fruits, higher values of 61–72% of pulp for the fruits obtained from the municipalities of Taperoa and Teixeira, in the state of Paraiba (Silva *et al.*, 1987*b*) and 73% for the fruits from various municipalities of the state of Pernambuco have been reported. Since the cultivars of this fruit are not well defined, the studies relate to the production place. In the present study, the half-ripe fruits contained the maximum pulp content (64·62%), which showed a significant difference from green mature or ripe fruits. The pulp was white with a greenish tinge, soft and juicy, and possessed a very characteristic taste, which changed from sour for green mature to sweet for half-ripe and ripe fruits. The total weight, volume and density of the fruit also increased from green mature fruits to half-ripe fruits, being maximum at this stage. The lower weight of ripe fruits compared with that of

Table 1. Dimensions of the umbu fruit and its components

Parameter	Statistical description	Apparent maturity			All the fruits
		Green	Half-ripe	Ripe	
No. of fruits	n	30	30	30	90
Length of fruit	Mean (cm)	2·88^a	3·55^c	3·19^c	3·21
	SD	0·25	0·24	0·30	0·38
Diameter of fruit	Mean (cm)	2·63^a	3·08^c	2·88^b	2·86
	SD	0·19	0·17	0·27	0·28
Length of seed	Mean (cm)	1·84^a	2·11^b	1·88^a	1·94
	SD	0·19	0·17	0·18	0·21
Diameter of seed	Mean (cm)	1·35^b	1·36^b	1·19^a	1·30
	SD	0·09	0·14	0·14	0·14
Thickness of pulp	Mean (cm)	0·64^a	0·86^b	0·84^b	0·78
	SD	0·08	0·15	0·14	0·15
Length/diameter of fruit	Mean	1·09^a	1·15^b	1·11^b	1·12
	SD	0·06	0·08	0·09	0·08

n = Number of fruits.
Means in each row followed by different superscript letters were significantly different ($p < 0·05$).
SD = standard deviation.

Table 2. Weight of various components and volume of the umbu fruit

Parameter	Statistical description	Apparent maturity			All the fruits
		Green	Half-ripe	Ripe	
No. of fruits	n	30	30	30	90
Weight of fruit	Mean (g)	10·95^a	19·02^c	16·19^b	15·39
	SD	2·55	2·54	3·89	4·52
	Mean (%)	100·00	100·00	100·00	100·00
Weight of seed	Mean (g)	2·19^a	3·05^b	4·28^c	3·17
	SD	0·35	0·50	1·24	1·17
	Mean (%)	20·52	16·09	27·20	21·27
Weight of skin	Mean (g)	2·72^a	3·66^b	2·90^a	3·09
	SD	0·63	0·58	0·53	0·71
	Mean (%)	25·01	19·29	18·57	20·95
Weight of pulp	Mean (g)	6·04^a	12·32^c	9·01^b	9·12
	SD	1·85	1·93	3·66	3·65
	Mean (%)	54·48	64·62	54·24	57·78
Volume of fruit	Mean (cm^3)	10·30^a	16·43^b	15·40^b	14·04
	SD	2·17	3·13	3·77	4·08
Density of fruit	Mean (g/cm^3)	1·06^a	1·18^b	1·05^a	1·10
	SD	0·06	0·17	0·05	0·12

n = Number of fruits.
Means in each row followed by different superscript letters were significantly different ($p < 0·05$).
SD = standard deviation.

half-ripe fruits could be attributed to the metabolic changes during ripening.

The data on physico-chemical parameters of the pulp of umbu fruit are presented in Table 3. The pH of the fruits increased with the advance in maturity, being 2·90 for green mature, 3·00 for half-ripe and 3·30 for ripe fruits. These relatively low pH values characterized the acidic taste of the pulp. Chaves *et al.* (1971) reported still lower pH values (2·65) for umbu fruits. The titratable acidity decreased with the advance in maturity. Ripe fruits were significantly less acidic (0·95%) than green mature (1·35%) and half-ripe fruits (1·13%). The soluble solids (degree Brix) content was highest (10·2%) in the ripe fruits. The Brix/acid ratio increased from 5·40 for green mature to 10·73 for ripe fruits.

The chemical analysis of the fruits is shown in Table 4. On average, the umbu fruit pulp has a moisture content of 87%; however, a higher value of 92·6% was reported by Benk (1981). There were no significant differences among the three maturities for moisture, fibre and tannin contents. Ripe and half-ripe fruits contained significantly higher reducing sugars (5·34 and 4·14%), respectively than green mature (2·79%) fruits. Benk (1981) reported a higher reducing sugars (7·09%) content in umbu fruit, although the stage of maturity of the fruit was not mentioned. The mean protein con-

Table 3. Physico-chemical parameters of the umbu pulp

Parameter	Statistical description	Apparent maturity			All the fruits
		Green	Half-ripe	Ripe	
pH	Mean	2·90^a	3·00^a	3·30^b	3·07
	SD	0·17	0·10	0·23	0·21
Degree Brix	Mean	9·30^a	8·90^a	10·20^b	9·47
	SD	0·27	0·42	0·45	0·67
Titratable acid (as anhydrous citric acid)	Mean (%)	1·35^c	1·13^b	0·95^a	1·14
	SD	0·02	0·04	0·10	0·18
Degree Brix/Titratable acidity	Mean	5·40^a	7·87^b	10·73^c	8·56
	SD	0·20	0·25	1·23	1·88

Means in each row followed by different superscript letters were significantly different ($p < 0·05$).
SD = standard deviation.

Table 4. Chemical composition of the umbu fruit (per 100 g of edible portion)

Constituent	Statistical description	Apparent maturity			All the fruits
		Green	Half-ripe	Ripe	
Moisture	Mean (g)	88·57[a]	87·81[a]	85·38[a]	87·25
	SD	0·47	0·34	0·10	1·44
Fat	Mean (g)	0·81[a]	0·82[a]	0·89[a]	0·85
	SD	0·02	0·02	0·03	0·03
Protein	Mean (g)	0·31[b]	0·24[a]	0·38[c]	0·31
	SD	0·06	0·02	0·03	0·07
Crude fibre	Mean (g)	1·09[a]	0·97[a]	1·06[a]	1·04
	SD	0·15	0·07	0·08	0·19
Total sugars	Mean (g)	3·37[a]	6·14[b]	6·63[b]	5·38
	SD	0·49	1·24	0·09	1·65
Reducing sugars	Mean (g)	2·79[a]	4·14[b]	5·34[b]	4·09
	SD	0·19	0·57	0·40	1·10
Non-reducing sugars	Mean (g)	0·58[a]	2·00[b]	1·29[ab]	1·29
	SD	0·33	0·70	0·43	0·76
Starch	Mean (g)	1·55[b]	1·39[b]	1·28[a]	1·41
	SD	0·14	0·27	0·14	0·21
Calcium pectate	Mean (g)	1·98[b]	1·19[a]	0·99[a]	1·39
	SD	0·37	0·06	0·06	0·44
Tannin	Mean (g)	0·13[a]	0·12[a]	0·12[a]	0·12
	SD	0·01	0·01	0·02	0·01
Ascorbic acid	Mean (mg)	18·4[c]	15·9[b]	13·2[a]	15·8
	SD	0·52	0·32	2·25	2·52

Means in each row followed by different superscript letters were significantly different ($p < 0·05$).
SD = standard deviation; <0·01 is reported as 0·01.

tent of the fruit was found to be low (0·31%) compared with reported values of 0·54% (Benk, 1981) and 0·96% (Chaves *et al.*, 1971). The starch content decreased with the advance in maturity and its concentration in ripe fruits was found to differ significantly from those of green mature and half-ripe fruits. The average value of ascorbic acid for all three maturities of umbu fruit was 15·8 mg/100 g, which is higher than the reported values of 13·1 mg/100 g (Benk, 1981) and 1·84 mg/100 g (Chaves *et al.*, 1971). The ascorbic acid content decreased significantly with the advance in maturity, being 18·4 mg/100 g for green mature, 15·9 mg/100 g for half-ripe and 13·2 mg/100 g for ripe fruits.

The ash and phosphorous contents (Table 5) found in this study are in good agreement with the values reported by Benk (1981); however, higher values of ash (0·47%, calcium (22·8 mg/100 g) and phosphorus (50·3 mg/100 g) were reported for the fruits from the

Table 5. Mineral content of the umbu fruit (per 100 g of edible portion)

Constituent	Statistical description	Apparent maturity			All the fruits
		Green	Half-ripe	Ripe	
Ash	Mean (g)	0·32[a]	0·27[a]	0·30[a]	0·30
	SD	0·02	0·04	0·06	0·05
Iron	Mean (mg)	1·5[a]	1·4[a]	1·4[a]	1·46
	SD	0·50	0·26	0·30	0·35
Calcium	Mean (mg)	16·2[a]	15·1[a]	15·8[a]	15·6
	SD	1·29	1·21	0·85	1·13
Phosphorus	Mean (mg)	32·7[b]	23·9[a]	29·9[ab]	27·9
	SD	3·37	2·56	3·12	2·97

Means in each row followed by different superscript letters were significantly different ($p < 0·05$).
SD = standard deviation.

state of Pernambuco (Chaves *et al.*, 1971). There were no significant differences among the three maturities for calcium, iron and ash contents. The iron content was found to be high (1·46 mg/100 g) compared with the 1·02 mg/100 g reported by Chaves *et al.* (1971) and the 0·6 mg/100 g reported by Benk (1981).

ACKNOWLEDGEMENTS

The authors wish to thank the Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq), Brazil and Inter-American Development Bank for financing this work pertaining to project PB-35 in the collaborative programme for the Development of Science and Technology (PDCT/NE) in North-east Brazil.

REFERENCES

Benk, E. (1981). Further contribution on exotic fruits. *Reichstoffe, Aromen, Kosmet.*, **31**, 234–5.

Chaves, N., Vieira, R., Coelho, M. A. S. C. & Regis, A. de A. (1971). Estudo de umbu, jaca e pinha. Relatório da Seção de Tecnologia Agropecuária da Divisão de Pesqisa e Experimentação Agropecuária. Convênio do Ministério da Agricultura (Estado da Pernambuco)/Superintendéncia do Densenvolvimento do Nordeste (SUDENE). Recife, 187–209.

Fundação Instituto Brasileiro de Geografia e Estatistica (FIBGE). (1989). *Anuário Estatístico do Brasil.* FIBGE, Rio de Janeiro.

Gomes, R. P. (1964). O umbuzeiro. *Seleções Agrícolas*, São Paulo, **XIX** (223), 29–32.

Gomes, R. P. (1985). *Fruticultura Brasileira.* Nobel, São Paulo.

Medeiros, J. W. A. (1967). O umbuzeiro. *O Agronomico*, Campinas **(3/4)**, 3–4.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K. & Bent, D. H. (1975). *Statistical Package for the Social Sciences.* McGraw-Hill, New York.

Popenoe, W. (1920). *Manual of Tropical and Subtropical Fruits.* Macmillan, New York.

Ranganna, S. (1977). *Manual of Analysis of Fruit and Vegetable Products.* Tata–McGraw-Hill, New Delhi.

Rizzini, C. T. & Mors, W. B. (1976). *Botânica Econômica Brasileira.* Editora Pedagogica e Universitaria, Universidade de São Paulo, São Paulo.

Schacterle, G. R. & Pollack, R. L. (1973). A simplified method for the assay of small amounts of protein in biological material. *Anal. Biochem.*, **51**, 654–5.

Silva, H., Silva, A. Q. da, Roque, M. L. & Malavolta, E. (1984). Composição mineral do unbuzeiro (*Spondias tuberosa*, A. Cam) In *VII Congresso Brasileiro de Fruticultura, Florianópolis, Anais*, **4**, 1129–34.

Silva, H., Silva, A. Q. da, & Oliveira, A. R. de. (1987*a*). Algumas informações pomológicas do umbuzeiro da Paraíba. I. Caracteristicas pomológicas. In *IX Congresso Brasileiro de Fruticultura, Campinas, Anais*, **2**, 691–6.

Silva, H., Silva, A. Q. da, Oliveira, A. R. de & Cavalcanti, F. B. (1987*b*). Algumas informações pomológicas do umbuzeiro da Paraíba. II. Caracteristicas tecnológicas. In *IX Congresso Brasileiro de Fruticultura, Campinas, Anais*, **2**, 697–701.

Steel, R. G. D. & Torrie, J. H. (1980). *Principles and Procedures of Statistics — A Biometrical Approach*, 2nd edn. McGraw-Hill, New York.