Chapter 12

Nutrient properties of important *Garcinia* fruits of India

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Abstract
The importance of natural products is increasing day by day as the safety of synthetic alternatives has generated lots of controversial questions. *Garcinia* species are an important group of plants, being used for different purposes, especially as fruit crops, source of edible oils and fats, and nutraceuticals in different parts of the world. The nutraceutical property of a fruit is determined by the metabolites like carbohydrates, proteins, vitamins and minerals and also the secondary metabolites such as phenols and flavonoids. The food and nutritive values of *Garcinia* species have attracted significant scientific attention and the present chapter is an attempt to review the nutrient properties of important *Garcinia* fruits in India.

Keywords: *Garcinia* fruits, Nutrient properties, Minerals, Vitamins, Phenolics

Introduction

Plants and fruits are nature's wonderful gift to mankind; indeed, the edible fruits are life enhancing medicines packed with vitamins, minerals, antioxidants and many phyto-nutrients. They are an absolute feast to our sight, not just because of their color and flavor but for their unique nutrition profile that help to keep human body healthy. There are plenty of underutilized fruit crops which possess immense nutraceutical value. The underutilized species are restricted to the geographical place of their availability but not explored properly for their constitution or utility (Gruere *et al.,* 2006). Majority of them produce fruits which are rich sources of carbohydrates, proteins, fats, vitamins and minerals than the conventional fruits (Krishnamurthy and Sarala, 2011). *Garcinia* is one such underutilized group of fruit bearing plants.

Many species of *Garcinia* have fruits with edible arils and are eaten locally. Fresh and dry *Garcinia* fruit rinds (exocarp) are used as spice, condiment and garnish in several cuisines to impart an acidic flavour to the food and to enhance shelf life (Utpala *et al.,* 2010). *Garcinia* species such as *G. cowa*, *G. kydia*, *G. cowa, G. lanceaefolia, G. mangostana, G. atroviridis* and *G. prainiana* were cultivated for their fruits world over. The best known species is the mangosteen (*G. mangostana*), also known as the 'queen of tropical fruits', which is now cultivated throughout Southeast Asia and other tropical countries. In Travancore, Malabar and Konkan region of south India, the fruits of *G. cambogia* and *G. indica* are used in garnishing curries and also as a substitute for tamarind. Fruit and syrup of *G. indica* is very popular in 'Konkan' region as a refreshing and rejuvenating drink. *Garcinia pedunculata*, *G. kydia*, *G. cowa* and *G. lanceaefolia* are the most important species in North Eastern parts of India, where the sundried slices of the fruits were used for culinary purposes and as folk medicine.

The seeds of *Garcinia* species yield oil that can be used as edible oil as well as illuminating fuels. *Garcinia* butter is obtained from the seeds and used mainly as an edible fat. The seed of *G. indica* fruits yield valuable edible fat known as 'kokum butter' and is popular in south India. Refined and deodorized fat from *Garcinia* seeds are generally white or creamy in colour and compares favorably with high class hydrogenated fat. *Garcinia* fats are rich in stearic acid and are considered nutritive, demulcent, astringent and emollient. The use and preparation of *Garcinia* butter is still under exploited. *Garcinia* species have been considered recently to have ample medicinal importance as well (Korikanthimath and Desai, 2005; Utpala and Nandakishore, 2014).

Garcinia species are abundant in the Western Ghats and in the North Eastern Himalayas. *G. indica* and *G. gummi-gutta* are the most common fruit species of the Western Ghats while *G. pedunculata, G. lanceaefolia* and *G. kydia* are the common fruit species of North Eastern foot hills of Himalayas. *G. xanthochymus* and *G. mangostana* are available in both the ecosystems. The nutraceutical property of a fruit is determined by the metabolites like carbohydrates, proteins, vitamins and minerals present in it and their relative amount. The secondary metabolites such as phenols and flavonoids also contribute significantly to the medicinal utility. The present chapter elaborates the nutritional constituents of important *Garcinia* species in India.

1. Primary metabolites of *Garcinia* fruits

Primary metabolites are directly involved in the growth and development of the plant and also serve as source of energy. The concentration of primary metabolites such as sugars, proteins and crude fats of the *Garcinia* fruits are given in **Table 1**. Carbohydrates were the major metabolites present in *Garcinia* fruits followed by proteins. Carbohydrates are the major nutrients in fruits. They are the primary energy source of the cell and the simplest biomolecules that are synthesized naturally. Reducing sugars are the simplest carbohydrate molecules having free aldehyde or ketone group and can reduce metal ions to lower oxidation state. Reducing sugars like glucose and fructose are the sweetness principles of a fruit. Carbohydrate content showed a great variation among various *Garcinia* species; from 3.75 % to 15.12 %. Total proteins ranged from 1.82 % to 4.93 %. The percentage of reducing sugars is less in comparison to the other organic acids present. This may be the reason of very sour taste of the fruits even when they are ripened. The palatability of *G. mongostana* was due to the high content of reducing sugars (1.28 %). *G. indica* showed a higher amount of total proteins (4.78 %), while total carbohydrates and crude fats were higher in *G. mangostana*. This indicates that *G. mangostana* provides more calories than other *Garcinia* species. Crude fats were very nominal in all the *Garcinia* fruits, showing only very small variation among them.

2. Mineral composition of *Garcinia* fruits

Minerals do not provide energy, but play a major role in metabolism and functioning of cells and are required in small amounts for human health. The mineral composition of the fruit rinds of *Garcinia* species is given in **Table 2**.

Table 1. Primary metabolite composition of *Garcinia* fruits (Utpala and Nandakishore, 2014)

Garcinia species	Total carbohydrates (g/100g)	Reducing sugars (g/100g)	Total proteins (g/100g)	Crude fats (g/100g)
G. gummi-gutta	7.11	0.51	3.25	0.34
G. indica	6.24	0.63	4.78	0.12
G. mangostana	15.72	1.28	1.82	0.49
G. xanthochymus	4.12	0.98	4.01	0.41
G. subelliptica	4.82	0.71	3.76	0.15
G. kydia	9.07	0.6	4.33	0.42
G. lanceaefolia	5.85	0.65	3.45	0.13
G. pedunculata	7.93	0.95	4.93	0.20

G. mangostana (163.6 mg/100g) was richer in total minerals followed by *G. indica* (109.3 mg/100g). Potassium, calcium and magnesium showed a great variation (CV% being 27.5, 40.6 and 20.87 respectively) among the species while amount of sodium, iron and phosphorus were almost similar.

Table 2. Mineral compositions of *Garcinia* fruits (Utpala and Nandakishore, 2014)

Garcinia species	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Phosphorus (mg/kg)
G. gummi-gutta	2.88	26.6	12.67	14.35	9.00	5.34
G. indica	1.55	44.5	13.21	33.45	12.06	4.51
G. mangostana	2.58	78.3	5.82	60.43	9.02	7.45
G. xanthochymus	2.06	28.4	13.07	30.62	10.82	3.48
G. subelliptica	1.52	43.3	12.33	34.45	9.00	5.43
G. kydia	2.54	38.7	12.54	25.25	10.00	4.32
G. lanceaefolia	1.35	52.3	12.54	30.23	9.00	3.64
G. pedunculata	2.48	27.3	13.21	35.43	10.12	4.32

Magnesium and potassium were found to be the predominant minerals in *Garcinia* fruits. *G. mangostana* is richer in potassium (78.3 mg), magnesium (60.43 mg) and phosphorus (7.45 mg/kg) (Utpala and Nandakishore, 2014). Potassium, calcium and magnesium are present in good percentage in fruit rind tissues, and make *Garcinia* an important medicinal fruit. Calcium is the major component of bones and teeth and is essential for muscular function and blood clotting (Decupyre, 2014). Other than potassium, *Garcinia* has a mineral content similar to major fruits like apple, grapes, peaches or banana (Decupyre, 2014). Magnesium, phosphorus and iron contents were also higher in *Garcinia* than the commonly consumed fruits.

3. Vitamin composition of *Garcinia* fruits

Vitamins are organic compounds that play a major role in regulation of enzymes, cell signals and metabolic pathways. The vitamins present in the detectable range were vitamins B1, B2, B3, B12 and C. Vitamin A, E and D could not be detected in *Garcinia* fruit extracts. The composition of vitamins in the fruits of *Garcinia* species are given in **Table 3**. Ascorbic acid was found to be the major vitamin in *Garcinia* fruits. The total vitamin content was highest in

G. mangostana (61 mg/100 g), followed by *G. pedunculata* (36 mg/100 g). Except ascorbic acid, other vitamins showed only small variation (<10%) among the species studied. Ascorbic acid was in a range of 14.0% to 60.0%. Ascorbic acid, known as vitamin C, is a water soluble vitamin, not synthesized in the body, but must get through foods or supplements. It is an important antioxidant and its deficiency causes delayed healing and scurvy. Ascorbic acid works as a preservative to prevent rancidity, acts as a dough conditioner in baking and prevents enzymatic browning. Riboflavin (vitamin B2) is another water soluble vitamin. As it is also not synthesized in the body or being stored, it is essential to eat foods rich in riboflavin every day. Riboflavin helps body cells use fat, protein and carbohydrates from foods to produce energy.

Table 3. Vitamin composition of *Garcinia* fruits (Utpala and Nandakishore, 2014)

Garcinia species	Thiamine (B1) (µg/100g)	Riboflavin (B2) (µg/100g)	Niacin (B3) (µg/100g)	Ascorbic acid (C) (mg/100g)	Vitamin B12 (µg/100g)	Total vitamin (mg/100g)
G. gummi-gutta	48	275	45	14.35	8.75	14.75
G. indica	52	320	63	33.45	12.06	34.00
G. mangostana	50	300	60	60.43	9.52	61.05
G. xanthochymus	37	250	50	30.62	10.76	30.97
G. subelliptica	50	281	45	34.45	9.03	34.94
G. kydia	47	267	50	25.25	10.15	25.82
G. lanceaefolia	52	283	45	30.23	8.02	30.62
G. pedunculata	49	276	47	35.43	8.12	35.81

4. Organic acids composition of *Garcinia* fruits

Organic acids are of great significance in plants. As intermediates in the metabolic processes of the fruit, acids are directly involved in growth and maturation. Fruit juices have a low pH, because they contain high levels of organic acids (James, 1985, Jena *et al*., 2002). The organic acids detected in the *Garcinia* fruits studied were (-) hydroxycitric acid (HCA), malic acid, citric acid, tartaric acid and acetic acid. The retention factor (R_f) values of standard acids were found to be oxalic acid (0.14), tartaric acid (0.21), malic acid (0.45), citric acid (0.38), hydroxycitric acid (0.24) and acetic acid (0.60) (Utpala and Nandakishore, 2014). The total acid content of *Garcinia* fruits and the percentage compositions of various organic acids present in the *Garcinia* acid extracts are given in **Table 4**. The total acidity of the fruits varied significantly from 4.39 % (*G. mangostana*) to 27.3 % (*G. kydia*). A very high variability in concentration was observed for HCA and malic acid.

G. kydia was the most acidic (27.3 %) followed by *G. gummi-gutta* (23.81 %). The anti-obesity compound HCA was highest in *G. gummi-gutta* (15.48 %), followed by *G. kydia* (8.97 %). *Garcinia* species and *Hibiscus sabdariffa* are the only abundant natural sources of HCA (Yamada *et al*., 2007). HCA was found to be the major organic acid in the Western Ghats species namely *G. gummi-gutta* and *G. indica* whereas in other species, malic acid was the predominant organic acid. During extensive animal studies, HCA has been proven to effectively curb appetite, suppress food intake, increase the rates of hepatic glycogen synthesis, reduce fatty acid synthesis and lipogenesis and decrease body-weight gain. Other organic acids were detected as minor compounds. *G. xanthochymus* had a total acid content of 10.95 % of which citric acid was the major acid component (8.0 %). HCA was absent in *G. xanthochymus*. In case of *G. mangostana*, the percentages of organic acids were very low and HCA could not be detected.

Table 4. Total acidity and major organic acids present in *Garcinia* fruits (Utpala and Nandakishore, 2014)

Garcinia species	Total acidity (%)	HCA (%)	Malic acid (%)	Oxalic acid (%)	Citric acid (%)	Tartaric acid (%)	Acetic acid (%)
G. gummi-gutta	23.81	15.48	4.62	0.18	0.62	0.11	0.07
G. indica	14.11	7.43	2.67	0.63	0.79	0.51	0.31
G. mangostana	4.39	0.26	0.54	0.73	1.42	1.66	0.26
G. xanthochymus	10.95	0.10	0.73	0.37	8.00	0.20	0.04
G. subelliptica	9.76	1.16	4.87	0.92	0.81	1.18	1.32
G. kydia	27.30	8.97	13.42	0.60	1.35	1.80	0.23
G. lanceaefolia	15.17	1.93	10.02	1.70	1.45	0.23	0.14
G. pedunculata	12.92	1.33	8.95	0.51	1.30	0.12	trace

The organic acids play a key role in food products because of their influence on organoleptic properties. Besides, they also provide the sour flavour to the product and also act as antimicrobial agent for enhancing shelf life (Lillian *et al*., 2013). The total content of organic acids in a food affects the product's acidity, whereas the levels of a specific organic acid can directly influence the flavor and taste of the drink. Malic acid and citric acids are α-hydroxy acids reported to have functions like enhancing salivation, gastric secretion and exfoliation and are therefore important constituents of food and cosmetic formulations (Fiume, 2001). Citric acid also acts as food preservative and acidifying agent. The higher carbohydrate content and low acid content explains the sweeter taste of *G. mangostana* compared to other *Garcinia* fruits.

5. Phenolic compounds and antioxidant activities of *Garcinia* fruits

Phenolic compounds are a class of secondary metabolites attributed with several bioactivities, especially antioxidant properties. Antioxidant activity of a substance is the ability of a molecule to eliminate or to neutralize a free radical. Several phytochemicals such as curcumin, tocopherol, catechin, xanthones and anthocyanins were attributed with antioxidant properties (Harborne, 2005). Phenolic compounds also facilitate pollination through colour and fragrance, defense against pathogens and prevent fruits consumed by herbivores (Harborne, 2005). In *Garcinia*, xanthones, biflavonoids and benzophenones were reported to be the major phenolic compounds (Aisha *et al.,* 2012).

The total phenolic contents (**Table 5**) were recorded to be highest in *G. indica* (5.01%), followed by *G. xanthochymus* (4.43%) and *G. kydia* (4.32%). The xanthone content was highest in *G. xanthochymus* (2.66 %) and was least in *G. indica* (0.9 %). The relative percentage of xanthones to the total phenolics was highest in *G. gummi-gutta*, *G. xanthochymus* and *G. subelliptica* (60.0%) and lowest in *G. indica* (20.0%).

Table 5. Total phenol, xanthone content and antioxidant activity of *Garcinia* fruits (Utpala and Nandakishore, 2014)

Garcinia species	Total phenolics (g/100g)	Total xanthones (g/100g)	DPPH activity IC_{50} (µg/ml)
G. gummi-gutta	3.26	1.96	38.39
G. indica	5.01	0.91	42.66
G. mangostana	2.33	1.30	39.42
G. xanthochymus	4.43	2.66	35.75
G. subelliptica	3.14	1.88	48.12
G. kydia	4.32	2.19	40.50
G. lanceaefolia	3.03	1.22	43.16
G. pedunculata	2.43	1.36	47.84
Ascorbic acid	-	-	10.25

As most of the *Garcinia* fruits are sour, they are consumed only as processed food or through formulations. The most commonly used forms are syrups, juices and dried rinds boiled along with other food ingredients. Hence the antioxidant activity of aqueous extract of fruits were also determined (**Table 5**). Piyawan *et al*. (2005) reported that antioxidant activity of *G. mangostana* is of moderate, close to that of orange, grapes, and papaya, while other tropical fruits such as mango, litchi and guava have higher antioxidant activities (IC_{50} ranging from 1.10 to 9.60), compared to *Garcinia* fruits.

6. Biochemistry of *Garcinia* seed butter

Lipids or fats are hydrocarbon molecules, but are hydrophobic. In plants, fats are the storage form of energy and found much abundant in seeds. Fats are the second largest energy source for living cells (Jain *et al*., 2005). *Garcinia* seed kernel contains (30-40%) fixed oil, in comparison to other vegetable seed fats like castor seed (50%), ground nut kernel (42%), mustard (35%), palm kernel (36%), sunflower (32%), sesame (50%) and coconut (60%). High yield of fixed oil indicates that *Garcinia* seeds can be utilized as a rich source of fatty acids. The physical properties of the seed fats of four *Garcinia* species showed that the yield of fatty oil is high in *G. gummi-gutta* (47%) while in *G. indica* and in *G. xanthochymus* it was around 30% and in case of *G. mangostana* it was less, around 24% (**Table 6**).

Table 6. Physical properties of *Garcinia* seed butter (Utpala and Nandakishore, 2014)

Parameters	*G. gummi-gutta*	*G. indica*	*G. xanthochymus*	*G. mangostana*
Total fat content (%)	46.54	29.33	25.71	24.20
Colour of fat	Light brown	Pale white	Creamy-yellow	Creamy-yellow
State at room temperature	Solid	Solid	Solid	Solid
Melting point (ºC)	39.4	40.3	38.2	37.9

Garcinia butter is solid at room temperature and is quite hard, almost as hard as cocoa butter, and is a good substitute in the recipes for cocoa butter. The melting point of *Garcinia* seed butter is high (about 40°C), hence it can be used along with cocoa butter to increase the heat resistance property and hardness of the chocolate. It is helpful in preventing heat induced softening and loss of consistency of chocolates, mainly in hot climatic regions (Utpala *et al*., 2012). Acid value and percentage free fatty acids represent the freshness and storage quality of an oil or fat. It is the measure of susceptibility and the extent of decomposition. The acid value of the four species of *Garcinia* varies from 3.7 to 4.5; which shows the butter is good for the consumption. Free fatty acid content is commonly called the free acidity percent and lesser the free fatty acid content, better is the fat. Other than *G. indica* oil, all are having very low acid value (**Table 7**). Saponification number gives the information concerning the character of the fatty acid present in the fat. Fats with the high saponification number yield quite soluble soaps. The saponification value of olive oil is 187-196, for sunflower oil, it is 188-194, for ground nut it is 188-195, for mustard oil it is 169-176 and for sesame oil it is 188-195, while it is very high in coconut oil and ghee (251-263 and 220 respectively). For *Garcinia* fats, the value ranged from 140 to 200. Iodine value is a measure of the unsaturated nature of the fat. The iodine value preferably should be 25-50. In different *Garcinia* seed butters, iodine value varies from 37-51(**Table 7**). Iodine value allows predicting the tendency of fat to become rancid. In coconut oil, the iodine value is very low (7.5- 10.5) and hence shows a high tendency to get rancid easily.

Table 7. Chemical properties of *Garcinia* seed butter (Utpala and Nandakishore, 2014)

Chemical properties	*G. gummi-gutta*	*G. indica*	*G. xanthochymus*	*G. mangostana*
Acid value (mg NaOH/g of oil)	3.7	4.9	4.8	4.5
Saponification number (mg KOH/g of oil)	187.9	200.2	190.3	140.5
Iodine value	50.2	39.4	37.4	51.8
Free acids (%)	1.42	5.64	2.82	2.21

The fatty acid profile presented in the **Table 8** shows that *Garcinia* butter has 7 important fatty acids with various percentages in different species. The major fatty acids present were palmitic acid, stearic acid, elaidic acid, oleic acid, linoleic acid, arachidic acid and eicosenoic acid. Palmitic acid is present in very high yield (47%) in *G. mangostana,* while it is moderate in other species. Palmitic acid is an ionic surfactant, which has a pleasing sensation to the body. It is thus mainly used to produce soaps, cosmetics and releasing agents. Palmitic acid is the commonest saturated fatty acid in the plants and animal lipids. Kokum butter from *G. indica* is popular in skin care products because of its ability to soften skin and heal ulcerations and fissures of the lips, hands and soles of feet. Palmitic acid helps to control obesity and also helps to recover some reproductive abnormalities (Scott *et al*., 1988). It is reported that the diet enriched with palmitic acid is good for diabetes (Utpala *et al*., 2012). Stearic acid is present in very high concentration (30-40%) in *G. gummi-gutta, G. indica* and *G. xanthochymus*; while its percentage is less in *G. mangostana* (2.3%) Stearic acid is commonly used in the manufacture of soaps, detergents, shampoo, shaving creams and other cosmetic products. It is one of the most common saturated fatty acids found in the nature following palmitic acid (Utpala and Nandakishore, 2014). Butter rich in stearic acid is solid at room temperature. It is also used in many food products because it remains stable at high temperatures. It is commonly used in margarine and other spreads. *Garcinia* fats could be taken as good source of stearic acid as well. A few plants which have stearic acid more than 30% in its seed oil are *Butyrospermum paradoxum* (shea), *Shorea robusta* (sal) and *Vateria* *indica* (dhupa). It is reported that the total plasma cholesterol is decreased by an average of 14% during the consumption of high stearic acid diet (Andrea and Scott, 1988). Oleic acid also present in a good percentage in all the four species of *Garcinia* (26-35%). High oleic acid makes the butter less susceptible to spoilage, so could be useful in food preservation. Oleic acid may hinder the progression of adrenoleuko dystrophy, a fatal disease that affects the brain and adrenal glands and also may be responsible for the hypotensive effects of olive oil (Teres *et al*., 2008). Linoleic acid is another important acid which is present in a moderate percentage (5-11%) in different *Garcinia* species. The use may include, helping to lose body fat and possibly preventing colon or breast cancer (Nirvair *et al*., 2007). It is a strong antioxidant with benefits such as lowering high cholesterol and controlling weight. Arachidic acid (1-8%) is a saturated fatty acid and a minor constituent of peanut oil (1.1-1.7%) and corn oil (3%). Arachidic acid is used for the production of detergents, photographic materials and lubricants. The food rich with arachidonic acid is attributed with anti-inflammatory properties (Adama *et al*., 2003).

Table 8. Fatty acid profile of *Garcinia* species (Utpala and Nandakishore, 2014)

Fatty acid	Saturated/ unsaturated	*G. gummi-gutta* (%)	*G. indica* (%)	*G. xanthochymus* (%)	*G. mangostana* (%)
Palmitic acid	saturated	6.31	3.25	3.05	47.20
Stearic acid	saturated	30.61	45.33	44.53	2.31
Elaidic acid	unsaturated	9.54	3.00	1.51	- -
Oleic acid	unsaturated	26.23	34.42	35.33	34.02
Linoleic acid	unsaturated	11.38	5.25	4.82	1.32
Arachidic acid	saturated	5.41	1.20	1.00	8.04
Eicosenoic acid	unsaturated	- -	2.25	1.01	0.51
Other fatty acids		10.52	5.30	8.75	6.61

Conclusions

The awareness towards natural options in every walk of life created a new thrust for the plant based products that involve food additives, nutracueticals, cosmetic ingredients and herbal medicines. Herbal Technology (HT) is emerging as a promising field of modern science for India. The rich floristic wealth of our region offers several underutilized plants that can be used as source of gum, resins, fats, oils, condiments and nutraceutics. *Garcinia* is one among such underutilized tropical forest tree that accounts to the economy of the ethnic community associated. Pharmacological works are in progress in different parts of the world to use the products from *Garcinia* fruits as anti obesity, anti cancer and to solve other digestive problems The vitamins, minerals, micro-nutrients, pigments and phenolic compounds of major *Garcinia* fruits in India were reviewed in the chapter and the fruits are having very high nutraceutical values.

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