Journal of Postharvest Technology
2021, **09**(4): 11-22
www.jpht.in

REVIEW ARTICLE

Medicinal and antioxidant activity of *Garcinia pedunculata*: a valuable underutilized fruit of Assam

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Received: 14.07.2021 Accepted: 17.09.2021

ABSTRACT

Garcinia pedunculata commonly known as “Amlavetasa” in India, and “Taikor” in Bangladesh, is an evergreen tree with a fluted trunk and short spreading branches. The fruit is globose with a diameter of 8-12 cm and has fleshy edible aril. The ripe fruit is golden yellow in colour. The mature fruit is usually eaten raw or cooked with pulses or with other vegetables. It is available particularly in Assam, Arunachal Pradesh and West Bengal regions of India. Usually, the ripe or raw fruits are sliced, sun-dried and preserved. The raw fruits are preferred for pickles and sundried fruits are used as spices in foods. Traditionally, the plant has been used for many ailments such as chronic catarrh, asthma, cough, bronchitis, fever, dysentery and as a cardiotonic. Since *Garcinia* species has a lot of medicinal properties and is considered as an underutilized fruit, so a review work was carried out to study its medicinal and antioxidant properties and products developed using *Garcinia,* with special reference to *Garcinia pedunculata*.

Keywords: *Garcinia pedunculata*, antioxidant activity, medicinal properties, underutilized, value addition

Citation: Islam, J., Devi, V., and Langching, J. 2021. Medicinal and antioxidant activity of *Garcinia pedunculata*: a valuable underutilized fruit of Assam. *Journal of Postharvest Technology*, **9**(4): 11-22.

INTRODUCTION

Fruits are an important part of a healthy diet, they are an excellent source of essential vitamins and minerals, and they are high in fiber. Fruits especially citrus are the important sources of major groups of phytochemicals that have been suggested as a natural source of antioxidants. The major groups of antioxidants present in citrus are polyphenols (e.g flavonoids) and vitamins such as vitamin C and E (Islam et al*.,* 2015). Some of the wild citrus fruits have considerable amount of antioxidants. On consumption, they help in lowering of degenerative disease induces such as cancer, heart disease, inflammation, arthritis, immune system decline, brain dysfunction and cataract (Biswas et al*.,* 2017). One such species of wild underutilized citrus fruit is *Garcinia.* Fruits of most *Garcinia* species are reported as edible and provide a food supplementary among the tribal peoples (Gogoi et al*.,* 2012).

The genus *Garcinia* belonging to the family: *Cluciaceae* has over 200 species distributed in the tropics of the world, chiefly in Asia, Africa and Polynesia. They are evergreen polygamous trees, shrubs and herbs. About 41 species and 5 varieties are currently recognized in India, out of which 35 species and all varieties occur in natural environments, while the rest are introduced into cultivation (Sabu et al., 2013). In India, species of *Garcinia* grow extensively in the ‘konkan’ region of Maharashtra, Goa,

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ISSN2348-4330

coastal areas of Karnataka and Kerala, evergreen forests of Assam, Khasi, Jaintia hills, West Bengal and Gujarat. Out of 35 species found in India, *Garcinia pedunculata*, *Garcinia xanthochymus*, Garcinia cowa and *Garcinia lancifolia* are the most important species found in North Eastern parts of India. Recently a new species of *Garcinia* was found in Assam known as *Garcinia Assamica* (Sarma et al*.,* 2016).

Most of the *Garcinia* species are known to have good medicinal value and are used in traditional medicines for treatment of various diseases (Deore et al*.,* 2011). In the fruits of certain species of *Garcinia* (-)-Hydroxycitric acid (HCA) has been found. This HCA is known to curb appetite, suppress food intake, increase the rates of hepatic glycogen synthesis, reduce fatty acid synthesis and lipogenesis, and decrease body-weight gain. This HCA is a good dietary supplement to any weight management (Gogoi et al., 2012).

Garcinia pedunculata commonly known as "Amlavetasa" in India, and "Taikor" in Bangladesh, is an evergreen tree with a fluted trunk and short spreading branches. The fruit is globose with a diameter of 8-12 cm and has fleshy edible aril. The ripe fruit is golden yellow in colour. The mature fruit is usually eaten raw or cooked with pulses or with other vegetables (Gogoi et al*.,* 2012). It is available particularly in Assam, Arunachal Pradesh and West Bengal regions of India (Gupta et al*.,* 2018).

In Assam *Garcinia pedunculata* is commonly known as Borthekera. It belongs to the family Clusiaceae and is an important fruit of North East India. The ripe fruit is eaten cooked or raw. Usually, the ripe or raw fruits are sliced, sun-dried and preserved. The raw fruits are preferred for pickles and sundried fruits are used as spices in foods. Traditionally, the plant has been used for many ailments such as chronic catarrh, asthma, cough, bronchitis, fever, dysentery and as a cardiotonic (Kagyung et al*.,* 2010). The fruits of the plant are used to treat different types of stomach related disease by the people of Assam (Sharma et al*., 2015).* In Assam, there are several traditional uses of *Garcinia pedunculata* fruit products. One of the most popular traditional preparation is 'tenga diya masor jol' prepared from sun dried sliced fruits of *Garcinia pedunculata.* Such slices are also used for enhancing the flavor while fermenting bamboo shoot locally known as 'kharisa'. Water extract of dry slices is use as cooling drink taken in warm weather. And this drink is reported as an antiscorbutic, astringent, cardio tonic and emollient (Biswas et al*.,* 2017). It is reported that the fruits of *Garcinia pedunculata* are used as ayurvedic medicine for treating female obesity as they are rich in (-) – hydroxycitric acid (HCA) (Gogoi et al*.,* 2015). In spite of having enormous health benefits, *Garcinia pedunculata* is underutilized fruit in India due to its season availability and very short shelf life (Biswas et al*.,* 2017).

CLASSIFICATION AND DISTRIBUTION OF *GARCINIA* SPECIES

Sweeney (2008) did a study on "phylogeny and floral diversity in the genus *Garcinia* (clusiaceae) and relatives" and found that genus *Garcinia* belonging to the family: *Cluciaceae* has over 250 species distributed in the tropics of the world, chiefly in Asia, Africa and Polynesia.

Nayar et al. (2014) did a study on "flowering plants of the Western Ghats" and found out that about 41 species and 7 varieties of *Garcinia* are currently recognized in India. Out of 41 species, 35 species and all varieties occur in natural environments, while the rest are introduced into cultivation (Maheshwari 1964, Singh 1993, Srivastava, 1994, Sabu et al*.,* 2013).

Parthasarathy et al. (2013) conducted a study on "Diversity of Indian *Garcinia*- a medicinally important crop in India". The work was done in India, mainly at Indian Institute of Spices Research, Calicut (IISR), on survey and collection of *Garcinia* genetic

species it was found that the most species of *Garcinia* grow extensively in a semi-wild state, in the Konkan region of Maharashtra, Goa, coastal areas of Karnataka and Kerala, evergreen forests of Assam, Khasi, Jaintia hills, West Bengal and Gujarat.

Shameer et al. (2017) did a study on "Diversity of *Garcinia* species on the Western Ghats" after conducting field surveys, herbarium examinations and literature references it was found that there are 9 species and 2 varieties which are indigenous to the Western Ghats out of which, 7 species and 2 varieties are endemic to the region.

Parthasarathy et al. (2013) conducted a study on "Diversity of Indian *Garcinia*- a medicinally important crop in India". The survey and collection of *Garcinia* genetic species revealed that out of 35 species found in India, *Garcinia pedunculata*, *Garcinia xanthochymus*, *Garcinia cowa* and *Garcinia lancifolia* are the most important species found in North Eastern parts of India.

Sarma et al. (2016) did a study on "A new species of *Garcinia* (clusiaceae) from Assam, North East India". During the plant explorations in the forest of Manas National Park and surroundings, Assam state, India, the authors collected flowering and fruiting specimens of *Garcinia.* On morphological examination it was found to be allied to *Garcinia nigrolineata*, but on further examination it was found to differ in several morphological characters from latte and then after comparing with other species it was found to be distinct and so considered as a new species of *Garcinia* and named as *Garcinia Assamica*.

Shameer et al. (2017) did a study on "*Garcinia gamblei* (clusiaceae), a new species from the Southern Western Ghats, India". As a part of taxonomic revision of the genus *Garcinia* in India, the authors collected flowering and fruiting specimens of *Garcinia* from Pomundi hills of Agasthyamala Biosphere Reserve in Thiruvananthapuram district of Kerala state, India. After critical examination of specimens, a new specimen showed unique morphological characters, and later it was described as a new species under the genus *Garcinia* and named as *Garcinia gamblei.*

MORPHOLOGICAL CHARACTERIZATION OF *GARCINIA PEDUNCULATA*

Gogoi et al. (2015) conducted a study on 'Morpho-biochemical characterization of *Garcinia* species of Assam' by studying comparative morphological characterization of five varieties of *Garcinia* species found in five districts of Assam i.e, Dibrugarh, Sivsagar, Jorhat, Golaghat and Nagaon. The ethno-botanical study revealed wide variations in fruit weight and volume. The *G. pedunculata* exhibited highest (620.80 g) fruit weight whereas *G. lanceaefolia* exhibited lowest (22.51 g) fruit weight. In respect of number of seeds per fruit *G. pedunculata* had 9.35 numbers of seed whereas *G. xanthochymus* showed 2.50 numbers of seed.

Gupta et al. (2018) conducted a study on "Morpho-Anatomical and Physicochemical Evaluation of *Garcinia Pedunculata* Roxb. Ex. Buch.-Ham." in which the pharmacognostic and phytochemical details about the plant was established. The presence of simple, petiolate leaf obovate-oblong in general, some elliptic and oblong with obtuse and sub-acute tip and paracytic stomata was revealed by macro and microscopical studies of leaf. Some diagnostic features noted from the anatomical study of the plant are bicollateral vascular bundle covered with sclerenchymatous fibers in leaf and 8-10 layer of collenchyma, scattered pericyclic fiber, the arrangement of phloem in the ring form in stem. The presence of palisade parenchyma with the epidermis, parenchyma fiber and scalariform vessels was revealed by powder microscopy. The presence of carbohydrate, glycoside, saponins, and phenolic compound was revealed by phytochemical evaluation.

MEDICINAL PROPERTIES OF *GARCINIA*

Sarma et al. (2015) conducted a study on "Ethnopharmacological survey of *Garcinia pedunculata* Roxb. Fruit in six different districts of Assam, India". The study was conducted to scientifically enumerate the ethnomedicinal use of *Garcinia pedunculata* fruit in six different districts of Assam of Northeast region of India with the help of open-ended and semi-structured questionnaire which was distributed among different sections of people. For this study, total 2600 samples at random were collected from six districts of Assam and out of that 1967 numbers of people (75%) found to use *Garcinia pedunculata* fruit and they considered it as a healer of dysentery, diarrhoea and jaundice.

Sarma et al. (2016) conducted a study on "Polyphenol rich extract of *Garcinia pedunculata* fruit attenuates the hyperlipidemia induced by high fat diet". The study aimed at evaluating the potential therapeutic action of the polyphenol-rich methanolic extract of the fruit in experimental induced obese rats. In vitro antioxidant and antidiabetic activity of G. pedunculata extracts, i.e., fruit extract (GF) and seed extract (GS) were determined by using various methods viz., 1,1-diphenyl-2 picrylhydrazyl (DPPH), 2,2′-Azinobis (3-ethyl benzthiazoline-6-sulphonic acid) (ABTS•+), nitroblue tetrazolium (NBT) and α-glucosidase inhibition assay for detection of antihyperglycemic activity. In vivo antilipidemic and anti-obesity activities were evaluated by administrating oral dose of GF for 60 days on a high-fat diet (HFD) induced hyperlipidemia in the rat. GF treated rat revealed a reduction in the body weight (~60%), serum total cholesterol (33%), triglycerides (32%), low-density lipoprotein (38%) and liver biomarker enzymes after 60 days high fat diet fed animals.

Ali et al. (2017) conducted a study on "Antihyperglycemic, antidiabetic, and antioxidant effects of *Garcinia pedunculata* in rats". In this study, the antihyperglycemic, antidiabetic, and antioxidant potentials of the methanolic extract of *Garcinia pedunculata* (GP) fruit in rats were investigated. The acute antihyperglycemic effect of different doses of GP was studied in normal male Wistar rats. Diabetes was induced by streptozotocin (STZ) injection in another cohort of male Wistar rats and they showed significantly higher blood glucose and glycated haemoglobin (HbA1c) levels, altered lipid profiles, and lower insulin levels compared to nondiabetic control animals. There were increased lipid peroxidation and reduced levels of cellular antioxidant enzymes in different tissues of diabetic rats. However, oral administration of GP extracts, especially the highest dose (1000 mg/kg), significantly ameliorated hyperglycemia (42%); elevated insulin levels (165%); decreased HbA1c (29.4%); restored lipid levels (reduction in TG by 25%, TC by 15%, and LDL-C by 75% and increase in HDL-C by 4%), liver and renal function markers, and lipid peroxidation (reduction by 52% in the liver, 39% in the kidney, 44% in the heart, and 46% in the pancreas); and stimulated tissue antioxidant enzymes to near normalcy. Overall, the findings suggest that *Garcinia pedunculata* (GP) fruit is effective against hyperglycemia and could be used in the treatment of diabetes and its complications and other oxidative stress-mediated pathological conditions.

Mundugaru et al. (2016) conducted a study on "Cardioprotective activity of fruit of *Garcinia pedunculata* on isoprenaline-induced myocardial infarction in rat". The study revealed the protective effect of *Garcinia pedunculata* aqueous fruit extract in isoprenaline-induced myocardial infarction in Wistar rats. Isoprenaline (200 mg/kg) administration subcutaneous once daily for two consecutive days significantly ($p<0.01$) increased the CK-MB, AST, ALT, ALP activity and CRP ($p<0.05$) levels. Pretreatment with extract (400 mg/kg) orally for 14 consecutive days significantly ameliorated the effect of isoprenaline by reducing the activity of CK-MB and the levels of ALP, SGPT respectively. No significant changes were seen in the case of SGOT activity and CRP levels. Severe necrotic lesions in the myocardial tissue were observed in the isoprenaline-treated group. In extract-treated group, mild degenerative changes of myocardial tissues to nearly normal cytoarchitecture were seen. The results indicate the cardioprotective effect of G. pedunculata against isoprenaline-induced myocardial infarction rat model.

Brito et al. (2017) did a study on "An overview of anticancer activity of *Garcinia* and *Hypericum"*. The study includes an overview of the *in vitro* and *in vivo* anticancer activity of secondary metabolites from *Garcinia* and *Hypericum* and the mechanisms involved in this activity. *Hypericum* no longer belong to *Clusiaceae* family, but was considered in the past by taxonomists, due to similarities with this family. Research in the area has shown that several compounds belonging to different chemical classes exhibit activity in several tumor cell lines in different experimental models. This review shows the significant antineoplasic activity of these compounds, in particular of these two genera and validates the importance of natural products in the search for anticancer drugs.

Choudhury et al. (2016) conducted a study on "Anticancer activity of *Garcinia Morella* on T-cell murine lymphoma via apoptotic induction". The study was conducted to evaluate the antioxidant and anticancer activity of methanol extracts of the leaf, bark and fruit of *G. morella* (GM) in different *in vitro* and *in vivo* experimental conditions. The results of this study showed that GM methanol extracts possessed *in vitro* antioxidant and anticancer properties, where the fruit extract (GF) showed maximum activity. The anticancer activity was further confirmed by the results of *in vivo* administration of GF (200 mg/kg) for ten days to Dalton's lymphoma (DLA) induced mice. GF extract significantly increased the mean survival time (MST) of the animals, decreased the tumor volume and restored the hematological and biochemical parameters. This study for the first time reported the anticancer property of GF on DLA. Further from the experiments conducted to elucidate the mechanism of action of GF on DLA, it was found that GF exerts its anticancer effect through induction of caspases and DNA fragmentation that ultimately leads to apoptosis. However, further experimentation is required to elucidate the active principle and validate these findings in various *in vivo* settings.

Priya et al**. (**2018) conducted a study on 'Biochemical Evidence for the Antitumor Potential of *Garcinia mangostana* Linn. on Diethylnitrosamine-Induced Hepatic Carcinoma". In this study the cancer was induced using DEN to the experimental rats and treated with GME (200, 400, and 600 mg/kg) to find its anticancer property. The cancer biomarkers such as alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA), hepatic hydroxyl proline, total tissue protein, and tumor necrosis factor-alpha levels were measured using ELISA. The vascular endothelial growth factor expressions were also seen in liver tissues using immunohistochemistry. It was found that there was a significant increase in serum AFP, CEA, hepatic hydroxylproline, and total tissue protein levels in HCC group versus the negative control group. The groups with HCC subjected to either high or low dose of GME elicited significant reduction of AFP, CEA, hepatic hydroxyproline, and increase in total protein in serum compared to the untreated HCC rats. Interestingly, treatment with GME elicited marked improvement in the liver histological feature and downregulation of tumor necrosis factor-alpha levels in HCC groups. GME extract may have chemopreventive benefits by reducing the tumor promoting growth factor levels in HCC-induced group, all findings on curative groups had proved clearly that the GME has anticarcinogenic effect on the development of liver cancer induced by DEN in rats.

Choudhury et al. (2017) conducted a study on Anticancer Activity of *Garcinia Morella* Chloroform Fraction And Its Active Compound Garcinol On Neuroblastoma. The study was conducted to evaluate the anticancer activity of *G. morella* fruit chloroform fraction and its isolated bioactive molecule garcinol on neuroblastoma cell line (SH-SY5Y). For the study methanol extraction was performed for the *G. morella* fruits through cold maceration and further fractionated with chloroform. The presence of Garcinol was confirmed by measuring the melting point. Further, the bioactive chloroform fraction and pure Garcinol was tested for anticancer activity against SH-SY5Y cells through MTT assay. The study reveals the anticancer ability of bioactive chloroform fraction of *G. morella* fruit and its active molecule garcinol. The study revealed that *G. morella* fruit and its bioactive

compound Garcinol have significant activity against neuroblastoma. This study opens an avenue to further elucidate the mechanism of action and development of alternative treatment of this dreaded disease.

Njume et al. (2011) conducted a study on "crude ethanolic extracts of *Garcinia kola* seeds heckle (*Guttiferae*) prolong the lag phase of *Helicobacter pylori.* Inhibitory and bacterial potential". The study was conducted as an attempt to identify potential sources of such compounds, the antimicrobial activity of five solvent extracts of *Garcinia kola* seeds were investigated against 30 clinical strains of *H. pylori* and a standard control strain, NCTC 11638, using standard microbiological techniques. Metronidazole and amoxicillin were included in these experiments as positive control antibiotics. All the extracts tested exhibited anti–*H. pylori* activity with zone diameters of inhibition between 0 and 25 mm. The ethanol extract demonstrated considerable anti–*H. pylori* activity with a percentage susceptibility of 53.3% and minimum inhibitory concentration for 50% susceptibility (MIC_{50}) values ranging from 0.63 to 5.0 mg/mL. Ranges of MIC_{50} values for amoxicillin and metronidazole were 0.01–0.63 mg/mL and 0.04–5.0 mg/mL, respectively. The inhibitory activity of the ethanol extract was similar to that of metronidazole ($P > .05$) as opposed to amoxicillin ($P < .05$). The extract caused a 12-hour extension of the lag phase of *H. pylori* at 1.25 mg/mL. The same observations were recorded when this concentration was doubled and quadrupled alongside a killing rate of 80.1% and 93.7%, respectively, after 24 hours and of 100% after 30 hours. These results demonstrate that the ethanol extract of *G. kola* may contain therapeutically useful compounds against *H. pylori*.

ANTIOXIDANT PROPERTIES OF *GARCINIA*

Niranjan et al. (2020) conducted a study on **"**In-vitro analysis of antioxidant and antimicrobial properties of *Garcinia mangostana* L. (pericarp) and *Clitoria ternatea* (flower)". The study was conducted to evaluate the phytochemical analysis, antimicrobial activity and radical scavenging and antioxidant properties of the *Garcinia mangostana* L. pericarp and *Clitoria ternatea* flower (blue) extract obtained by methanol solvent. The extracts were evaluated antioxidant activity by DPPH (1,1-diphenyl-2-picrylhydrazyl) and antimicrobial activity through well diffusion method. Antimicrobial activity of mangosteen pericarp extract was recorded highest zone of inhibition against *Staphylococcus aureus* (11mm) while butterfly pea flower extract was recorded highest inhibition against E. coli (12mm). *Mangostana* extract and butterfly pea extract were observed to have high-quality antioxidant activity. The IC50 values of mangosteen extract was 51.53 µg/ml and butterfly extract were 92.42µg/ml evaluated. Based from the results methanol was proper solvent to extract the antioxidant antimicrobial compounds form *Clitoria ternatea* and mangosteen.

Kureshi et al. (2019) conducted a study on **"**Comparative evaluation of antioxidant properties of extracts of fruit rinds of *Garcinia* species by *in vitro* assays". For the study fruit rind extracts of eight *Garcinia* species, namely *G. cambogia, G. cowa, G. indica, G. loniceroides, G. mangostana, G. morella, G. pedunculata and G. xanthochymus* were prepared using six solvents of varying polarity, namely hexane, chloroform, ethyl acetate, methanol, water and water: methanol (hydroalcoholic; 80: 20). The total phenolic content and antioxidant properties of these extracts were determined. It was found that different extracts of fruit rinds of *G. cambogia, G. cowa, G. indica, G. loniceroides, G. mangostana, G. morella, G. pedunculata and G. xanthochymus* have different antioxidant properties. In general, hexane extract of *G. cowa, G. loniceroides and G. xathochymus*, ethyl acetate extract of *G. cowa* showed higher antioxidant activity in DPPH, ABTS and reducing power model of in vitro assay.

Ali et al. (2017) conducted a study on "Antihyperglycemic, antidiabetic, and antioxidant effects of *Garcinia pedunculata* in rats". In this study, the antihyperglycemic, antidiabetic, and antioxidant potentials of the methanolic extract of *Garcinia pedunculata* (GP) fruit in rats were investigated. The acute antihyperglycemic effect of different doses of *G.pedunculata* was

studied in normal male Wistar rats. Diabetes was induced by streptozotocin (STZ) injection in another cohort of male Wistar rats and they showed significantly higher blood glucose and glycated haemoglobin (HbA1c) levels, altered lipid profiles, and lower insulin levels compared to nondiabetic control animals. The oral administration of *G.pedunculata* extracts, especially the highest dose (1000 mg/kg), significantly ameliorated hyperglycemia (42%); elevated insulin levels (165%); decreased HbA1c (29.4%); restored lipid levels (reduction in TG by 25%, TC by 15%, and LDL-C by 75% and increase in HDL-C by 4%), liver and renal function markers, and lipid peroxidation (reduction by 52% in the liver, 39% in the kidney, 44% in the heart, and 46% in the pancreas); and stimulated tissue antioxidant enzymes to near normalcy. Overall, the findings suggest that *Garcinia pedunculata* (GP) fruit is effective against hyperglycemia and could be used in the treatment of diabetes and its complications and other oxidative stress-mediated pathological conditions.

Mudoi et al. (2012) conducted a study on "In vitro antioxidant activity of *Garcinia pedunculata*, an indigenous fruit of North Eastern (NE) region of India". The study was conducted to investigate the antioxidant properties of the dried pulp of *Garcinia pedunculata* (DPGP) as few scientific studies regarding its antioxidant activity has been reported. Antioxidant activity of the methanolic extract of DPGP with reference to standard antioxidants have been investigated employing various well-established in vitro methods i.e., 1, 1-diphenyl-2- picrylhydrazyl (DPPH) radical scavenging activity, H2O2 radical scavenging activity, reducing power and in vitro lipid peroxidation. Chemical composition analysis of DPGP revealed that it is one of the rich sources of ascorbic acid, phenolics and flavonoid compounds. FTIR analysis of DPGP revealed presence of some functional groups like carboxylic acids, amines, amides, lactone, phenols and carbohydrate which demonstrates that DPGP may be rich sources of alkaloids, polyphenolic compounds, quinines, amino acids etc. DPGP extract showed potential antioxidant activity against DPPH and H2O2 free radicals. Total reducing-power assay revealed the potential reducing power of DPGP. Phenolics and ascorbic acid might contribute to its free radical scavenging potential.

Jayaprakasha et al. (2006) conducted a study on **"**Antioxidative and antimutagenic activities of the extracts from the rinds of *Garcinia pedunculata*". For the study the hexane and chloroform extracts from the fruit rinds of *Garcinia pedunculata* were tested for their antioxidative and antimutagenic activities. Both the hexane and chloroform extracts showed antioxidant activity studied through β-carotene–linoleate model system and α, α-diphenyl-β-picrylhadrazyl (DPPH) method at various concentrations. At 500 ppm concentration, in case of β-carotene–linoleate model system, the hexane and chloroform extracts of G. pedunculata showed 60 and 67% antioxidant activity respectively, whereas the free radical scavenging activity was 45% and 65%, respectively with DPPH method. The antimutagenicity of the hexane and chloroform extracts against the mutagenicity of direct acting mutagen sodium azide was determined by the Ames test. Both the extracts showed strong antimutagenicity at or above 1250 µg/plate in the tester strains of *Salmonella typhimurium* (TA100 and TA1535). However, the hexane extract showed higher antimutagenic potential than the chloroform extract. Thus, this preliminary study documents for the first time the antioxidant and antimutagenic properties of the extracts from the fruit rinds of *G. pedunculata*.

Gogoi et al. (2016) conducted on Antioxidant activity Of *Garcinia* Species of Assam. It was carried out with the evaluation of antioxidant activity of four *Garcinia* species *i.e., Garcinia pedunculata*, *Garcinia cowa*, *Garcinia lanceifolia* and *Garcinia xanthochymus* found in Assam. For the study one gram of dried fruit sample was extracted in 10 ml methanol, centrifuged at 10,000 rpm for 20 minutes and the supernatant was used for assay, after making up volume to 10 ml by methanol. To 50 µl – 700 µl of methanolic sample extract methanol was added to make up the volume to 1 ml. To it 1 ml of DPPH (0.1 mM in methanol) was added and the mixture was incubated at room temperature in dark for 30 minutes. The absorbance was measured at 517 nm taking methanol as blank. A mixture of equal volume of methanol and DPPH reagent served as control. A decreasing intensity

of the purple colouration was taken as increasing scavenging activity. Antioxidant activity of L-ascorbic acid and quercetin were also assayed as standard. The study revealed that that ascorbic acid and phenol are the important component of Garcinia species and high content of ascorbic acid in Garcinia pedunculata and high phenol content of *Garcinia xanthochymus* can explain their good antioxidant scavenging activity.

PRODUCTS DEVELOPED USING *GARCINIA* FRUIT

Biswas et al. (2017) conducted a study on "Few novel value-added products prepared from fruits of *Garcinia pedunculata* Roxb. ex Buch-Ham". The objective of the study was to prepare some value-added products from the fruit to take their benefits in off season. For the study, the raw pulps were utilized for preparation of various products like – juice, dry powder, jam, squash and pickles at Bio-chemistry laboratory, Rain Forest Research Institute, Jorhat, Assam. All the processed fruit products are found to be superior in nutritive and shelf stability.

Sowmya et al. (2019) conducted a study on "Formulation and sensory evaluation of value-added products developed with underutilized *Garcinia indica* fruit*".* The objective of the study was to to take advantage of health promoting properties of Kokum, for whichg five different value-added products namely, Kokum pickle (KP), Kokum sauce (KS), Kokum sambar mix (KSM), Kokum spice candy (KSC), Kokum popsicles (Kpops) were developed and standardized. Sensory evaluation was conducted on all the products and the results indicate that, Kokum popsicle were highly acceptable among all other kokum products, followed by Kokum Squash, Kokum Spice Candy, Kokum Pickle and Kokum sambar mix with good acceptability scores.

Pritam et al. (2013) conducted a study on "Process development of jam utilizing under exploited fruit Kokum (*Garcinia indica*)". The objective of the study was to preserve nutritional characteristics of kokum and for which value-added product such as kokum jam was formulated. The developed product was packed and quality parameters were assessed during different storage periods. The storage stability of jam was good with respect to flavour and consistency. The percent reduction in anthocyanin content was significantly higher in jam stored at room temperature (31.5%) than at refrigerator storage (22.50%). The microbial load of jam was under the limit at the end of 90 days. The prepared preserved product was safe and fit for consumption. Product provides nutritional, phytochemical benefits to human population.

Monkongtanawat et al. (2016) conducted a study on "Product development of *Garcinia cowa* Roxb tea mixed with high β-Glucan content from edible mushroom". The objective of this research aimed to develop the *G. cowa* Roxb tea substituted with high β-glucan content from local edible mushrooms. Product development of the tea was determined using randomized complete block design (RCBD), which was composed of six treatments– *G. cowa* Roxb leaves and *P. ostreatus* powder proportions as follows: 100:0, 80:20, 60:40, 40:60, 20:80, and 0:100, respectively. The result of sensory testing by 50 panelists using 9-point hedonic scale found that the most appropriate ratio of *G. Cowa* Roxb: P. ostreatus was the 80:20. The highest average liking scores of 4 attributes (colour, aroma, taste, and overall liking were 7.10, 6.16, 6.02, and 6.70, respectively. From the result of consumer testing, most of consumers (35%) rated "extremely like" (7.88 out of 9-point). Ninety-one percent of consumers recognized the new product had more nutritional value added than other marketed tea;76% purchased the new product.

Byanna et al. (2013) conducted a study on "Standardization of sweet orange and kokum blended RTS beverage using sugar substitutes". For the study, sweet orange and kokum(*Garcinia cowa*) at the ratio of 88:12 RTS beverage with sugar and sugar substitutes and their combinations revealed that the treatments 50 per cent sucrose + 50 per cent fructose and 50 per cent sucrose + 50 per cent sucralose were at par with sucrose in respect of overall acceptability scores and these were rated the

better recipes in sensory evaluation. The sweet orange and kokum blended RTS beverage with sugar substitutes had storage stability up to 6 months.

CONCLUSION

The current review highlights the medicinal and antioxidant properties of *Garcinia pedunculata* with context to other species of *Garcinia* and product development using *Garcinia*. *Garcinia pedunculata* which is an underutilized fruit of North-east, is found to be rich in medicinal and antioxidant properties and products developed from *Garcinia* are nutrient rich and superior in taste and health. Being a seasonal fruit, its utilization is not proper due to lack of adequate facilities and hence it is considered indigenous in the region. Based on the reviewed literature, the study concludes that there is further scope of value addition of *Garcinia pedunculata* which will be an effective method for utilizing this superfruit and making it available off-season which will enhance its production and market value.

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