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# A Study on Nutrient and Medicinal Compositions of Selected Indian *Garcinia* Species

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**Abstract:** The Genus *Garcinia* is one of the tropical underutilized medicinal fruit crops. It contains around 200 species, out of which 35 species are available in India. In India it is present in two different ecosystems, the Western Ghats and the Himalayan foot hills. *G. indica, G. gummi-gutta, G. xanthochymus*, *G. subelliptica* and *G. mangostana* are the common species of Western Ghats while *G. lanceaefolia*, *G.pedunculata*, and *G. kydia* are common species in North eastern Himalayan foot hills. The medicinal importance of *Garcinia* is due to the presence of HCA (hydroxycitric acid) an anti-obesity compound. Among the primary metabolites, carbohydrates are present in good percentage. The mineral composition showed a great variation in the percentages of potassium, calcium and magnesium (SD being 17.2, 3.5 and 12.15 respectively). The study of vitamin content, organic acids, xanthones and anti-oxidant activity reveals that *Garcinia* is an important medicinal crop with ample nutraceutical properties.

**Keywords:** Antioxidant activity, *Garcinia*, metabolites, minerals, nutraceutical, vitamins, xanthones.

## INTRODUCTION

The quest for wellness and for natural products that contribute to health has led to intensified research in identifying plants that have great nutraceutical value. There are plenty of underutilized species as well as the forest plants which possess immense nutraceutical value. The tropical forest trees generate a variety of natural resources which help to sustain the livelihood of local communities, including food, fodder, shelter, medicine, fibre, resin, oils and other numerous products [1]. Majority of them are richer sources of carbohydrates, proteins, fats, vitamins and minerals than the conventional fruits [2].

These crops are called as underutilized species as they are restricted to the geographical place of their availability but not explored properly for utility and scientific importance [3]. *Garcinia* is one such underutilized genus, which is abundant in Western Ghats and in North-eastern Himalayas. It has been considered recently to have ample medicinal importance [4].

The present work focuses on the assessment of major nutritional and medicinal components present in the fruits of a few species of *Garcinia* available in India. The nutraceutical property of a fruit is determined by the metabolites present in it and their relative amount. A fruit's nutritional value is estimated by the availability of the components like Carbohydrates, proteins, vitamins and minerals. The secondary metabolites such as phenols and flavonoids contribute to its medicinal utility.

Carbohydrates are the major nutrients in fruits. They are the primary energy source of a 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 [5]. Lipids or fats are hydrocarbon molecules like carbohydrates, 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. Proteins are functional molecules of a cell, functions ranges from cell structure components to enzymes. Plant proteins are the source of several essential amino acids which human cells cannot biosynthesize [6].

Minerals and vitamins are very essential molecules required in small amounts. Minerals do not provide energy, but play a major role in metabolism and functioning of cells. Vitamins are organic compounds that play a major role in regulation of enzymes, cell signals and metabolic pathways.

Organic acids are of great significance in plants. As intermediates in the metabolic processes of the fruit, these acids are directly involved in growth and maturation. Fruit juices have a low pH, because they contain high levels of organic acids [7].

Phenolic compounds are a class of secondary metabolites. Phenolic compounds are responsible for facilitating pollination through colour and fragrance, defence against pathogens and prevent consumed by herbivores [8]. In *Garcinia*, xanthones are reported to be a major phenolic compound. Xanthones are yellow coloured compounds; show a wide range of biological activities such as antimicrobial, antiviral, anti-inflammatory, anti-cancer and antioxidant activities [9]. Antioxidant activity of a substance is the ability of a molecule to eliminate or to neutralize a free radical. Antioxidant activities in a plant are mostly due to terpenoides (curcumin, tocopherol) or flavonoids (cathechin, xanthones, and anthocyanins) [8].

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## MATERIALS AND METHODS

A total of 8 species of *Garcinia*, belonging to two Indian ecosystems namely Western Ghats and North-eastern Himalaya were selected for the study. The species selected were, *G. gummi-gutta*, *G. indica*, *G. subelliptica*, *G. xanthochymus* and *G. mangostana* from Western Ghats and *G. kydia*, *G. lanceaefolia* and *G. pedunculata* from North-eastern Himalaya.

### Primary Metabolite Analysis of *Garcinia* Fruits

Total carbohydrates (Phenol-$H_2SO_4$ method), reducing sugars (Nelson-Somogyi method), total protein (Lowry's method) and crude fat (gravimetric method) contents of fruits were determined by standard protocols [10].

### Mineral Analysis of *Garcinia* Fruits

#### *Sample Preparation*

Samples were prepared by the method of Motsara and Roy [11] with slight modification. 5g of dried fruit rinds were finely powdered and taken in a 250 ml conical flask. Di-acid digestion with 25 – 30 ml of di-acid mixture ($HNO_3$ and $HClO_4$ in ratio 9:4) was done and the mouth of the flasks was closed by using glass funnel. After mixing the contents, the digestion of the samples were carried out on a hotplate (90-95 °C) in a fume-hood for about 1-2 hrs till the content becomes clear. The flasks were cooled at room temperature and added 50 ml double distilled water. After a thorough mix, the contents were filtered through Whatman No.1 filter paper into a 100 ml standard flask. The final volume was made up to 100 ml with double distilled water.

#### *Determination of Phosphorus*

Phosphorus content in the digested sample was estimated by spectrophotometric vanadium phosphomolybdate method. Phosphates react with molybdate and vanadate to form a yellow-coloured vanadomolybdophosphoric heteropolycomplex, whose colour intensity is directly proportional to the concentration of phosphate present in the sample, which can be read on the spectrophotometer at 470 nm wavelength [2].

#### *Determination of Sodium and Potassium*

Sodium and Potassium content in the sample was determined by flame emission spectroscopy (FES) using separate standards for sodium and potassium. In the high temperature of the flame, atoms of sodium and potassium gets to excited state, later causing to emit radiation in the visible region of the electromagnetic spectrum. The intensity of the spectrum is proportional to the metal ions present [12].

#### *Determination of Other Minerals*

Major minerals such as calcium and magnesium and the minor minerals namely Zn, Mn, Cu and Fe were determined by Atomic absorption spectroscopy (AAS). In this method, the absorption of light at a specific standard wavelength by the ion during its excitation was determined. Comparing with the absorption spectra of the standards, the amount of mineral in the sample was calculated [12].

### Vitamin Analysis

Fat soluble vitamins were extracted from fruits using methanol-chloroform (1:1) and water soluble vitamins were extracted by using phosphate buffer of pH 7.5. The amount of vitamins present in the extracts was determined in a UV-Vis (Ultraviolet-visible spectra) spectrophotometer using their respective molar extinction coefficient values. The molar extinction coefficients of vitamins are Vitamin B1 (11305 cm-1/M at 246nm), B2 (12200 at 445nm), B3 (4200 at nm), B12 (27500 at 361nm), C (14200 at 266nm), A (53500 at 325nm) and E (21000 at 292nm). Two milliliters of sample was taken in a quartz cuvette. Against the solvent as blank, the absorption of the sample at the wavelength respective to the vitamin was determined.

Amount of vitamin (mg/g of tissue) = $\varepsilon$ x A$\lambda$ x mol.mass x 1000

### Organic Acid Profiling

Organic acids from the dried fruit rind were extracted by refluxing the 5g of powdered sample with distilled water for 2 hours. The Organic acids present in the extract were first detected using paper chromatography method using Whatman No.1 filter paper. Solvent system used for chromatography was standardized as Butanol-Formic acid-Water (4:1.5:5). 1% Bromocresol green in ethanol was used as indicator. Retention factor ($R_f$) of various spots produced by sample were compared with $R_f$ of standard acids to identify the acids present.

The total acid content in the fruit rind extract was estimated by titration method, against 0.075N sodium hydroxide with phenolphthalein as indicator. End point was the appearance of pale-pink coloration.Organic acid profiling of dried fruit rinds for selected species of *Garcinia* was performed by reverse phase-High Performance Liquid Chromatography (rp-HPLC). Organic acid profiling was performed using HPLC system comprising of Shimadzu LC-10AT pump, SPD-10A VP UV-VIS detector, SCL-10A VP controller and C-18 reversed phase column. Flow rate was fixed to 1.0 ml/min and detection was done at 214nm. 50mM phosphate solution of pH 2.1 was used as mobile phase and standard organic acids such as malic acid (7 mg/ml), citric acid (5 mg/ml), hydroxycitric acid (5 mg/ml), oxalic acid (1 mg/ml), tartaric acid (5 mg/ml) and acetic acid (1 mg/ml) were used. Succinic acid (5 mg/ml) was used as internal standard for calculation of response factor (F). Using this factor, amount of individual acid compositions were calculated.

### Estimation of Total Phenols and Xanthones from *Garcinia* Fruits

The total phenol content of the *Garcinia* fruit extracts were determined by Folin - Ciocalteu method [10]. Xanthones were estimated by UV absorption method at 243nm wavelength in a UV-Vis spectrophotometer [9].

### Antioxidant Activity of Aqueous Extracts of *Garcinia* Fruits

Antioxidant activities of various concentration of *Garcinia* aqueous extract was determined by DPPH (1,1-

**Table 1. Primary metabolite composition of *Garcinia* fruits.**

| Sample | Total Carbohydrates (g/100g) | Reducing sugars (g/100g) | Total proteins (g/100g) | Crude fats (g/100g) |
|---|---|---|---|---|
| *G. gummi-gutta* | 6.46 | 0.51 | 3.25 | 0.34 |
| *G. indica* | 5.67 | 0.63 | 4.78 | 0.12 |
| *G. mangostana* | 15.12 | 1.28 | 1.82 | 0.49 |
| *G. xanthochymus* | 3.75 | 0.98 | 4.01 | 0.41 |
| *G. subelliptica* | 4.38 | 0.71 | 3.76 | 0.15 |
| *G. kydia* | 8.25 | 0.60 | 4.33 | 0.42 |
| *G. lanceaefolia* | 5.32 | 0.65 | 3.45 | 0.13 |
| *G. pedunculata* | 7.21 | 0.75 | 4.93 | 0.20 |
| SD | 3.58 | 0.25 | 0.99 | 0.14 |

**Table 2. Mineral compositions of *Garcinia* fruits.**

| Sample | 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 |
| SD | 0.58 | 17.24 | 3.49 | 12.15 | 1.12 | 1.27 |

diphenyl-2-picrylhydrazyl) radical scavenging assay method from which $IC_{50}$ (50% Inhibitory Concentration) was calculated [13]. DPPH is a nitrogen centred free radical; the colour of which changes from violet to yellow on reduction by $H^+$ or electron donation. Ascorbic acid as positive control and $IC_{50}$ (µg/ml) of the *Garcinia* aqueous extracts were determined.

## RESULTS AND DISCUSSION

Primary metabolites, products and intermediates of metabolism, are directly involved in the growth and development of the plant. Primary metabolites serve as the source of energy. The concentration of primary metabolites, namely, total sugars, reducing sugars, total proteins, total phenols and the crude fats, of the fruits are given in Table **1**. Carbohydrates were the major metabolites present followed by proteins. Carbohydrate content showed a great variation among the species; from 3.75% to 15.12% (Standard deviation SD = 3.58;). Total proteins ranged from 1.82% to 4.93% (SD = 0.99). Reducing sugars are the sweetening compounds in a fruit. 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. Similar findings were reported by Miguez, *et al*. (2004) in a study with chestnut fruits [14]. The Palatability of *G.mongostana* was due to the high 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* species, showing only very small variation among them (SD = 0.14;).

The mineral composition of the fruit rinds of *Garcinia* species is given in Table **2**. *G. mangostana* (163.6 mg/100g) was richer in total minerals followed by *G. indica* (109.28

mg/100g). Potassium, calcium and magnesium showed a great variation (SD being 17.2, 3.5 and 12.15 respectively) among the species while amount of sodium, iron and phosphorus are almost similar.

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).

The study reveals that Potassium, Calcium and Magnesium are present in good percentage in per gram of fruit rind tissue, and makes *Garcinia* an important medicinal fruit. Calcium is the major component of bones and teeth and is essential for muscular function and blood clotting [15]. Other than potassium, *Garcinia* has a mineral content similar to major fruits like apple, grapes, peaches or banana [15]. Magnesium, phosphorus and iron contents were higher in *Garcinia* than the commonly consumed fruits.

The *Garcinia* fruit extracts do not contain vitamin A, E and D. The vitamins present in the detectable range were vitamins B1, B2, B3, B12 and C. The composition of vitamins in the fruits of *Garcinia* species are as given in Table **3**. Ascorbic acid was found to be the major vitamin content.

The total vitamin content was highest in *G. mangostana* (61 mg/100g), followed by *G. pedunculata* (36 mg/100g). Except ascorbic acid, other vitamins showed only a small variation (<10%) among the species studied. Ascorbic acid was in a range of 14%-60%. Ascorbic acid, known as vitamin C, is a water soluble vitamin not synthesised in the body, but must get through foods or supplements. It is an important antioxidant and its deficiency causes delayed healing and scurvy [17]. Ascorbic acid works as a preservative to prevent rancidity, acts as a dough conditioner in baking and prevents enzymatic browning. Riboflavin is another water soluble vitamin (vitamin B2). As it is also not synthesised 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 [16].

Paper chromatography indicates the presence of six organic acids, which were identified by comparing the retention factor of the (RF value) spots produced by the sample with that of standards. The acids 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).

The total acid content of *Garcinia* fruits and the percentage compositions of various organic acids present in the *Garcinia* acid extract are given in Table **4**. *Garcinia* and *Hibiscus sabdariffa* are the only abundant natural sources of HCA [18]. 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 is highest in *G. gummi-gutta* (15.48%), followed by *G. kydia* (8.97%). HCA was found to be the major organic acid in Western Ghats species namely *G. gummi-gutta* and *G. indica* whereas in other species, malic acid was the predominant organic acid. Other organic acids are present as minor compounds. *G. xanthochymus* had a total acid content of 10.95 g% of which citric acid was the major acid component (8%). HCA was absent in *G. xanthochymus* In case of *G. mangostana*, the percentages of organic acids were very low and HCA was absent.

The organic acids play a key role in food products because of their influence on the organoleptic properties. Besides, they also provide the sour flavour to the product and also act as antimicrobial agent for enhancing shelf life [19]. 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 [20]. HCA is reported to be a natural potent anti-obesity compound reduces lipid and sugar levels in blood and enhancing their utilization by the cells [21]. Malic acid and citric acids are α-hydroxy acids and reported to have functions like enhancing salivation, gastric secretion and exfoliation. Hence they have a high use in food and cosmetic

**Table 3. Vitamin composition of *Garcinia* fruits.**

| Sample | 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 |

**Table 4. Total acidity and major organic acids present in *Garcinia* fruits.**

| Sample | 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* | 15.92 | 1.33 | 8.95 | 0.51 | 1.30 | 0.12 | trace |

**Table 5. Total phenol, total xanthone content and antioxidant activity of *Garcinia* fruits.**

| Sample | Total phenols (g/100g) | Total xanthone (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 |

formulations [22]. Citric acid is also acts as food preservative and acidifying agent [23]. The higher carbohydrate content and low acid content explains the sweeter taste of *G. mangostana*.

The total phenol content (Table **5**) was found to be highest in *G. indica* (5.01%), followed by *G. xanthochymus* and *G. kydia*. The xanthone content was highest in *G. xanthochymus* (2.66%) and was least in *G. indica* (0.9%). Xanthones are a class of phenolic compounds; hence the relative percentage of xanthones to the total phenols was highest in *G. gummi-gutta*, *G.xanthochymus* and *G. subelliptica* (60%) and lowest in *G. indica* (20%).

As *Garcinia* fruit except *G. mangostana* 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 was determined (Table **5**).

$IC_{50}$ is the amount of substance required to eliminate 50% of free radicals from the reaction mixture. The $IC_{50}$ value is the concentration of each fruit extract required to scavenge the DPPH radical to 50% of the control [24]

Piyawan *et al*. [24] reported that antioxidant activity of *G. mangostana* is of moderate, and is closer to that of orange, pummelo, grapes, and papaya. The other tropical fruits, such as mango, litchi, guava and skins of grapes have antioxidant activities higher level of with $IC_{50}$ ranging from 1.10 to 9.60 [24].

In this study, the antioxidant activities of *Garcinia* fruit aqueous extracts were of a close range. Among them, *G. xanthochymus* showed a higher activity whereas, *G. subelliptica* and *G. pedunculata* showed lesser activities. Even though, the total phenols were higher in *G. indica*, the antioxidant activity was lower. The higher antioxidant activity of *G. xanthochymus* and *G. gummi-gutta* thus could be due to the xanthones present.

## CONCLUSION

There is an increasing awareness for the use of plant products as nutraceuticals. There are many plants, most of

them underutilized, which have great nutritional and medicinal value. *Garcinia* is a genus that contains plants rich in anti obese compounds. The nutritional value of certain *Garcinia* species endemic to India (in the Western Ghats and Eastern Himalayas) was studied. From the foregoing discussion it is very clear that the content of primary metabolites, products and intermediates of metabolism, namely, total sugars, reducing sugars, total proteins, total phenols and the crude fats, of the *Garcinia* species indicted that carbohydrates are the major metabolites present followed by proteins. The Palatability of *G.mongostana* is due to the high reducing sugars (1.28 g%). The mineral composition of the fruit rinds of *Garcinia* species indicate that *G. mangostana* (163.6 mg/100g) is rich in total minerals followed by *G. indica* (109.28 mg/100g). The study reveals that Potassium, Calcium and Magnesium are present in good amounts in the fruit rind tissue, and makes *Garcinia* an important medicinal fruit. The vitamins present in the detectable range were vitamins B1, B2, B3, B12 and C.

Acids present in Garcinia are oxalic acid, tartaric acid, malic acid, citric acid, hydroxycitric acid and acetic acid. *Garcinia* is a good natural source of HCA. The anti-obesity compound, HCA, was highest in G. *gummi-gutta* (15.48%), followed by *G. kydia* (8.97 g%). HCA was found to be the major organic acid in Western Ghats species, namely, *G. gummi-gutta* and *G. indica* whereas in other species, malic acid was the predominant organic acid while other organic acids were present as minor compounds. *G. xanthochymus* had a total acid content of 10.95 g% of which citric acid was the major acid component (8%). HCA was absent *G. xanthochymus*. In case of *G. mangostana*, the percentages of organic acids was very low and HCA was also absent. The organic acids play a key role in food products because of their influence on the organoleptic properties. Besides, they also provide the sour flavour to the product and also act as antimicrobial agent for enhancing shelf life. The total phenol content was found to be highest in *G. indica* and was least in *G. mangostana*. Xanthones are a class of phenolic compounds; hence the relative percentage of xanthones to the total phenols was highest in *G. gummi-gutta*, *G. xanthochymus* and *G. subelliptica* and lowest in *G. indica*.

As *Garcinia* fruits, except *G. mangostana*, 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. The antioxidant activity of aqueous extract of fruits was determined as $IC_{50}$ value. In this study, the antioxidant activities of Garcinia fruit aqueous extracts were of a close range. Among them, *G. xanthochymus* showed a higher activity whereas, *G. subelliptica* and *G. pedunculata* showed lesser activities. Even though, the total phenols were higher in *G. indica*, the antioxidant activity was lower than many. The higher antioxidant activity of *G. xanthochymus* and *G. gummi-gutta* thus could be due to the xanthones present.

The study amply proves the nutraceutical property of *Garcinia* species particularly *G. gummigutta* and *G. xanthochymus*.

## CONFLICT OF INTEREST

The authors confirm that this research article has no conflicts of interest.

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