Chemical composition of baobab fruit (*Adansonia digitata* L.)

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Abstract

The physical properties and chemical composition of the fruit of the baobab tree, *Adansonia digitata* L., were investigated. The pulp was found to be acidic, and rich in ascorbic acid, iron, calcium and pectin. The pectin was mainly water soluble and had a low degree of esterification and a low intrinsic viscosity. It was of a poorer quality than commercial pectin and citrus waste pectin.

Résumé

On a étudié les propriétés physiques et la composition chimique du fruit de baobab, *Adansonia digitata* L. On a constaté que la pulpe était acide, et riche en acide ascorbique, fer, calcium et pectine. La pectine était en grande partie soluble dans l'eau et avait un faible degré d'estérification, et une faible viscosité intrinsèque. Élle était de moins bonne qualité que la pectine commerciale et la pectine obtenue à partir des déchets d'agrumes.

Rusumen

Fueron investigadas las propriedades fisicas y la composición química del fruto del baobab, *Adansonia digitata* L. Se descubrió que la carne era acídica y abundante en ácido ascórbico, hierro, calcio y pectina. La pectina era en su mayor parte soluble en agua y tenia un bajo grado de esterificación y una viscosidad intrinseca baja. Resultó ser de una calidad más inferior a la de la pectina comercial y la pectina obtenida de sobrantes cítricos.

Introduction

The fruit of the baobab tree, *Adansonia digitata* L., is oblong, pendulous on long stalks, woody and indehiscent. The large brown seeds are arranged in rows in two to eight locules per fruit. The seeds are attached to fibrous strands from the wall of the fruit and are embedded in a yellowish-white pulp. According to Purseglove (1968), the fruit pulp, which contains tartaric acid, is made into a drink and is also used as a fruit seasoner. In the Sudan, the pulp is commonly chewed, sucked, or made into a drink. The seed kernels are edible and the seeds contain 19 per cent oil (Magboul and Mustafa, 1979).

This study presents data on the physical properties and chemical composition of Sudanese baobab fruit, and on the characterisation of its pectic substances.

Materials and methods

Fruits were collected from Khartoum market and 20 fruits were selected randomly without grouping according to variety or degree of ripeness.

A vernier caliper was used to measure fruit dimensions. The weights of the fruits, pulp and seeds and the number of seeds per fruit and their colour were noted.

The pulp was separated from the seeds, mixed, and passed through a British Standard sieve No. 50.

pH was measured using a Philips pH meter. The following were determined according to AOAC (1970): moisture, page 211 (14·004); total soluble solids, page 237 (15·012); alcohol-insoluble solids, page 591 (34·045); protein, page 16 (2·051); crude fibre, pages 129–131 (7·053–7·057); ash, page 211 (14·006); ash alkalinity, page 527 (31·016); and ascorbic acid, pages 777–778 (39·052, 39·054–39·055). Fat was assayed by extracting the sample for 24 hours with petroleum ether (boiling point range 40°C to 60°C) in a Soxhlet extractor.

The ash solution was used for the determination of iron, calcium, phosphorus and magnesium. The thiocyanate method (Vogel, 1961) was used for iron, absorption being measured at 480 mμ with a Bausch and Lomb Spectronic 20. Calcium was precipitated as oxalate (AOAC, 1970, page 213 (14·014)). Phosphorus was assayed using the micro-molybdenum blue colorimetric method (AOAC, 1970, pages 373–374 (22·037–22·039)) with a Klett Summerson photoelectric colorimeter fitted with a red filter. Magnesium was also estimated (AOAC, 1970, page 36 (3·013)).

For the determination of total and reducing sugars according to Munson and Walker's method (AOAC, 1970, page 533 (31·038)), the pulp was extracted with 80 per cent ethanol using a Soxhlet apparatus and the pH of the extract was adjusted to 7·5 with anhydrous sodium carbonate. Total pectic substances were extracted from the sugar-free residue and determined by the modified uronic acid carbazole reaction by adding borate (Bitter and Miur, 1962).

Starch was isolated (Hassid and Newfeld, 1964), acid hydrolysed and the dextroses estimated by the gravimetric Fehling method (AOAC, 1970, pages 141 and 533 (8·017 and 31·039)). Multiplying this by 0·9 gave the starch equivalent.

The alcohol-insoluble solids from the pulp were subjected to successive extractions with water, acid and alkali (Nour, 1977), and anhydrouronic acid was determined quantitatively (Bitter and Miur, 1962).

The water-soluble pectin was extracted, precipitated, dried at room temperature, ground and passed through a 60 mesh sieve (Gee *et al.*, 1958). Its equivalent weight and the contents of anhydrouronic acid and acetyl were determined (McCready, 1970). The method of Owens *et al.*, (1952) was used for the intrinsic viscosity determinations.

The pulp and water-extract were acid hydrolysed, followed by neutralisation (McCready and Gee, 1960); sugars were identified by paper chromatography. Ethyl acetate-pyridine-water (8:2:1 v/v) was used for the pulp hydrolyzate and the individual spots were detected with diphenylamine (0·75 g) dissolved in a mixture of ethyl acetate (25 ml), aniline (4 ml) and 80 per cent phosphoric acid (55 ml w/v). Ethyl acetate-pyridine-water (5:2·5:3 v/v) was used for the water-extract hydrolyzate separation, the spots being identified with a mixture of trichloroacetic acid (2 per cent) and aniline (2 per cent) in ethyl acetate.

Results and discussion

Table 1 gives the physical properties of the fruit.

Table 1
Physical properties of baobab fruit

	Mean ± s.d.
Length (cm)	17·1 ± 1·9
Width (cm)	8·0 ± 0·5
Weight (g)	165 ± 26
Weight of pulp per fruit (g)	28 ± 4·0
Weight of seeds per fruit (g)	63·7 ± 14·7
Number of seeds per fruit	156 ± 37·5

The chemical composition of the pulp (dry basis) is shown in Table 2. Values for crude protein, total carbohydrates and ash are in agreement with

Table 2
Chemical composition of baobab fruit pulp

Constituents (dry basis)	Mean ± s.d.
Total soluble solids (%)	79·3±1·2
Alcohol insoluble solids (%)	57·3±2·4
Total sugars (%)	23·2±0·2
Reducing sugars (%)	18·9±0·5
Total pectin (% galacturonic acid)	56·2±0·9
Starch (%)	Nil
Protein (%N × 6·25)	2·6±0·3
Fat (%)	0·2±0·01
Crude fibre (%)	5·7±0·2
Ash (%)	5·3±0·02
Ascorbic acid (mg/100 g)	300 ±6·2
Iron (mg/100 g)	8·6±1·1
Calcium (mg/100 g)	655 ±34
Phosphorus (mg/100 g)	50·8±4·6
Moisture	6·7±0·03
pH	3·3±0·04

those reported by Oliviera (1974) while those for fat and crude fibre are lower. The pulp was acidic, and Airan and Desai (1954) have shown this to be due to the presence of the organic acids citric, tartaric, malic, succinic and ascorbic. The raffinose, sucrose, galactose, glucose and fructose identified agree with the findings of Airan and Desai (1954) for ripe Indian baobab fruit. Green (1932) reported the absence of starch in the pulp: this is confirmed by this study. The pulp was found to be rich in ascorbic acid (see also Carr, 1955; Nicel, 1957; Carr, 1958), iron and calcium. Although thiamine was not measured in this study, the pulp has been reported to be a valuable source of this vitamin (Toury *et al.*, 1957; Oliviera, 1974).

This study also showed that the pulp is rich in pectin (average 56 per cent). Fractionation showed that most of it was water-soluble (Table 3), hence the protopectin content was low. The isolated water-soluble pectin was slightly coloured (yellowish-white), probably because sun drying* had degraded the pigments.

Table 3
Anhydrouronic acid content (%) of water, acid and alkali extractions of alcohol insoluble solids obtained from baobab fruit (dry weight basis)

Water-soluble fraction	46·98
Acid-soluble fraction	1·50
Alkali-soluble fraction	0·82

Acid hydrolysis of the isolated pectic substances followed by identification of the released monosaccharides revealed the presence of galacturonic acid, rhamnose, galactose, arabinose and xylose. These sugars are thought to be characteristic components of the pectic group of plant

Table 4
Chemical composition of the water-soluble fraction of baobab pectin

	Mean ± s.d.
Moisture (%)	11·9±0·4
Protein (%N × 6·25)	1·6±0·02
Methoxyl (%)	1·3±0·1
Degree of esterification (%)	27·1±0·4
Anhydrouronic acid (%)	60·2±0·3
Acetyl (%)	0·09±0·0
Ash (%)	5·9±0·3
Ash alkalinity (mg NaOH/g)	17·4±0·5
Calcium (%)	0·80±0·08
Magnesium (%)	0·22±0·06
Equivalent weight	334

* Drying in a dish in a sunny window.

polysaccharides (Francis and Bell, 1975). However the occurrence of glucose shows that the pectic acid was contaminated.

Since no simple chemical derivatives are characteristic of pectic substances isolated from parent plant tissue, the usual practice is to use arbitrary chemical and physical characters. Baobab pulp pectin was found to have a low methoxyl content, i.e. it had a low degree of esterification (see Table 4); this may be due to the presence of esterifying enzymes during ripening. No other fruit has been reported in the literature as having such a low value.

The intrinsic viscosity values of the water-soluble baobab pectin at different concentrations are shown in Table 5. These values are low and are approximately one-fifth of those of commercial apple pectin. Thus baobab pectin is different in structure from that of commercial apple pectin and could be lower in molecular weight, i.e. have a low degree of polymerisation. The high protein and ash contents may have contributed to the low intrinsic viscosity.

Table 5
Intrinsic viscosity of water-soluble baobab pectin at 23°C

Concentration (g/ml)	Intrinsic viscosity (g^{-1})
0·05	0·20
0·10	0·20
0·20	0·25
0·30	0·40
0·40	0·45
0·50	0·50

In conclusion, the pectin of baobab pulp has a low degree of esterification and a low intrinsic viscosity. It will probably not give a good jelly of high solids content, because it tends to precipitate rapidly in acid media to form irregular gels. It is of lower quality than commercial apple pectin and citrus waste pectin (Mubarak *et al.*, 1977).

During fruit ripening, the pectin may be depolymerised or de-esterified, and such changes would have to be quantified before definitive conclusions about the potential value of baobab pectin can be reached.

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