Carica candicans Gray (Mito), an Alimentary Resource from Peruvian Flora

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In addition to some histological observations, the chemical composition of *Carica candicans* Gray (Caricaceae) fruit and seeds, a plant common in Peruvian nutritional habits, was determined. The fruit contains high amounts of total proteins (8.2% on dry weight basis) and carbohydrates (70.1%) and appreciable contents of vitamin C and minerals. The oil extracted from seeds is in high amount (41.6%). The fatty acid composition, with a prevalence of oleic, palmitic, and linoleic acids, suggests a possible use of this oil in alimentation.

Keywords: *Carica candicans; proximate composition; fruit; seeds*

INTRODUCTION

The diet of Andean populations is mainly based on plants rather than on animal products, and a large body knowledge about vegetal foods derived from America after the conquest exists (Gross et al., 1989). Actually, a number of vegetables are used as nutrition by the local populations, but, for most of them, chemical composition data are not available.

In this paper we report on a species of the Caricaceae family, the fruit of which is largely employed in Peruvian nutritional habits. The genus *Carica* (Caricaceae) comprises ∼30 species; the fruits of some of them are used as foods in tropical countries (Sturtevant, 1919; Uphof, 1968). Thirteen species, among which is *Carica candicans* Gray, grow in Peru (MacBride, 1936−1962), on the mountains of the coast and on the west sides of the Andes, between 2000 and 3000 m above sea level. The plant is usually known by the vernacular names "mito" in central Peru, "jerju" in Parinacochas, "uliucana" in Carumas, and "quemish", "ckemish", and "papayo" (Soukup, 1987). The plant is not cultivated but is widely distributed in the wild state. The fruit is characterized by a pleasant aroma and is normally eaten when ripe (Uphof, 1968; Soukup, 1987). In Huarochirí it is used roasted because roasting produces a sweeter taste. In addition to alimentary uses, the fruit is also employed as a digestive aid, probably due to the content of proteolytic enzymes found also in other fruits of *Carica* species (Brocklehurst et al., 1981; Goodenough and Kilshaw, 1988; Baeza et al., 1990). In Huaraz, the fruit is administered in the treatment of leishmaniasis. Data concerning the chemical composition of this fruit are not found in the literature.

In this paper we report some histological observations on the fruit and the seed, on their proximate compositions and on the physicochemical characteristics of the oil obtained from the seeds.

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MATERIALS AND METHODS

Materials. Fruits of *C. candicans* were collected in March 1995 in Cajatambo Province, central Peru. The plant was identified by Dr. V. De Feo. Ten fruits (average weight = 230 g) were oven-dried at 110 °C to constant weight; endocarp, mesocarp, and seeds were then separated and weighed, resulting in 44.2% endocarp (w/w), 38.3% mesocarp, and 17.5% seeds. Microscopic observations on fruit and seeds were performed by using an MIC 5000 stereomicroscope [Inter Continental, Anzio (Rome)]. Moisture was determined by oven-drying at 130 °C to constant weight, according to AOAC Method 925.10 (AOAC, 1990). Total fat content was obtained according to the Soxhlet extraction method, using diethyl ether, as reported in AOAC methods. The nitrogen content in the fruit and in the seeds was determined according to the Kjeldahl procedure, as described in AOAC Method 920; the factor N × 6.25 was used to convert nitrogen into crude protein. Crude fiber was determined in the fruit and in the seeds by using the ceramic fiber filter method, according to AOAC Method 962.09. Ash was determined by using AOAC Method 940.26; in addition, soluble and insoluble ashes were determined in the fruit, according to the same method. The determination of sugars and reducing sugars was performed according to AOAC Inversion Method 925.36. Carbohydrate content was obtained by subtracting the sum of protein, fat, ash, fiber, and moisture from 100. Titrable acidity (total acid), expressed as citric acid monohydrate, was determined by tritating a 10 g sample to end-point pH 8.1 with 0.1 NaOH, in accordance with the method reported by the International Federation of Fruit Juice Producers (1968). Ascorbic acid was determined by using the 2,6-dichloroindophenol titrimetic method, according to AOAC Method 967.21. Reference material was an ascorbic acid solution (1 mg/mL) prepared from L-ascorbic acid (99%), Aldrich. The pectic substances were determined according to the procedure of Dietz and Rouse (1953). Minerals were determined by using a Perkin-Elmer 5000 atomic absorption spectrophotometer, equipped with an HGA 500 programmer, and an air/acetylene flame. Briefly, in a typical experiment, 1.00 g of the dried pulverized *C. candicans* fruits was ashed in a platinum crucible in a muffle furnace for 8 h at 400 °C and allowed to cool. Wet ash was added to 10 drops of H_2O_2 and 3−4 mL of HNO_3 (1:1). Excess

10.1021/jf980513d CCC: $18.00
Published on Web 07/31/1999

Table 1. Percent Composition of *C. candicans* Fruit and Seed[a]

constituent	fruit		seed	
	dry	fresh	dry	fresh
moisture		88.8 ± 5.1		7.6 ± 0.8
total lipids	2.9 ± 0.2	0.3 ± 0.1	45.0 ± 4.3	41.6 ± 4.0
total protein	8.2 ± 0.4	0.9 ± 0.1	29.4 ± 4.1	27.1 ± 3.3
crude fiber	10.6 ± 0.6	1.2 ± 0.2	16.4 ± 2.2	15.1 ± 1.4
total ash	8.3 ± 0.5	0.9 ± 0.2	3.4 ± 1.2	3.2 ± 1.1
soluble ash	7.5 ± 0.4	0.8 ± 0.1		
carbohydrate	70.1 ± 4.4	7.9 ± 1.3	5.8 ± 2.0	5.3 ± 1.6
direct reducing sugars	25.4 ± 2.6	2.8 ± 0.3		
indirect reducing sugars	26.9 ± 1.7	3.0 ± 0.7		
pectins		1.2 ± 0.1		
minerals (mg%)				
calcium	134.0 ± 7.2	15.0 ± 1.9		
magnesium	89.1 ± 5.7	10.0 ± 1.1		
iron	4.0 ± 1.7	0.5 ± 0.2		
phosphorus	117.0 ± 13.1	13.1 ± 2.6		
sodium	26.0 ± 3.4	2.9 ± 0.4		
chloride	712.4 ± 41.5	80.0 ± 4.9		
acidity (mg of citric acid)		37.0 ± 6.2		
vitamin C (mg)		45.0 ± 3.1		

[a] n = mean value of five determinations ± SD. Confidence level 95%.

HNO_3 was evaporated and the crucible was returned to the furnace for 1 h at 400 °C. After cooling, the ashes were dissolved with hot 1 N HCl (10 mL) and filtered through Whatman No. 41 ashless filter paper. Solution was collected in a 100 mL volumetric flask, 5 mL of concentrated HNO_3 was added, and the volume was made up to 100 mL with deionized distilled water. An aliquot of 10 mL of this mother solution was used to determine each element. Necessary dilution to obtain solutions suitable for the ranges of the instrument was made with 10% HCl and/or distilled deionized water. Interference was prevented by adding solutions (in deionized distilled water) of 5% $La(NO_3)_3$ (1 mL, for Ca and Mg) or 4% CsCl (for Na and K). Solutions [atomic absorption standard solutions, Aldrich, or solutions prepared from nitrates (K and Mg), Aldrich] were tested before and after each set of measures. Calibration graphs were drawn from the data in which the same analytical procedure was applied to the samples. All reagents were Superpur, Merck.

Extraction and Characterization of Seed Oil. Seeds were dried to constant weight. Twenty-five grams of cleaned seeds was ground in a coffee mill and then extracted with a Soxhlet apparatus by using ethyl ether, peroxide-free. Acidity number was determined by titration with 0.5 N KOH, according to AOAC Method 940.28. Refraction index was calculated by using the Abbe refractometer, according to AOAC Method 921.08. Saponification number was performed by AOAC Method 920.160. Hener number was determined according to AOAC Method 960.162. Reichert−Meissl−Wollny and Polenske values were determined according to AOAC Method 925.41. Iodine absorption number was detemined by using the Hanus method, according to AOAC Method 920.158.

After saponification of the ethereal extract, fatty acids were determined both by preparing their methyl esters (FAMEs), using dimethylformamide dimethyl acetal (Pierce) treatment (Thénot et al., 1972), which were analyzed by GLC, and by preparing their *p*-Br-phenacyl esters (Borch, 1975), which were determined by HPLC (Senatore, 1983). The FAMEs were chromatographed using a Supelco SPB 1 capillary column (30 m × 0.25 mm i.d.) on a Perkin-Elmer Σ 115 instrument, fitted with an FID and a relative computer. Injector and detector temperatures were 250 and 270 °C, respectively; oven temperature was 100 °C for the first 2 min after injection, programmed to 260 °C at 5 °C min^{-1}, and isothermally held for 15 min. Helium carrier gas was flowing at 30 mL min^{-1}. Identification of FAMEs was done by comparing their retention times with those of authentic samples at known concentration under the identical operating conditions. *p*-Br-Phenacyl esters were separated by HPLC, by using a Waters 6000 A instrument, equipped with a UV−vis detector at 254 nm and an RP8 semipreparative column, eluting with $CHCN_3/H_2O$ mixtures, from 70:30 to 100:0, at a flow of 1 mL min^{-1}. The identification of *p*-Br-phenacyl derivatives was done by comparison of their retention times with those of authentic samples available in our laboratory.

RESULTS AND DISCUSSION

The *C. candicans* fruit is a large berry (12−15 × 6−7 cm), blunt at the base and pointed at the extremity, penta- or hepta-angled, at first green and then green-yellowish at maturity. The pulp is yellow-white, juicy, and aromatic, containing many seeds and clad with a a fibrous white membrane. The epicarp is constituted by a row of rectangular cells, with a cutinized wall. The mesocarp is constituted by some rows of polymorphous cells, having thin walls and in which starch granules, pigments, irregular vascular blundes, and druses of calcium oxalate of different sizes, arranged in untidy rows under the epicarp, are present. The endocarp is constituted by a row of rectangular cells of different sizes and a thin wall, which makes a sinuous line, in which the ovules are grouped in columns.

The seeds are ovoid (8−10 mm); their epidermis have a sarcotesta constituted by a yellowish mass; a sclerenchymatous layer is formed by a row of round, small cells; the tegmen is constituted by some rows of yellowish flattened cells. The albumen is constituted by rectangular cells, with a thin wall and in regular rows, in which small amounts of oil and granules of starch are observable. The embryo is located at an extremity. The seeds are grouped in rows clad by the edible part of the fruit, each seed being coated with an abundant mucilage.

Table 1 shows the proximate and mineral compositions of the fruit of *C. candicans*. Its nutritional value is quite interesting. Indeed, the fruit presents a good amount of total proteins (8.2% on a dry weight basis) and a high content of carbohydrates (70.1%). Also, the vitamin C content (45 mg/100 g of fresh fruit) is appreciable and similar to those of *Citrus* fruits (Documenta Geigy, 1963). It is possible to underscore the great similarity between the composition of the fruits of *C. papaya* and *C. candicans*, if compared with the literature data concerning the papaya fruit (Lassou-

Table 2. Physicochemical Characteristic of Seed Oil from *C. candicans*[a]

yield	41.6% ± 2.7
appearance	clear
color	yellow-green
odor	characteristic
taste	characteristic
refraction index (25 °C)	1.4645
acidity no.	4.4
saponification index	207
iodine absorption no.	81.60
Hener index	96.20
RMW value	0.88
Polenske value	0.44

[a] n = mean value of five determinations ± SD. Confidence level 95%.

Table 3. Fatty Acid Composition of the Seed Oil from *C. candicans*[a]

fatty acid	%[b]	%[c]	fatty acid	%[b]	%[c]
caprylic ($C_{8:0}$)	1.2	1.2	palmitic ($C_{16:0}$)	30.3	30.3
pelargonic ($C_{9:0}$)	0.5	0.5	stearic ($C_{18:0}$)	2.5	2.5
capric ($C_{10:0}$)	1.0	1.0	oleic ($C_{18:1}$)	35.9	36.0
lauric ($C_{12:0}$)	2.3	2.3	linoleic ($C_{18:2}$)	17.4	17.4
myristic ($C_{14:0}$)	3.0	3.1			

[a] Mean value of four determinations. [b] Determined as methyl esters. [c] Determined as *p*-Br-phenacyl esters.

diere, 1969; Holland et al., 1992), The mineral composition reveals a good presence of calcium and high levels of chloride. This constituent pattern suggests the use of this fruit in alimentation. On the other hand, the high percentage of pectins could suggest its use in the industrial manufacture of pectins.

Seed composition reported in the same table reveals a high percentage of ether extract (41.6%), if compared with other oils, for example, soy (18.7%) and sunflower (27.6%) (Karl et al., 1979). In addition, the total protein content (29.4% as dry weight basis) could permit the use of defatted seed as animal feed.

The physicochemical characteristics of *C. candicans* seed oil are reported in Table 2. The refraction index is very similar to those of olive, maize, and soy oils (Karl et al., 1979), the saponification index is slightly greater, and the iodine absorption number is lower, indicating a lower unsaturation degree when compared with other oils (Karl et al., 1979).

The percent composition of fatty acids in seed oil is reported in Table 3. Oleic, lineoleic, and palmitic acids represent up to 83% of the oil, whereas the odd compounds are represented only by pelargonic acid in very low amounts (0.5%). The unsaturated fatty acids represent 53.3% of the oil, and the ratio of unsaturated to saturated fatty acids is similar to those reported for olive oil (Fidanza, 1990). The oil shows a good fatty acid composition with oleic acid as the main component (35.9%), followed by palmitic acid (30.3%) and linoleic acid (17.4%). The oleic acid content is very similar to the amount recorded in sunflower oil (34%) and slightly lower than that found in maize oil. The linoleic acid content is lower than those of soy, maize, and sunflower oils, and palmitic acid content is higher. However, the quality of *C. candicans* oil is inferior to that of *C. papaya* (Table 3) because of its higher content in palmitic acid.

Our data could suggest an alimentary use of *C. candicans* oil. However, its particular taste, probably due to the presence of caprylic and capric acids, together with the fact that the plant is actually not cultivated, represents a severe limitation in the widespread use of this oil. However, a deficit of fats and oils is reported for Peru (Van der Linden and Lopez Cabrejos, 1989); this oil, together with the exploitation of other nontraditional sources, could represent a possible alternative.

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Received for review May 15, 1998. Revised manuscript received June 14, 1999. Accepted June 15, 1999.

JF980513D