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A Review

Medico-nutritionally enriched fruit-Tamarind

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ABSTRACT
The name tamarind is derived from the Arabic word 'Tamar-u'l-Hind' because the dark brown pulp of the fruit was thought to resemble dried dates. It was therefore called the Tamere-hindi or 'date of India. Tamarind is a valued mostly for its fruit and pulp, which is used for a wide variety of domestic and industrial purposes. Tamarind is not a desert fruit, although the sweet tamarind is often eaten fresh directly from the pods. This is usually removed from the pod and used to prepare juice, jam, syrup, candy and pickles. The acidic pulp is used as a favourite ingredient in culinary preparations such as curries, chutney , sauces, ice cream and sherbet in countries, where the grows naturally. The leaves are an important source of food and herbal medicine and the edible pulp of ripe fruits is used as a flavouring agent in cooking, soups, jams, chutneys, sauces, pickles etc. The fruit pulp of tamarind forms the "Tamarind of Commerce". This suggests that tamarind seed coat, a by-product of the tamarind gum industry, could be used as a safe and low cost source of antioxidant. Tropical fruit tree are important crops which supplement and improve the quality of diet. Many of the species have multi-purpose uses in that they produce non food products such as fuel, timber, fodder, medicines and industrial products for small holders. Harvesting from these trees enable rural people to provide nutrition for a balanced diet and generate income thus alleviate poverty.

Key words: Enriched fruit, Industrial use, Medicinal uses, Nutritional fruit.

INTRODUCTION

India is the world's largest producer of tamarind products. It is particularly abundant in the India states of Madhya Pradesh, Bihar, Andhra Pradesh, Karnataka, Tamil Nadu and West Bengal. The production in India is mainly concentrated in the drier southern states and the produce is collected by the villagers and sold in the market. In India, the average production of tamarind pods per tree is 175 kg and processed pulp is 70 kg/tree (Kulkarni *et al.,* 1993). Tamarind (*Tamarindus indica L*) can be found throughout much of the tropics; it is grown unattended in backyards, roadsides or waste lands. Tamarind is ideally suited for avenue plantings as a roadsides tree, in and around villages as a multipurpose species for agro-forestry system or as protective firebreaks for forest margins. It is a valuable timber species widely used for making furniture, tool handles, charcoal, oil mills, rice pounders and fuel wood. The leaves are an important source of food and herbal medicine and the edible pulp of ripe fruits is used as a flavouring agent in cooking, soups, jams, chutneys, sauces, pickles etc. The fruit pulp of tamarind forms the "*Tamarind of Commerce*".

NUTRITIONAL PROPERTIES

Tamarind is a nutritious fruit with a variety of uses. Tamarind has many valuable properties and virtually every part of the tree has been utilized by both rural and urban dwellers. The most valuable and commonly used part of the tamarind tree is the fruit. The pulp constitutes 30-50 % of the ripe fruit, the shell and fibre account for 11-30% and seed about 25-40 %. Fruit compositions are variable, depending on locality (Table 1). The compare in the proximate composition and food energy vale of ripe tamarind by different scientist is shown in Table 2.

Tamarind has low water content and a high level of protein, carbohydrates (60-72 %) and minerals. The soluble solids content varies from 54-69.9 ^{0}Brix ((Benero *et al.,* 1974). Ishola *et al*., (1990) reported that of Nigerian tamarind is poor in protein (87.9 g/kg) and oil (25.3 g/kg). The pulp contains oil, which is greenish in colour and liquid at room temperature. The saponification value of the oil is high but the iodine value is low. The physico-chemical properties of the pulp and seed are shown in Table 3.

The major volatiles constituents of tamarind pulp include furan derivatives (44.4 %) and carboxylic acid (38.2%). The components of which are furfural (38.2%), palmitic acid (14.8%), oleic acid (8.1 %) and phenyl acetaldehyde (7.5%) by Wong *et al.,* (1998). According to Lee *et al.,* (1975) the most abundant volatiles constitutes of tamarind is 2-acetal-furan, coupled with traces of furfural and 5-methyl furfural, which form the total aroma of tamarind. The colour of the red type is due to water soluble red rose anthocyanin pigments, while in the common type leuco-cyanidin is present (Bhattacharyya, 1974). According to Lakshinarayan Rao *et al.,* (1954) about 55 % of the total nitrogen in the tamarind pulp was non protein or soluble in 10% trichloroacetic acid, and 70% of this contributed by free amino acid. The several free amino acids were identified in the tamarind pulp: proline, serine, â-alanine, phenylanine and leucine. These amino acids were present higher quantities in the ripe fruit than in immature fruits, indicating the accumulation of free amino acids during the maturation and ripening of tamarind. In general, the dried tamarind pulp of commerce contains 8-18 % tartaric acid (as potassium bitartarate) and 25-45 % reducing sugars of which 70 % in glucose and 30 % fructose (Table 4).

Table 1: Average composition of tamarind fruit (Gunasena and Hughes, 2000)

Constituents	Amount (per 100 g)
Water	17.8-35.8 g
Protein	2.0-3.0 g
Fat	0.6 g
Carbohydrates	41.1-61.4 g
Fibre	2.9 g
Ash	2.6-3.9 g
Calcium	34.0-94.0 mg
Phosphorus	34.0-78.0 mg
Iron	0.2 – 0.9 mg
Thiamine	0.33 mg
Riboflavin	0.1 mg
Niacin	1.0 mg
Vitamin C	44.0 mg

Lewis and Neelakantan (1964a) reported that one of half of the tartaric acid was present as potassium bitartartrate. The tender fruit contain most of the tartaric acid in free form (upto 16 %), which can be easily extracted with hot water. Lewis *et al.,* (1961) also reported that tartaric acid is present at all stages of fruit development as an optically active (+) isomer. The most commonly found isomer in fruit is malic acid; about 1.37 mg/l existed as the (-) form in tamarind fruits.

Tamarind pulp is also rich in minerals, high in potassium (62-570

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Table 2: Proximate composition and food energy value of ripe tamarind (Gunasena and Hughes, 2000)

Constituents	Pulp (%)				
	A	B	C	D	E
Water	20.60	15.0-47.0	22.60	33.89	62.5-69.2
Protein	3.10	1.40-3.40	3.10	3.28	1.40-3.30
Lipid	-	-	0.40	0.50	0.71-0.81
Fat	0.40	0.90-1.00	0.40	0.50	-
Carbohydrates (30-40 %					
Reducing sugar and)	70.80	62.50	71.80	59.76	-
Total sugars	-	-	-	-	21.4-30.85
Fibre	3.00	5.10	3.00	1.79	-
Cellulose	-	-	-	-	1.80-3.20
Pentose	-	-	-	-	4.20-4.80
Total acidity	-	-	-	-	17.10-18.40
Free tartaric acid	-	-	-	-	8.40-12.40
Ash	2.10	1.50-4.20	2.10	2.57	1.16-1.72
Calcium	-	0.07	-	-	-
Phosphorus	-	0.11	-	-	-
Energy (kcal/100g)	-	-	272.0	230.0	-
Sources	*(A) Purseglove (1987), (B) FAO (1988), (C) Leung and Flores (1961), (D) Wenkam and Miller (1965), and (E) Hasan and Ijaz (1972)*				

Table 3: Some physico-chemical properties of the lipid extracted from the pulp and seed of tamarind (Ishola *et al.,* 1990)

Components	Pulp	Seed
Saponification value, mg KOH/g	301.3	266.6
Iodine vale	120.6	78.1
Unsaponified matter, g/kg	139.0	31.3
Acid value, g/kg	896.0	292.6
Free fatty acid, g/kg	448.0	46.3
Peroxidase value, m Eq/kg	123.3	98.9

mg/100g); phosphorus (86-190 mg/100g). It also excels in riboflavin and is a good source of thiamin and niacin, but poor in vitamin A & C (Leung and Flores, 1961). The ascorbic acid content in tamarind in very small and varies from 2-20 mg/100g (Ishola et al., 1990). The other organic acids reported in tamarind fruit are oxalic acid, succinic acid, citric acid and quinic acid (Lewis and Neelakantan, 1964a). The tamarind pulp does not contain any detectable amounts of phytic acid but trypsin activity is higher than in the seed (Ishola *et al.,* 1990).

INDUSTRIAL SIGNIFICANCE OF TAMARIND

Tamarind is a versatile fruit, which can be used for many purposes. The unique sweet/sour flavour of the pulp is popular in cooking and flavouring. Virtually, every part of the tree (wood, rood, leaves, bark and fruits) has some value in commerce and particularly in the subsistence of rural people. Tamarind is a valued mostly for its fruit and pulp, which is used for a wide variety of domestic and industrial purposes. Tamarind is not a desert fruit, although the sweet tamarind is often eaten fresh directly from the pods. This is usually removed from the pod and used to prepare juice, jam, syrup, candy and pickles. The acidic pulp is used as a favourite ingredient in culinary preparations such as curries, chutney , sauces, ice cream and sherbet in countries, where the grows naturally. Tamarind has several uses are discussed below:

1. Value added products:

Tamarind pulp is used as raw material for manufacture of several industrial products i.e. tamarind juice concentrate (TJC), tamarind pulp powder (TPP), tartaric acid, pectin, tartrates and alcohols.

(a) Tamarind kernel powder (TKP):

It is prepared by decorticating the seed and pulverizing the creamy white kernels. The decorticated seed is ground to the required mesh size by machines to obtain a yield of 55-60 %. The powder tends to deteriorate during storage under humid conditions; hence storage in a dry place in moisture proof container is important. Mixing with 0.5 % of sodium bisulphate before packing will prevent enzymatic deterioration. The tamarind kernel powder will become rancid and brown on storage and the storage ability and colour will be better if it is defatted. The tamarind kernel powder, when boiled in water containing boric acid and phenol as preservatives gives a very good paper adhesive.

(b) Pectin:

Poly saccharides obtained from tamarind seed kernels form mucilaginous dispersion with water and posses the characteristics property of forming gels with sugar concentrates, like fruit pectin. Tamarind polysaccharides does not contain galacturonic acid and methyluronate and is therefore not regarded as true pectin, it is termed as 'Jellose' (Rao, 1948). Jellose is prepared by adding TKP to 30-40 times its weight of boiling water, containing citric acid or tartaric acid at a concentration of 0.2 %. It is stirred with boiling upto 30-40 min. The resultant solution is kept overnight for setting and supernatant liquid is siphoned off and concentrated under vacuum, passed though a filter press and then dried in drum drier. The resultant product is pulverized in a ball mill. A good sample of jellose should have a relative viscosity of 5.0% at 35^{0}C in 0.5 % solution, which is some what higher than corn starch. Jellose is much cheaper than corn starch

Table 4: Proximate composition of dried pulp of tamarind fruit

S. No.	Constituents	Percentage, %
1.	Moisture	15.00-30.00
2.	Protein	2.00-8.79
3.	Fat/oil/lipid, crude	0.50-2.53
4.	Carbohydrate, total	56.70-70.70
5.	Fibre, crude	2.20-18.30
6.	Tartaric acid	8.00-18.00
7.	Reducing sugars	25.00-45.00
8.	Total ash	2.10-2.90
9.	Pectin	2.40-4.00
10.	Cellulosic residue	19.40
11.	Albuminoids	3.00-4.00
12.	Total available carbohydrates	41.77
13.	Alcoholic insoluble sugars	22.70
14.	Water soluble sugar	20.50
15.	Non- reducing sugars	16.52
16.	Total sugars	41.20
17.	Starch	5.70
18.	Tannin (mg)	600.00
19.	Ascorbic acid (mg)	3.00-9.00
20.	β-carotene equivalent (µg)	10.00-60.00
21.	Thiamine	0.18-0.22
22.	Riboflavin	0.07-0.09
23.	Niacin	0.60

and is required in smaller quantities.

(c) Tamarind juice concentrate (TJC):

It is prepared by extracting cleaned pulp with boiling water using the counter current principle, where dilute extracts are used for extracting fresh batches of the pulp. An extract is obtained containing 20 % soluble solids. The extract is separated from the pulp by sieving and id concentrated under vacuum in a forced circulation evaporator. When the soluble solids reach 68%, the pulp is placed in cans or bottles. It sets like jam on cooling. The yield of the concentrate is about 75 % of the pulp used. The chemical compositions of TJC are moisture (30%), tartaric acid (13%), invert sugar (50%), protein (2.0%) and crude fibre (2.0%).

(d) Tamarind pulp powder:

This is prepared by concentrating, drying and milling the pulp into a powder form. Manjunath *et al.,* (1991) reported that an average the total solid content of tamarind pulp powder varied from 18.6-25.0 %, acidity (8.7-11.1%) with an average value of 9.9% (as tartaric acid). Invert sugar (15.8-25.0 %), protein (1.7-2.4 %), starch (20.0-41.3 %), ash (2.1-3.2%) among the minerals, calcium (74-143mg) and potassium (23.8-27.7mg) are present in to TPP. The fruit pulp is made into a refreshing drink after dissolving inn water and squeezing by hand. The recommended concentration of tamarind pulp in syrup is between 20-24 %, so as to produce a beverage with distinctive flavour and acidity. Such syrup contains 56.7% total solids, 43.8% reducing sugars and total acidity of 1.11 % as tartaric acid. The extraction and processing techniques of the pulp for the preparation of canned tamarind syrup, clarified tamarind juice and other soft drinks have reported by Bueso (1980).

(e) Tamarind Pickle:

Pulp is used commercially to prepare tamarind pickle. Pickles are hot, spicy and of salty-sour taste and can be preserved for several month. Preservation is due to the preserve of salt, increased acidity and spices. When making pickles, fresh mature tamarind fruits are selected and soaked in cleaned water for 12 hrs and the pulp is separated. For each kg of tamarind, one kg of sugar is added and boiled, stirring the mixture continuously. The mixtures of spices are added. Spice mixture for one kg of tamarind should include the following: coriander (40g), cumin seed (50g), black cumin (30g), cloves (3-4), cardamom (3-4 pieces), cinnamon (3-4 pieces), chillies (10-12), salt (30g), mustard oil (250ml) and black pepper (30g). These are ground into a paste and added to the boiling tamarind and mixed thoroughly. The prepared product packed into pre-sterilized glass jar or plastic bag and stored at cool and dry place.

(f) Jam:

For manufacturing tamarind jam, ripe fruit are shelled and the pulp is boiled for 10 min. The pulp is then drained and separated from the seeds. For every cup of pulp, two cups of brown sugar are added. The mixture is then cooked and constantly stirred while boiling unit it becomes thick in consistency. The resulting jam is cooled, packed in dry and sterilized jar and then sealed.

(g) Syrup:

Tamarind syrup is made by boiling immature fruit pulp until it is soft and then strained through cheese cloth. To every cup of juice, a half teaspoon of baking soda is added. The mixture is boiled down to one half the origin quantities, removing the rising scum in the process. The juice is again strained and for every cup obtained, a quarter cup of sugar is added. The mixture is boiled again for 20 min. The cooled syrup is poured into sterilized bottles and then sealed.

(h) Candy:

Sweetened tamarind fruit is made by peeling whole ripe fruit and pouring boiling (62^0C) sugar syrup over the fruits and placing in a deep enamel basin. Boiling syrup is prepared by mixing three parts of sugars with one part of water. After soaking for three days, the fruits are drained of the old syrup and again covered with freshly prepared syrup. The process is repeated until the fruits are sweet enough. The sweetened fruit are arranged on bamboo racks, dried in sun and covered with a wire screen to keep off flies. Final drying is done in an oven at low temperature. After cooling, the dry fruits are wrapped in cellophane.

2. Medicinal uses:

The laxative properties of the pulp and diuretic properties of leaf sap have been confirmed by modern medical science. Tamarind pulp was used as gentle laxative under the name '*Pulpa tamarindorum*'. The pulp is said to improve loss of appetite, it is available commercially in tablets form in Thailand for reduction of excess body weight. Tamarind pulp alone or in combination with lime juice, honey, milk, dates, spices or camphor is used as a digestive, even for elephant and as a remedy for biliousness and bile disorders. Tamarind has been used in the treatment of a number of ailments, including the alleviation of sunstroke, Datura poisoning and the intoxicating effects of alcohols and "ganja" (*Cannabis sativa L.*). It is used as a gargle for sore throats, dressing of wounds and is said to aid the restoration of sensation in case of paralysis. Both the fruit pulp and the leaf are regarded as pungative, diaphoretic and emollient. Tamarind is also said to aid in the cure of material fever.

Seed powder of tamarind has been used to treat boils and dysentery. Seed powder has also been externally applied on eye disease and ulcers. Boiled pounded seed are reported to treat ulcers and bladder stones and powder seed husks are used to treat diabetes. The seed can also be used orally, with or without cumin seed and palm sugar for treatment of chronic diarrhea and jaundice.

Tamarind leaves are usually ground into powders and used in lotion or infusion. The leaves, mixed with salt and water are used to treat throat infection, cough, fever intestinal worms, urinary troubles and liver ailments. Internally, leaves and pulp act as a cholagogue, laxatives are used in treating congestion of the liver, habitual constipation and hemorrhoids. Leaf extracts also exhibit antioxidant

activity in the liver. Also taken internally, the leaves are used in cardiac and blood sugar reducing medicines.

3. Other uses:

The fruit pulp may be used as fixative with turmeric (*Curcuma longa*) and annatto (*Bixa orellana*) in dyeing and it is also serving to coagulate rubber latex. The seed testa contains 23% tannin, which when suitable blended is used for tanning leather and imparting colour fast shades to wool. In leather tanning, tamarind tannin gives a harsh and highly coloured leather which is not suitable for shoe uppers, but could be used for heavy soles, suitcases etc.

The fruits are reported to have antifungal and antibacterial properties. When the bitter principle is extracted with benzene and subsequently digested with petrol, it yields 0.67% of a brown, odourless liquid named ' *tamarindienal*', identified as 5-hydroxy 2-oxo-hexa-3,5 dienal. It is a potent fungicidal agent to cultures of *Asperigillus niger* and *Candida albicans* and possesses a strong bactericidal activity towards cultures of *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*. Extracts from tamarind fruit pulp have also shown molluscicidal activity against *Bulinus trancatus* snails. This activity is believed to be due to the presence of saponins in the fruit. Tamarind plant extracts have been used to purify drinking water.

The ethanol extract prepared from the seed coat exhibited anti-oxidative activity as measured by the thiocyanate and thiobarbituric (TBA) method. Ethyl acetate extracts prepared from the seed coat also had strong antioxidant activity. This suggests that tamarind seed coat, a by-product of the tamarind gum industry, could be used as a safe and low cost source of antioxidant. The seed is also used as filler for adhesive in the plywood industry and a stabilizer for bricks, as a binder for sawdust briquettes and a thickener for some explosives. Ground, boiled and mixed with gum, the seed produces strong wood cement.

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