International Journal of Biomedical and Health Sciences
Vol. 5, No. 2, June 30, 2009
Printed in Nigeria

0794-4748/2009 $12.00 + 0.00

http://www.asopah.org

IJBHS 2009031/5202

The food potential of Tucum (*Astrocaryum vulgare*) fruit pulp

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(Received April 2, 2009)
(Accepted May 12, 2009)

ABSTRACT: The tucum (*Astrocaryum vulgare*) fruit pulp, which constitutes 34-55% of the fruit is rich in oil and carbohydrate and has a modest high-quality protein content. It has a high calorific density (gross energy = 299.6 kcal/100g) and its fat – protein – carbohydrate energy composition resembles that of human milk. Tucum pulp oil composition indicates that it contains no cholesterol and that it is a good source of dietary palmitic and oleic acids, β-carotene, ∝ - tocopherol, β- sitosterol and camposterol.

Tucum fruit harvesting, consumption as well as the food processing and product development possibilities for the tucum pulp are discussed.

Keywords. Tucum; Fruit pulp; Proximate composition; Fatty acids; Energy; Processing; Product development.

Introduction

The identification and cultivation on a mass scale of plant foods having a high nutritional and economic value has been suggested as a way to alleviate hunger in less developed countries [NAS, 1975]. Minor crops of local origin, when studied and introduced into neighbouring or distant areas could provide substantial benefits. They can be grown as garden crops and as ornamentals in rural, peri-urban, and urban areas, with significant and direct impact on the local diets, requiring only simple cultivation, harvesting and processing technology.

Such crops, because they will flourish in lands otherwise of marginal value for conventional agriculture, possess an advantage in a poor economy over grain and legume crops, which require significant capital outlay, fertile soils and a constant flow of inputs such as inorganic fertiliser and pesticides for their cultivation (Balick, 1979; Balick and Gershoff, 1981).

The genus *Astrocaryum* includes about 50 species of prickly cocosoid palms, which are indigenous to the evergreen rain forest of Central and South America up to an altitude of 2,000 feet. Their habitat ranges from the flood plains of alluvial rivers and swamps underwater for more than half the year, to well drained forests, far above the level of high water (Arckoll, 1988, Schultes, 1977). Thus the genus *Astrocaryum* occupies an area of South and Central America, which is environmentally analogous to the habitat of the Africa oil palm (*Elaeis guineensis*) and the genus *Raphia* in West Africa. Species belonging to the genus could therefore be introduced to West Africa through naturalisation and acclimatization (Anon, 2000). According to Prance (1994), at least forty species of Astrocaryum (including *A. vulgare*) deserve the attention of economic botanists.

The palm *Astrocaryum vulgare* Mart, also known as tucum or Awarra grows principally in Brazil, the Guiana, Peru, Venezuela and neighbouring areas (Eckey, 1954, Arckol, 1988, Cavalcante, 1977). The tucum palm fruit possesses a fleshy mesocarp (pulp) and a seed, both of which are rich in oil and carbohydrate, while its leaves yield cordage fibre (Kirby, 1963, Schultes, 1977). Tucum kernels are exploited in the country of origin to produce fat mainly for soap making (Vaughan, 1970).

Although modest amounts of kernels have featured in international trade (Eckey, 1954; Vaughan, 1970; Arckol, 1988) only wild palms have been exploited. The tucum fruit is commonly available in open markets in areas of South America, where it is eaten or used to make juice (Cavalcante, 1977). Little, however, is known of the tucum palm outside its area of origin.

Detailed examination of the composition of the fruit, fruit pulp, fruit pulp oil (Oboh Oderinde, 1988a) and kernel and kernel fat (Oboh and Oderinde, 1989), purification of pulp oil (Oboh, 1995) and the modification of pulp oil and kernel fat to enhance their suitability for inclusion in fatty food formulations (Oboh, 1988b, 1988c) and as raw material for the synthesis of oleochemicals (Oboh, 1994, 2009) have been undertaken.

This paper reviews the nutrient, energy and oil composition of the tucum fruit pulp from a human dietary standpoint and suggests processing and product development opportunities for the material.

Tucum Pulp Composition

Table 1 shows the composition of the tucum fruit as reported by various authors. Fruit weight for the Nigerian grown produce ranged from 30.0-38.0g (Oboh and Oderinde, 1988a), while Eckey (1954) has reported a range of 15.0-20.0% for fruits from South America. Reported fruit pulp (epicarp and mesocarp) content range from 34.0 to 55.0% of the fruit (Oboh & Oderinde, 1988a; Eckey, 1954; Lubrano, 1994).

Table 1. Tucum fruit characteristics.

Characteristic	**Oboh & Oderinde (1988)**	**Eckey (1954)**	**Lubrano (1994)**
Fruit weight g	30.0-38.0	15.0-20.0	-
Pulp content%	51.0	34.0	55.0
Fruit colour	Orange	Orange	Orange

These indicate that tucum pulp could be a valuable and abundant food material if its nutrient composition was found to be suitable.

Table 2 shows the proximate composition of tucum pulp. Included for comparison are the compositions of cow's milk and human milk. Tucum pulp due to its lower moisture content contains higher proportions of protein, carbohydrate, ash and fat, and therefore, a higher energy density than human or cow's milk. It is made up of protein (5.9%), crude fibre (5.7%), ash (1.9%), oil (22.0%) and moisture (45.0%).

Table 2. Proximate composition (g/100g) of tucum pulp, human milk and cow's milk

	Tucum pulp[a]	**Human milk**[b]	**Cow's milk**[b]
Crude protein	5.9	1.0-1.5	3.0-4.0
Crude fibre	5.7	-	-
Ash	1.9	0.2	0.75
Carbohydrate	19.5	7.0-7.5	4.5-5.0
Oil	22.0	3.0-4.0	3.5-5.0
Moisture	45.0	87.5	87.0
[a]Gross Energy (kcal)	299.6	-	-

[a]Oboh & Oderinde (1988a)
[b]White *et al* (1973)

The nutrient energy composition of tucum pulp as calculated from proximate composition is shown in Table 3. Included for comparison are values for *Jessenia bataua* milk (from the *Jessenia bataua* palm fruit pulp), cow's milk and soybean milk.

Table 3. Fat-protein-carbohydrate energy composition of tucum pulp, human milk, cow's milk and a milk-like beverage from *Jessenia bataua* fruit pulp.

%Calories (approx) from each component	**Tucum pulp**[a]	***Jessenia bataua* milk**[b]	**Human Milk**[b]	**Cow Milk**[c]	**Soybean Milk**[c]
Fat	66.1	55.3	45.9	49.8	37.6
Protein	7.9	7.4	5.6	20.9	37.9
Carbohydrate	26.0	37.3	48.5	29.3	24.6

[a] Calculated from proximate composition (Table 2) according to FAO (1978), using the following average values (kcal/g): protein = 4, carbohydrate = 4, fat = 9
[b]Balick & Gershoff (1981).
[c]USDA (1983).

Protein

Protein is the most important of the major dietary nutrients. It constitutes 5.9% of tucum pulp. The fat-protein- carbohydrate energy composition indicates comparable energy from protein for tucum pulp (7.9 %), *J. bataua* milk (7.4%), and human milk (5.6%). These are lower than values for cow's milk (20.9%) and soybean milk (37.9%). As can be seen from the fat–protein–carbohydrate energy composition of human milk where energy from protein constitutes only 5.6%, human protein requirement can be met by a diet containing less than 10 % of its calories from high quality protein.

Bora *et al.* (2001) have published information on the quality of tucum protein. This is presented in Table 4. Except for lysine and methionine, whose concentration in tucum pulp protein amount to 91.9 and 24.5% respectively, of their concentration in the FAO reference protein, other essential amino acids in pulp are present in concentrations higher than recommended by the FAO. These authors did not determine the concentration of tryptophan.

Carbohydrate.

Carbohydrate constitutes 19.5 % of fresh tucum pulp and accounts for 26.0% of its energy. Dietary carbohydrate provides a source of energy and the substrates for many synthetic pathways (White *et al*, 1973). Carbohydrate energy for tucum mesocarp is similar to that for cow milk (29.3%) and soybean milk (24.6%). Together protein and carbohydrate account for a third of tucum pulp nutrient energy.

Oil

Oil constitutes 66.1% of tucum pulp energy giving it a high calorific density. Dietary fat has five important functions:

- as a source of energy,
- for cell structure and membrane function,
- as a source of essential fatty acids for cell structure and prostaglandin synthesis,
- as a vehicle for oil-soluble vitamins, and
- for control of blood lipids.

In addition, fat contributes to the palatability of food and is important in cooking and food processing. Tucum pulp oil is made up mainly of triacylglycerols (Oboh & Oderinde, 1988a, Lubrano, 1994). Its fatty acid composition is given in Table 5.

Table 4. Amino acid composition (g/100g of protein) of tucum pulp protein[a].

Amino acid	Pulp protein	% FAO (1981) reference protein
Essential		
Isoleucine	3.33	111.0
Leucine	7.36	113.2
Lysine	5.02	91.3
Methionine	0.54	24.5
Phenylalanine	5.40	192.8
Threonine	5.54	138.5
Valine	5.83	116.6
Tryptophan	n.d[b]	
Non-essential		
Alanine	6.0	
Arginine	6.12	
Aspartic acid	11.12	
Cystine	4.24	
Glutamic acid	14.29	
Glycine	7.65	
Histidine	2.28	
Proline	3.68	
Serine	6.37	
Tyrosine	4.61	

[a]Bora *et al* (2001).
[b]Not determined.

Table 5: Fatty acid (g/100g), unsaponifiable matter and β-carotene content of tucum pulp oil.

Fatty acid[a]	Oboh & Oderinde (1988a)	Lubrano *et al* (1994)
16:0	30.4	26.0
18:0	2.2	1.5
18:1	59.9	62.0
18:2	2.9	5.0
20:0	4.6	4.5
Proportion of 16:0 in 2-position of triglycerides	19.4	
Unsaponifiable matter	-	1.0
Beta – carotene (mg/kg)	135.5	

[a]16:0 = palmitic, 18:0 = stearic, 18:1= oleic, 18:2 = linoleic, 20:0 = arachidic.

The dominant fatty acids of tucum pulp oil are oleic (about 60%) and palmitic (about 30%). Also present are minor proportions of stearic, linoleic and arachidic acids, which together constitute about 10%. Dietary lipids containing high proportions (50-80%) of monounsaturated fatty acids (MUFA) such as oleic acid maintain low plasma cholesterol and LDL-cholesterol concentration even when present in the diet as a relatively high proportion of energy (Lee & Foglia, 2000; Gurr, 1991). Eaten fresh or consumed as milk-like beverage, dietary tucum pulp due to its high proportion of oleic acid could serve to control blood lipids by maintaining relatively low plasma cholesterol and LDL-cholesterol concentrations.

Tucum pulp triglycerides have 21.2% of their palmitic acid in their 2-position (Oboh & Oderinde, 1988a). This is higher than the proportion of this fatty acid (9.3%) in the 2- position of palm (*Elaeis guineensis*) oil triglycerides Oboh, 2004). The presence of palmitic acid in the 2-position increases fat absorption (Tomarelli *et al* 1968, Filler *et al,* 1969). The increased absorption arising from the proportion of palmitic acid at this position could increase the availability of tucum fatty acids compared to other oils with less palmitic acid in their triacylglycerol 2- position, for example, palm oil.

Lubrano *et al* (1994) have reported the composition of the unsaponifiable matter in tucum pulp oil. They reported an unsaponifiable matter content of 1% consisting mainly of α-tocopherol (Vitamin E) and the phytosterols β-sitosterol and campesterol. Tucum pulp also contains a considerable amount of β-carotene (pro-vitamin A) (Table 5). Chaves and Pechnik (1947) have reported a vitamin A content of 52,000 i.u. per 100g of pulp. Others (Rodriguez-Amaya, 1996 and Johns and Maundu, 2006) have reported β-carotene and β-cryptoxanthin values of 107µg/g and 3.6µg/g respectively, and a vitamin A activity in mixed foods of 930 retinol activity equivalents/100g for tucum pulp. These micronutrients protect fats and fatty foods against autoxidation, which could lead to the development of off- flavours and the destruction of labile constituents, for example essential fatty acids and vitamins. They also exert a hypocholesterolemic effect (Nettleton, 2003) and offer some protection against cancer (Ashfaq, 1999) and blindness. Thus tucum pulp is rich in desirable lipids and lipid soluble micronutrients.

Fibre

On a wet weight basis crude (insoluble) fibre constitutes about 5.7% of the tucum fruit pulp (Table 2). Its fibre content is in the same range as that of bambara nuts (6.2%), soybean (4.7%), cowpea (4.8%), and fresh mature coconut (6.6%) (Van Gastel and van den Wijngaart, 1997) Dietary fibre is not digested, as humans are not capable of secreting the enzymes necessary for the breakdown of its complex constituent molecules to the basic monomeric units that can be adsorbed by the intestinal tract. However, increased consumption of dietary fibre is now actively promoted by nutritionists, to prevent or alleviate the so-called diseases of affluence including diabetes, colon cancer, heart disease, obesity, rectal tumours and gallstones (Wills *et al*, 1998, Nettleton, 2003). Other conditions claimed to be due to lack of dietary fibre are constipation, appendicitis, deep vein thrombosis and haemorrhoids (Wills *et al*, 1998).

TUCUM PULP UTILISATION

Harvesting

The tucum palm is a medium tall palm growing up to 50ft tall. The trunk is heavily spined and even the inflorescences are covered by a thorny spathe. Tucum fruits grow in bunches of about 11 feet long on the tree, the weight of a single bunch being about 100 pounds. Soon after the first bunch ripens and falls, bunches are pulled down with a hooked stick (FAO, 1986).

Post Harvest Treatment

Fruits

Fruits are stored for 2 days in sacks to ripen and for the pulp to soften slightly. They must be eaten within 3 – 4 days (i.e. before they dry and rot where bruised). (FAO, 1986; Prance, 1994). Fresh fruits are eaten fresh or used to make vegetable milk (Covalcante, 1977).

Processing Possibilities

Juice Extraction

Pulp juice (also called palm milk) is extracted from the fruit pulp of some Amazonian palms (Cavalante, 1977; Brun, 1968). Balick and Gershoff (1981) have described the preparation and consumption of pulp juice. This involves the softening of the pulp, its separation from seed, and extraction of nutrients followed by straining to recover the milk. In a typical process fruits are boiled in water and macerated to separate fruit pulp from seeds. The mash is allowed to settle and then strained to separate seeds, pulp pieces and fibre from milk.

For village level production on a small scale, larger volumes of milk can be produced by steaming or boiling the fruits in water to sterilise them (i.e. to inactivate enzymes and micro organisms and soften their pulps) followed by separation of the pulp from the nuts by pounding in a mortar or by the use of a motorised fruit digester (UNIFEM, 1993). Palm milk can then be separated from the resulting mass of seed and pulp by using a fruit press (Jones and Kuipers, 2003; Fellows and Hampton, 1992).

Consumption of Pulp Juice.

Palm milks are consumed in their areas of origin in the following ways (Cavalcante, 1977):

- mixed with cassava meal, water and sugar
- mixed with cassava meal and eaten with grilled fish or shrimps
- as an ice cream pop suckle flavouring

Palm fruit milks are drinks of high calorific density. Being consumed with sugar and starch, they are further enriched.

Potential Products Based on Tucum Pulp Juice.

Packed juice.

Juice can be pasteurised with or without additives and packaged in bottles or jars. To preserve its carotene content, dark bottles would be preferred. Due to the high oil content of pulp, it could be necessary to add antioxidant before packaging. Nutrient (vitamin, mineral, etc) supplementation may be undertaken. Detailed analysis of pulp juice to determine its nutrient composition would be important in order to know which materials to add.

Vegetable – dairy products.

Tucum pulp juice is cholesterol-free and rich in monounsaturated fatty acid. Vegetable-diary products based on tucum juice could offer an improved nutritional profile compared with cow's milk based products which are rich in saturated fat. Also the inclusion of non-fat milk solids would improve the protein quality of pulp juice as well as making possible the production of a range of vegetable-diary products such as filled milk, yoghurt, cheese etc.

Vegetable-diary yoghurt can be prepared on a cottage scale. It has been identified as a profitable project for village entrepreneurs (Anon, 1998).

Flour

The tucum fruit has a thick pulp which can be cut into thin slices and dried. Dried slices can be further processed into flour. Three types of flour could be produced.

Full fat flour

This can be produced by drying of the pulp to suitable moisture content, followed by milling into flour. This can be undertaken at village level by slicing the pulp manually, followed by sun drying and size reduction. The latter can be undertaken by pounding in a mortar or by the use of a small motorised mill.

Partially defatted flour

This can be produced from dried slices by removing some of the oil using a suitable method. At village level, this could be done by the use of a small expeller. Expeller press cake can then be milled into flour.

Zero-fat flour

This could be prepared by solvent extraction of suitably milled dried slices. The equipment and materials required for solvent extraction is beyond the means of village level production. The proximate composition of oven dried and defatted tucum meal is given in Table 6. Included for comparison are the protein, fibre and ash contents of low fat, whole and brown coconut flours.

Table 6: Proximate composition of dried and defatted tucum pulp and coconut flours (g/100g)

	Tucum	Coconut	flour
	Meal[a]	low fat[b]	brown[c]
Moisture	-	5.0	-
Protein	17.9	24.0	25.0
Crude fibre	17.4	10.0	7.7
Fat	trace	0.5	0
Ash	5.6	5.0	4.7
Carbohydrate (by difference)	59.1	n.a	n.a
Energy (Calculated, kcal/100g)	308.0	n.a	n.a
Colour	orange	white	brown

[a]Oboh (1985). [b]Hagenmayer (1979). [c]Hegenmeyer (1975). [d]Not available

Dried and defatted tucum meal consists mainly of carbohydrate (59.1%) and has a lower protein (17.9%) and higher fibre (17.5%) contents than coconut flours (24.0% and 25.0% protein for low fat white flour and brown flour respectively and 10.0% and 7.7% crude fibre).

Tucum meal, high fat, low fat or very how or zero fat, could be used in the same manner as pajibaye meal derived from the pulp of the pajibaye (*Bactris gasipaes*) palm fruit, which is similar to cassava meal and corn meal and is often substituted for them. (Clements and Mora Urpi, (1987). Pajebaye meal is also used for baking cakes, bread and pastry products especially when mixed with wheat flour (Calvo, 1981, Tracy, 1985).

Conclusion

The tucum fruit pulp is rich in carbohydrate and fat, with modest amounts of protein and fibre. Tucum pulp has a multi-use potential. Potential products include fortified and packaged juice, vegetable-dairy products and a variety of flours.

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