REVIEW ARTICLE

Medicinal and nutritional aspects of wild edible fruits from Western Ghat of India

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Abstract

The Western Ghats is a mountain range western coast of the Indian peninsula that covers an area of 160,000 km^2. It is one of the eight biodiversity hotspots in the world. It contains a very large proportion of the country's flora and fauna, many of which are endemic to this region. According to a survey, the Western Ghats are older than the Himalayas and home to many wild edible fruits that are rarely eaten and are traditionally being used as medicine for several ailments. These wild edible fruits provide a variety of nutrients, vitamins and secondary metabolites. Hence, this review, we documented 28 important wild edible fruiting plants from Western Ghat. The most species of wild edible fruit plants belong to the families of *Anacardiaceae*, *Clusiaceae*, *Malvaceae*, *Myrtaceae*, *Phyllanthaceae*, *Moraceae*, *Rutaceae,* etc. Conventionally, tribal and rural people often rely on wild edible fruits for their food, which could provide primary dietary constituents and natural bioactive compounds. In this study, we have precisely recorded the medicinal importance, nutritional constituents, occurrence, and the biological activities of wild edible fruits prevalent to Western Ghat.

Key words: Wild edible fruit, Western Ghat, nutritional value, ethnomedicinal significance

INTRODUCTION

India is one among the tropical countries that comprises rich vegetation and biodiversity. Western Ghats - stretching about 1600 km from the north of Mumbai to the southern tip of India [Figure 1]. This biodiversity hotspot contains a large number of the plant and animal species; many of which are only found here. Of the 7402 species of flowering plants occurring in the Western Ghats, 5588 species are native or indigenous.[1] Among, more than 500 medicinal plant species including wild edible fruiting plants used in traditional medicine.[2] This review has documented the noteworthiness of the wild edible fruits from Western Ghat. As per the knowledge of rural and tribal communities, more than 70 wild edible fruits are being consumed by local people of Western Ghat range. This study documented detailed nutritional value and medicinal usage of 28 important wild edible fruits[Figure 3]. Since, wild edible fruits consist of essential nutrients, vitamins, and secondary metabolites, they can be considered for cultivation, consumption, and utilization.

The diverse variety of wild edible fruit plants traditionally used as food, medicine, preparation in wine and pickles. Preserved products such as salted fruits are locally used and very popular among tourists.[3] Wild edible fruits were used in olden days to treat various disorders, including intestinal ailments, diabetes, anemia, bronchitis, asthma, cough, toxemia, diarrhea, cold, acidity, jaundice, cancer, colitis, hiccough, poisoning, and dysentery.[4] The wild edible fruits have ethnobotanical importance and are rich in minerals, vitamins, carbohydrates, proteins, fats and fiber, nitrogen, phosphorus, potassium, calcium, magnesium, sodium, iron, zinc, copper, and manganese.[4,5] In addition to their basic nutritional value, these fruits often have nutraceutical values which reportedly provide health and medical benefits.

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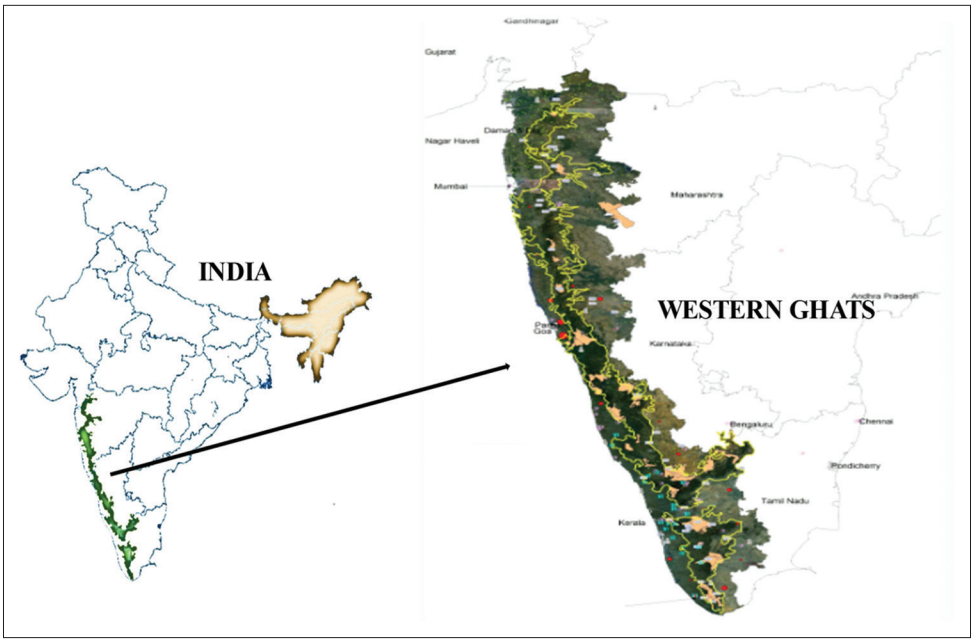

Figure 1: Western Ghat in the Indian peninsula

Hence, the documentation of wild edible fruits enhances the usage of natural food resources. It is imperative to have knowledge on the occurrence, distribution, and phenology of these species for their proper utilization. In this review, we have documented the information of 28 wild edible fruits, their vernacular names, form of usage, and their dietary and fruiting seasons [Table 1].

Nutritional and Other Uses of Wild Edible Fruits

Wild edible fruits are rich in dietary fibers, carbohydrates (starch and sugar), vitamins, and minerals; they serve as nutritional supplements for growth and development of tribal and rural people.[18] Some wild edible fruits have been identified to possess better nutritional values than cultivated fruits.[19,20] Very common wild edible fruiting plants, *Artocarpus hirsutus*, *Artocarpus heterophyllus*, *Carissa carandas*, *Carissa spinarum*, *Phyllanthus emblica*, *Garcinia gummi-gutta*, *Mangifera indica*, *M. indica,* and *Spondias pinnata*, that have better nutritional values and are consumed fresh as well as its tender fruits are used for pickling, salting, and other culinary preparations. The local wine is made from *Syzygium cuminii*, *C. carandas*, *C. spinarum*, and *P. emblica*. The fruits species, *Chrysophyllum roxburghii*, *C. carandas*, *C. spinarum*, *P. emblica*, *G. gummi-gutta*, *S. cuminii,* and *Solanum americanum* possess highly medicinal properties. Evaluation of nutritional features of wild edible fruits has attracted rising attention in the last few years.[21-25] As well as some of the wild edible fruits also contain anti-nutritional factors, for example, phytic acid and tannins that can diminish the nutrient bioavailability, especially if they are present at high levels.[26] Anti-nutritional components could help to prevent and treat several important diseases.[22] The detailed available nutrients of all 28 fruits are given below [Table 2].

Medicinal and Nutritional Importance of Wild Edible Fruits

Aegle marmelos

This plant belongs to the family *Rutaceae* and is extensively distributed all over India. Locally called as Bilvapatre (K) and used to prepare juice and wine. It is widely used in indigenous systems of Indian medicine due to its various medicinal properties and has characterized the variety of phenolics in fruit, as chlorogenic acid (136.8 µg/g), ellagic acid (248.5 µg/g), ferulic acid (98.3 µg/g), gallic acid (873.6 µg/g), protocatechuic acid (47.9 µg/g), and quercetin (56.9 µg/g).[51] The fruits are rich in mineral and vitamin contents.[27,52] *A. marmelos* fruits are generally used to cleanse and tone up the intestines. Regular intake of this fruit for 2–3 months results in evacuation of old accumulated fecal matter from bowels. Its fruits are used as astringent, anti-diarrheal, laxative, digestive, stomachache, antiviral, for dysentery, gastric troubles, constipation, and gonorrhea.[53-57] The unripe fruit is the most effective remedy for chronic diarrhea and dysentery without fever. The fruit helps in healing of the ulcers as its high mucilage content coats the stomach mucosa, thereby aiding the healing process.[58,59]

Anacardium occidentale

It is commonly called as Godambi (K), belongs to the family *Anacardiaceae*. The fruits are used in making alcoholic and nonalcoholic beverages, jam, jelly, and vinegar. Pseudo fruit known as the cashew apple is the part of the tree that connects it to the cashew nut, the real fruit.[60] The cashew apple is the stalk that bears the fruit and is said to be a rich source of reducing sugars, vitamins, and minerals.[61] In general, the ripe cashew apples are juicy, fibrous with very delicate skin and are eaten fresh or sprinkled with salt and sugar.[62]

Table 1: Wild edible fruits of Western Ghat with vernacular name, a form of usage and fruiting seasons

S. No	Scientific name	Family	Vernacular name	A form of usage	Fruiting season	References
1	*Aegle marmelos*	*Rutaceae*	Bilva patre	Juice and wine	Mar–June	[6,7]
2	*Anacardium occidentale*	*Anacardiaceae*	Godambi	Jam, jelly, vinegar, pectin, and alcoholic beverage	March–April	[8,9]
3	*Aporosa lindleyana*	*Phyllanthaceae*	Salle mara	Consumed ripen fruit.	Feb–July	[5]
4	*Artocarpus gomezianus*	*Moraceae*	Wottehuli	Consumed raw fruit.	Dec–Jan	[5]
5	*Artocarpus hirsutus*	*Moraceae*	Hebbalasu	Ripe fruits consumed fresh	May–jun	[5]
6	*Carissa carandas*	*Apocynaceae*	Kavalikatti	Ripe fruits consumed fresh; wine is made;	Apr–May/ Sep–Oct	[5]
7	*Carissa spinarum*.	*Apocynaceae*	Kouli hannu	Consumed fresh, as pickle and jams	Jun–Aug	[5]
8	*Catunaregum spinosa*	Rubiaceae	Maggaare	Ripe fruits consumed fresh	Jun–Jul	[10]
9	*Cordia dichotoma*	Boraginaceae	Challe hannu	Consumed fresh, Pickled	Dec–Feb	[11]
10	*Cucumis dipsaceus*	Cucurbitaceae.	Southe	Consumed fresh, juice	Oct–Feb	[12]
11	*Dimocarpuslongan*	Sapindaceae	Kaanakendele	Ripe fruits consumed fresh	Aug–Nov	[5]
12	*Elaeagnus conferta*	*Elaeagnaceae*	Halige hannu	Consumed fresh	Jan–Mar	[11]
13	*Elaeocarpus tectorius*	Elaeocarpaceae	Bikki	Consumed fresh	Aug–Oct	[13]
14	*Flacourtia indica*	Salicaceae	Karimullu hannu	Consumed fresh	Aug–Oct	[5]
15	*Garcinia gummi-gutta*	*Clusiaceae*	Mantulli	Fruit, juice and as souring agent	Mar–may	[5]
16	*Grewia tiliifolia*	*Malvaceae*	Thadaslu	Ripe fruits consumed fresh	May–Jun	[11]
17	*Mimusops elengi*	*Sapotaceae*	Renjalu hannu	Consumed fresh	Mar–May	[14]
18	*Opuntia dillenii*	*Cactaceae*	Papaskalli	Consumed fresh	All season.	[13]
19	*Passiflora edulis*	*Passifloraceae*	Sharbathballihannu	Consumed fresh, juice is prepared	Oct–Nov	[15,16]
20	*Phoenix sylvestris*	Arecaceae	Kadu karjura	Consumed fresh dried fruits Consumed	Sep–Oct	[14]
21	*Phyllanthus emblica*	*Phyllanthaceae*	Kadu nelli	Consumed fresh, jam, juice and wine	Jan–Apr	[5]
22	*Rhodomyrtus tomentosa*	*Myrtaceae*	Thavute gida	Consumed fresh	Feb–May	[13,17]
23	*Rubus ellipticus*	*Rosaceae*	Kadumulli hannu	Consumed fresh	Feb–Apr	[5]
24	*Semecarpus anacardium*	Anacardiceae	Gere hannu	Dry fruits consumed fresh	Dec–Mar	[14]
25	*Solanum americanum*	Solanaceae	Ganike hannu	Ripe fruits consumed fresh	Throughout the year	[5]
26	*Spondias pinnata*	*Anacardiaceae*	Vrykshamla	Ripe fruits consumed fresh, Pickled	Jun–Aug	[5]
27	*Tamarindus indica*	Caesalpinioideae	Hunsehannu	Ripe fruits consumed fresh and used as souring agents	Dec–Jan	[5]
28	*Ziziphus rugosa*	*Rhamnaceae*	Kottemullu, Bilichurimullu	Ripe fruits consumed fresh	Feb–Mar	[5]

*K: Kannada

Table 2: Wild edible fruits and their nutritional values

S. No	Scientific name	Nutritional contents	References
1	*Aegle marmelos*	Water - 64.2% Total dietary fibre- 31.8% Protein - 1.8% Carbohydrates - 31.8% Fat - 0.3% Calcium - 85.0 mg/100 g Phosphorus - 31.8 mg/100 g Iron- 0.6 mg/100 g Potassium - 600 mg/100 g Copper - 0.21 mg/100 g	[27]
2	*Anacardium occidentale*	Carbohydrates - 20.1 g/100 g Raw protein - 21.5 g/100 g Ash- 2.6 g/100 g Sodium - 165 mg/kg Calcium - 38.0 mg/100 g Magnesium - 250.0 mg/100 g Potassium - 620.0 mg/100 g Phosphorus - 510.0 mg/100 g Zinc - 5.5 mg/100 g Iron - 4.5 mg/100 g	[28]
3	*Aporosa lindleyana*	Moisture content - 92.43% Protein - 0.02% Fat - 1.16% Reducing sugars - 4.91% Non–reducing sugar - 1.06% Iron - 3.71 mg/100 g Sodium - 11.6 mg/100 g Potassium - 346.09 mg/100 g	[21]
4	*Artocarpus gomezianus*	Moisture - 87.78% Fat - 15.00% Fiber - 8.43% Protein - 0.36% Carbohydrates - 8.62% Zinc - 24.92 ppm copper - 12.84 ppm Iron - 802.01 ppm Sodium - 0.68% Potassium - 1.47%	[29]
5	*Artocarpus hirstutus*	Moisture- 73.630±0.915% Thiamine - 0.048±0.016 mg/g Riboflavin - 0.841±0.082 mg/g Niacin - 0.984±0.061 mg/g Vitamin C - 5.882±0.001 mg/g Carotene - 0.00888±0.008 mg/g	[30]
6	*Carissa carandus*	TSS- 6.76% Acidity- 3.94% Ascorbic acid- 6.98 mg/100 g Total sugars- 3.96% Iron- 3.15% Calcium- 2.82% Phosphorus- 6.24 mg/100 g	[31]

(Contd...)

Table 2: *(Continued)*

S. No	Scientific name	Nutritional contents	References
7	*Carissa spinarum*	Moisture - 81.05% Fat - 7.30% Protein - 2.07% Carbohydrates - 18.66% Calcium - 29 mg/100 g Phosphorus - 32.1 mg/100 g Iron - 3.45 ppm Total phenolics - 5.31TAE/g Flavonoids - 0.44mg/100 g	[32]
8	*Catunaregum spinosa*	Moisture- 25%±1.15% Protein- 12.5%±0.9% Fat - 0.18%±0.01% Carbohydrates - 60.28%±4.6% Total sugars - 8.50% Fiber - 12.6%±0.2%	[10]
9	*Cordia dichotoma*	Moisture - 70% Calcium - 55 mg/100 g Zinc- 2 mg/100 g Phosphorus- 275 mg/100 g Iron - 6 mg/100 g Manganese- 2 mg/100 g Copper - 1.6 mg/100 g Potassium- 98.54 mg/100 g	[33]
10	*Cucumis dipsaceus*	Moisture - 89.1% Proteins - 85.9 mg/g Starch - 1.07 mg/g Zinc – 130 ppm Iron - 1200 ppm Sodium- 100 ppm Potassium - 4200 ppm Phosphorus - 412 ppm Calcium - 14820 ppm Nitrogen- 6300 ppm	[34]
11	*Dimocarpus longan*	Moisture - 81.4% Proteins - 1.2 g/100 g Fat - 0.1% Carbohydrates - 12.38–22.25% Reducing sugar - 3.85–10.16% Carotene- 20 μg/100 g Vitamin K- 196.5 mg/100 g Ascorbic acid - 163.7 mg/100 g Ash- 0.7 g/100 g	[35,36]
12	*Elaeagnus conferta*	Nitrogen - 0.57±0.015 mg/100 g Phosphorus- 1.29±0.08 mg/100 g Potassium- 1338.6±3.2 mg/100 g Magnesium- 140.1±1.12 mg/100 g Sodium- 184.3±0.57 mg/100 g Iron- 21.33±0.58 mg/100 g Zinc- 5.51±0.01 mg/100 g Copper- 0.94±0.04 mg/100 g Manganese- 3.80±0. mg/100 g 08	[37-39]

(Contd...)

Table 2: *(Continued)*

S. No	Scientific name	Nutritional contents	References
13	*Elaeocarpus tectorius*	Moisture -72.18% Crude proteins -3.69% Crude fat -1.13% Crude Carbohydrates -18.01 g/100 g Crude Fibre - 2.23% Calcium - 31.56 mg/100 g Magnesium- 39.36 mg/100 g Potassium- 188.3 mg/100 g Phosphorus- 49.2 mg/100 g Sodium- 21.81 mg/100 g Copper- 0.65 mg/100 g Zinc - 0.88 mg/100 g Iron - 4.16 mg/100 g	[40]
14	*Flacourtia indica*	Moisture - 74.4% Fat - 0.17% Fiber - 6.0% Total sugar %- 14.74 Phenol - 1.63 mg/g Ascorbic acid- 53.44 mg/100 g Iron -15.23 mg/100 g Sodium -146.3 mg/100 g Potassium -1184.3 mg/100 g	[41]
15	*Garcinia gummi-gutta*	Moisture - 86.91% Total sugars - 8.6 mg/100 mg Reducing sugars - 5.92 mg/100 mg Non reducing sugars - 2.67 mg/100 mg Sodium - 2.1 mg/100 g Potassium - 169.7% Fibre - 3.1% Proteins -0.61%	[42]
16	*Grewia tiliifolia*	Potassium - 1302±2 mg/100 g Sodium - 239.3±1.15 mg/100 g Phosphorus - 2.52±0.04 mg/100 g Calcium - 109.4±0.20 mg/100 g Magnesium - 239.3±1 mg/100 g. Nitrogen - 0.96±0.020 mg/100 g Iron - 31.3±0.05 mg/100 g Zinc - 5.4±0.43 mg/100 g Copper - 2.3±0.05 mg/100 g Manganese - 2.7±0.015 mg/100 g	[41]
17	*Mimusops elengi*	Moisture - 79.27% Proteins - 1.29% Fat %- 2.67% Carbohydrates - 60.02% Reducing sugar - 8.9% Non reducing sugar - 6.3% Fiber -1.13% Potassium - 98.54 mg/100 g Sodium -5.16 mg/100 g Calcium - 21.57 mg/100 g Magnesium - 10.54 mg/100 g	[21]

(Contd...)

Table 2: *(Continued)*

S. No	Scientific name	Nutritional contents	References
18	*Opuntia dillenii*	Moisture - 81.91% Crude proteins - 0.88% Crude fat - 1.01% Crude carbohydrates - 8.99 g/100 g Crude fiber - 5.48% Calcium - 19.54 mg/100 g Magnesium- 10.73 mg/100 g Potassium - 642.8 mg/100 g Phosphorus - 32.6 mg/100 g Sodium -116.5 mg/100 g Copper- 0.02 mg/100 g Zinc - 0.95 mg/100 g Iron - 3.22 mg/100 g	[40]
19	*Passiflora edulis*	Protein- 0.67 g/100 g Fat- 0.18 g/100 g Ash- 0.49 g/100 g Carbohydrate- 14.45 g/100 g Dietary fiber- 0.2 g/100 g Calcium- 4 mg/100 g Iron - 0.36 mg/100 g Magnesium - 17 mg/100 g Phosphorus- 25 mg/100 g Potassium - 278 mg/100 g Sodium - 6 mg/100 g Zinc - 0.06 mg/100 g Copper - 0.05 mg/100 g	[43]
20	*Phoenix sylvestris*	Moisture - 70.44% Crude proteins - 2.18% Crude fat - 0.57% Crude carbohydrates - 21.21 g/100 g Crude fiber - 3.52% Calcium - 24.43 mg/100 g Magnesium- 58.89 mg/100 g Potassium -131.1 mg/100 g Phosphorus - 32.5 mg/100 g Sodium - 43.41 mg/100 g Copper - 0.32 mg/100 g Zinc - 0.71 mg/100 g Iron - 9.91 mg/100 g	[40]
21	*Phyllanthus emblica*	Moisture -79.8% Ash - 0.62% Ascorbic acid-5889 ppm Protein - 0.69% Phosphorus - 28.2 mg/100 g Calcium - 27.6 mg/100 g Magnesium -11.8 mg/100 g Sulfur -16.6 mg/100 g Iron -3.3 mg/100 g	[44]
22	*Rhodomyrtus tomentosa*	Protein - 4.00±0.12 g/100 g Ash - 98±0.05 g/100 g Total dietary fiber- 66.56±2.31 Calcium - 200.24 mg/100 g Magnesium - 66.51 mg/100 g Potassium - 620.93 mg/100 g Phosphorus - 57.87 mg/100 g Sodium - 113 mg/100 g Zinc - 1.65 mg/100 g Iron - 4.20 mg/100 g	[13,45]

(Contd...)

Table 2: *(Continued)*

S. No	Scientific name	Nutritional contents	References
23	*Rubus ellipticus*	Moisture - 86.60% Proteins - 4% Fat - 7.10% Carbohydrates - 72.20% Total sugars - 8.50% Fiber -7.90% Ascorbic acid - 0.011% Total phenols - 6100±0.082 mg/100 g Flavonoids - 320±0.12 mg QE/100 g	[46,47]
24	*Semecarpus anacardium*	Moisture - 78.01% Crude proteins - 3.04% Crude fat - 1.84% Crude carbohydrates - 11.37 g/100 g Crude Fiber - 4.33% Calcium - 26.11 mg/100 g Magnesium- 66.51 mg/100 g Potassium- 248.6 mg/100 g Phosphorus- 29.7 mg/100 g Sodium- 22.67 mg/100 g Copper- 0.48 mg/100 g Zinc - 0.16 mg/100 g Iron - 9.97 mg/100 g	[40]
25	*Solanum americium*	Water - 90/100% Protein - 1.9 g/100 g Fat - 0.1 g/100 g Carbohydrates - 7.4 g/100 g Calcium - 274 mg/100 g Iron - 4.0 mg/100 g Carotene - 0.5 mg/100 g Vitamin C - 17 mg/100 g	[48]
26	*Spondias pinnata*	Moisture - 74.01% Crude proteins - 2.13% Crude fat - 0.71% Crude carbohydrates - 19.89 g/100 g Crude fiber - 1.29% Calcium - 66.41 mg/100 g Magnesium - 31.37 mg/100 g Potassium - 165.2 mg/100 g Phosphorus - 23.5 mg/100 g Sodium - 21.09 mg/100 g Copper - 0.73 mg/100 g Zinc - 0.62 mg/100 g Iron - 2.25 mg/100 g	[40]
27	*Tamarindus indica*	Moisture - 11.19% Proteins - 7.16% Fat - 6.24% Carbohydrates - 60.02% Fiber - 7.16% Manganese - 0.13 mg/100 g Iron - 1.05 mg/100 g Sodium - 112.76 mg/100 g Potassium - 187.73 mg/100 g Calcium - 21.57 mg/100 g Magnesium - 10.54 mg/100 g	[49]

(Contd...)

Table 2: *(Continued)*

S. No	Scientific name	Nutritional contents	References
28	*Ziziphus rugosa*	Moisture - 62.2% Proteins - 11% Fat - 5% Carbohydrates - 26% Zinc - 3.074 ppm Copper - 62.4 ppm Manganese - 609.1 ppm Iron - 916.728 ppm Sodium - 185% Potassium - 168% Phosphorus -16.5% Calcium - 17.1% Magnesium - 22% Nitrogen - 19.4%	[50]

The fruit comprises some volatile compounds, for example, esters, terpenes, and carboxylic acids.[63] The fruit is used for treating asthma, wound, and oral syphilis [Table 3].[64-66] Conventionally, cashew apples are used to treat a variety of infectious diseases such as scurvy, diarrhea, uterine, dropsy, cholera, and Rheumatism.[67] Cashew nuts contain various phytochemicals, and these phytochemicals provide a range of therapeutic properties such as anti-diabetic, anti-inflammatory, and analgesic properties as well as exhibit cytotoxic activity against various tumor cell lines [Figure 2].[61,68,69]

Aporosa lindleyana

It is commonly known as Salle Mara (K) and belongs to the family *Phyllanthaceae* and is a native fruit of Western Ghat. Nutraceutically, this fruit is rich in carbohydrates. Its leaves, stems and roots have been used to treat various ailments such as skin diseases, diabetes, infertility, and hepatic diseases.[21,70] Pharmacological activities of *A. lindleyana*, different solvent extract of bark showed antibacterial activity against *Bacillus subtilus*, *Escherichia coli, and Klebsiella pneumoniae* and the antifungal activity exhibited against *Penicillium chrysozenous*, *Candida albicans,* and *Aspergilus niger* compared with the standard drug fluconazole. Furthermore, the bark extracts showed moderate analgesic activity.[71]

Artocarpus gomezianus

It belongs to the family *Moraceae* (Monkey jack), an underutilized edible fruit of central Western Ghat. It is commonly called Wottehuli, Wonta (K). The ripened fruits are used as a spice in cooking South Indian dishes. The edible pulp of the fruit acts as a tonic for liver disorders such as fatty liver and cirrhosis. The pericarp of the fruit have shown anti-carcinogenic, pancreatic lipase inhibitory and cytotoxic inhibitory activities.[27,72] It also has antioxidant and anxiogenic activities.[73]

A. hirsutus

It belongs to the *Moraceae* family, the fruit is locally called as Hebbalasu (K). It is common in the Western Ghat from North Karnataka to Malabar Coast and Travancore. The juice from the unripe fruits is believed to induce appetite and also when applied to the anus relieve the pains of hemorrhoids.[74] The methanolic fruit extract of *A. hirsutus* was found to be effective in DPPH radical scavenging.[75] Fruit is rich in ß-carotene and essential amino acids. The ripe fruits also possess sour, sweet, cooling, appetizing, and aphrodisiac properties.[76] The fruits, leaves, and bark of *A. hirsutus* are used for anorexia, small pimples, cracks on the skin and sores.[77]

C. caranda

This is locally called Karanda (K). Karanda has a long history of use in the traditional system of medicine**,** which belongs to the *Apocynaceae* family. It is used by tribal healers of Western Ghat region of Karnataka as hepatoprotective and antihyperglycemic.[78,79] The fruit is rich in Vitamin C. The fruits, leaves, and bark are rich in tannins.[80] In Ayurveda, the unripe fruits were used as anthelmintic, antipyretic, antidiabetic, and biliary disorders.[80,81] It is useful in the treatment of diarrhea, anorexia, and intermittent fevers. Fruits have also been studied for its analgesic and anti-inflammatory activities.[82,83] The ripe fruit is cooling and acidic used to treat sore throat, mouth ulcer and skin disorders.[84] 2-phenyl ethanol, linalool, isoamyl alcohol, β-caryophyllene, benzyl acetate, carissol, and lanost-5-en3β-ol-21-oic acid are some of the many volatile compounds present in the fruit.[85,86]

C. spinarum

It belongs to the *Apocynaceae* family and is widely distributed in the various parts of India. It is called Koulihannu (K) and consumed fresh. The shrub has been traditionally used to treat inflammation, arthritis, microbial infection, and viral infection. The fruit contains various compounds, namely, carissol (an epimer of α-amyrin), lupeol, oxalic, tartaric, citric, malic, malonic and glycolic acids, the fruit could be considered as nutritious as well as a good source of protein.[32,87] Root of *C. spinarum* is ground and applied to the wounds of cattle to kill worms. It is also used to treat rheumatism by the mundas (a tribal community) of central India. It is a

Table 3: The biological activities of wild edible fruits

S. No	Wild edible fruits name	Antioxidant	Anti-cancer	Anti-bacterial	Anti-inflammatory	Anti-fungal	Anti-diabetic	Anti-emetic
1	*Aegle marmelos*							
2	*Anacardium occidentale*		✓		✓		✓	
3	**Aporosa lindleyana*							
4	*Artocarpus gomezianus*		✓					
5	*Artocarpus hirsutus*	✓						
6	*Carissa carandas*				✓		✓	
7	*Carissa spinarum*	✓		✓				
8	*Catunaregum spinosa*							
9	*Cordia dichotoma*						✓	
10	*Cucumis dipsaceus*							✓
11	*Dimocarpus longan*	✓	✓					
12	*Elaeagnus conferta*	✓	✓		✓		✓	
13	*Elaeocarpus tectorius*	✓						
14	*Flacourtia indica*	✓						
15	*Garcinia gummi-gutta*	✓						
16	**Grewia tiliifolia*							
17	*Mimusops elengi*		✓	✓		✓		
18	*Opuntia dillenii*	✓			✓			
19	*Passiflora edulis*	✓		✓				
20	*Phoenix sylvestris*	✓						
21	*Phyllanthus embilica*				✓			
22	*Rhodomyrtus tomentosa*		✓					
23	*Rubus ellipticus*	✓					✓	
24	*Semecarpus anacardium*	✓	✓					
25	*Solanum americanum*		✓					
26	*Spondias pinnata*	✓						
27	*Tamarindus indica*			✓		✓		
28	*Ziziphus rugosa*	✓		✓				

S. No	Wild edible fruits name	Anti-helminthic	Wound healing	Anti thirst	Anti- microbial	Anti-viral	References
1	*Aegle marmelos*					✓	[53-57]
2	*Anacardium occidentale*						[61,68,69]
3	**Aporosa lindleyana*						*
4	*Artocarpus gomezianus*						[72]
5	*Artocarpus hirsutus*						[75]
6	*Carissa carandas*						[80-83]
7	*Carissa spinarum*				✓		[196]
8	*Catunaregum spinosa*	✓					[88]
9	*Cordia dichotoma*	✓	✓				[93]
10	*Cucumis dipsaceus*						[98]
11	*Dimocarpus longan*						[101,102]
12	*Elaeagnus conferta*				✓	✓	[41,103-110]
13	*Elaeocarpus tectorius*						[11-50,52-112]

(Contd...)

Table 3: *(Continued)*

S. No	Wild edible fruits name	Anti-helminthic	Wound healing	Anti thirst	Anti- microbial	Anti-viral	Reference
14	*Flacourtia indica*						[197]
15	*Garcinia gummi-gutta*		✓				[198]
16	**Grewia tiliifolia*						*
17	*Mimusops elengi*						[133-135]
18	*Opuntia dillenii*						[199]
19	*Passiflora edulis*						[200]
20	*Phoenix sylvestris*				✓		[201]
21	*Phyllanthus embilica*				✓		[155-160]
22	*Rhodomyrtus tomentosa*						[164]
23	*Rubus ellipticus*						[168-170]
24	*Semecarpus anacardium*				✓		[176]
25	*Solanum americanum*						[181]
26	*Spondias pinnata*			✓			[183,185]
27	*Tamarindus indica*						[187]
28	*Ziziphus rugosa*						[195]

*The fruits with no phytochemical analysis data

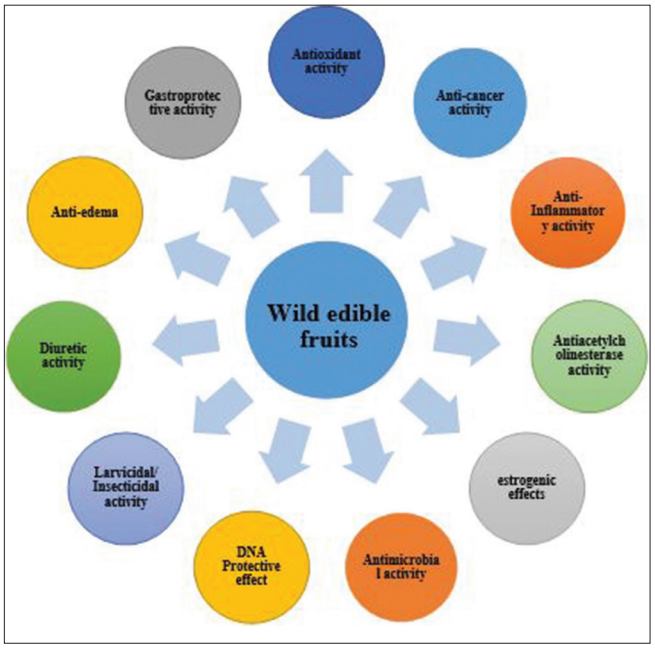

Figure 2: Pharmacological activities of wild edible fruits

strong purgative and is used as one of the ingredients in some purgative preparations. The root of *C. spinarum* also acts as a repellent of snakes, when ground powder of the roots mixed with water is poured into the holes of snakes.[87]

Catunaregum spinosa

It is a large deciduous thorny shrub which belongs to *Rubiaceae*. It is commonly called Maggaare (K). Conventionally, the pulp of the fruit was used for anthelmintic properties[88] and abortifacient in folklore remedy. Some of the vital components such as glycosides, randioside A, triterpenoid glycosides and randianin, six saponins dumetoronins A to F are found in the ripened fruit. It has pharmacological potentials such as anti-inflammatory, analgesic, anti-allergic, and antibacterial activities [Table 3].[89-92]

Cordia dichotoma

It is commonly called as Challehannu (K), belongs to the *Boraginaceae* family. It is one of the important traditional and medicinally important plants. The whole plant of *C. dichotoma* is edible and consumed afresh. Raw fruits are pickled and are also used as vegetables.[93] The fruit has been reported to be rich in polysaccharides. Ripe fruit of *C. dichotoma* produces a jelly-like, sticky mass. Unani system of drug medicine uses this plant as an antibacterial, antiviral and antitussive. *C. dichotoma* is used as a prime ingredient in various herbal preparations such as Joshandah, which is used as a remedy for various ailments particularly in common cold, cough, respiratory distress, and fevers.[94,95] Fruit also contains some anti-nutritional factors such as phytic acid (355 mg), phytate phosphorus (100 mg), and oxalic acid (250 mg) per 100 g.[96] The aqueous and ethanolic extracts of *C. dichotoma* fruit possesses wound healing and anthelmintic properties.

Cucumis dipsaceus

It is a flowering fruit belonging to the *Cucurbitaceae* family. *C. dipsaceus* commonly known as Cucurbits, locally called as south (K) and is consumed as a leafy vegetable.[12] The fruit is traditionally used for gastrointestinal disorders, diarrhea, stomach pain, and constipation.[97] The fruit juice is used as a demulcent in anti-acne lotions and as an antidote for poisoning. *C. dipsaceus* fruit is used as anti-emetic and

Figure 3: Wild edible fruits found in the Western Ghats

as fodder.[98,99] The fruit extract which acts as nutraceutical supplements in the human diet, contains a large amount of all essential amino acids and minerals.

Dimocarpus longan

A range of tropical and subtropical fruit (Soapberry). It belongs to the *Sapindaceae* family, grown throughout south-east Asia. The ripe fruits are consumed fresh. It contains two subspecies, that is, (i) *Longan* and (ii) *Malesianus*.[100] *Longan* fruits were used as a medicine in ancient times to enhance memory,[101] promote blood metabolism, relieve insomnia, and prevent amnesia. Its secondary metabolic products have also shown to have antioxidative, anti-obesity, anticancer, anti-tyrosinase, and immune-modulatory activities.[101,102]

Elaeagnus conferta

It is a dense thorny shrub or small bushy deciduous tree, belonging to family *Elaeagnaceae*, locally called as Haligehannu (K) found in the lower temperate zone. The fruit is edible and consumed fresh. *Elaeagnus* fruits contain carotenoids, anthocyanin, carbohydrates, phytic acid, ascorbic acid, flavonoids, and sterols. Conventionally, fruits of *E. conferta* have shown anti-tumor, anti-microbial, anti-viral, anti-fungal, antioxidant, anti-inflammatory, and anti-diabetic activities.[41,103-110]

Elaeocarpus tectorius

It belongs to the family *Elaeocarpaceae*, commonly known as Bikkipalzam. The fruits are consumed by the tribal people of Western Ghats. The fruits are used in the treatment of rheumatism, pneumonia, ulcers, piles, and leprosy Pharmacological investigations have shown the positive results for the presence of alkaloids, phenolic compounds, tannins, flavonoids, saponins, glycosides, terpenoids, and steroids. *Elaeocarpus* species have exhibited anti-inflammatory, anti-microbial, anti-anxiety, analgesic, anti-depressant, anti-asthmatic, anti-diabetic, sedative, tranquillizing, anti-convulsive, and anti-hypertensive properties.[111,112]

Flacourtia indica

It belongs to the *Salicaceae* family and is a small shrub found in the deciduous forests of the Western Ghats. This fruit is commonly called as Karimullu hannu (K), and is consumed fresh. A wide range of diseases can be treated with this fruit. Conventionally used in Ayurvedic, Siddha, Tibetian and folk medicine for jaundice and spleen disorders.[113] Fruits are used as an appetizing and digestive agent.[113] The fruit is rich in copper and manganese.[41] Caffeic acid, ferulic acid and p-coumaric acid were found in extracts of the peel and pulp of *F. indica*.[14,114]

G. gummi-gutta

It is commonly known as Malabar tamarind, belongs to the family *Clusiaceae*. The fruit juice is used as a souring agent.[115,116] There are 35 species in India, of which 17 species are reported to be from the Western Ghats. Fruits are widely collected and commercially exploited due to its medicinal importance. Fruits are traditionally used to treat constipation, piles, irregular menstruation, and intestinal parasites. It is also used as a food flavoring agent and a preservative.[114-117] *G. gummi-gutta* yields a high amount of oil and this is known to possess potential therapeutic properties. Commercially, these fruits are used for preparation of cosmetics and functional foods.[118-121] The fruit contains 10–30% (-) hydroxycitric acid, a well-known hypo-lipidemic agent that plays a crucial role in weight management.

Grewia tiliifolia

The genus *Grewia* which belongs to the *Malvaceae* family, commonly called as Thadaslu. The ripe fruits are consumed fresh. Medicinal properties of *G. tiliifolia* have been mentioned in Siddha, Ayurveda and Unani systems of medicine.[49,122-124] The fruit is rich in potassium and magnesium. As per Ayurveda medication, different parts of plant portions of *Grewia* have been used to treat irritation, fever, injury, ulcerative colitis, and diabetes.[125-127] This plant is used by the tribal people of Western Ghat to treat jaundice, throat pain, wounds, urinary infection, and dysentery.[128]

Mimusops elengi

It is commonly known as Bakul or Spanish cherry and belongs to the *Sapotaceae* family. The plant is grown in Western Ghat and used in traditional medicine. The fruits are edible and have a sweet and sour taste. It is a good aphrodisiac, diuretic, astringent to the bowels and good in treating *gonorrhea*. The pulp of the ripe fruits is sweetish and astringent and used in curing chronic dysentery.[129,130] Ripe fruits are given to pregnant women to induce delivery. Sometimes they are used as an abortifacient.[131,132] In Ayurveda, *M. elengi* is known for its teeth strengthening property. It has a variety of active phytoconstituents and possesses activities such as antibacterial[133] anti-hemorrhoidal,[131] antifungal,[134] and anti-cariogenic.[135]

Opuntia dillenii

O. dilleniid belongs to the family *Cactaceae*. The fruit has chemical composition of fibre, phenolics, saccharose, and minerals.[136] Conventionally, *O. dillenii is used* as a medicine for the treatment of diseases including *gonorrhea*, stomach disorders, and inflammatory lesions. It is also useful for the treatment for whooping cough and constipation, as well as for the excessive of bile secretion, spasmodic cough, and expectoration.[137,138]

Passiflora edulis

It is also known as passion fruit**,** belongs to the family of *Passifloraceae*. Locally it is called Sharbathballi hannu (K). It is consumed fresh and also in the form of juice. This fruit is used as traditional folk medicine for sedative, antiasthmatic, and emetic. It is used as moisturizing cosmetic agents in many countries.[139] The current most common use in clinical practice is in the treatment of anxiety and sleep disorders. It has been used as an ethnic remedy for the cure of numerous infectious disorders of bacterial, fungal, viral, mycobacterium, and protozoal origin. The pulp serves as a stimulant and a tonic.[140-142] The chemical components of fruit *P edulis* are quercitine, rutin, vitexina, isoorientin, saponarin, and homovitexin.[143] Six sulforaphanes and thirteen carotenoids have been isolated and identified in fruits of *P. edulis.*

Phoenix sylvestris

It belongs to Arecaceae, also known as Indian date. It is known for its nutritional value. The word *"Phoenix" means* purple, *"sylvestris*" means wild. It is generally called the wild date palm. *P. sylvestris,* also known as Kadu karjura (K). Consumption of the fresh fruit helps to cure various ailments such as constipation, abdominal and heart complaints, as

well as an aphrodisiac, sweetener and diuretic. Fruits contain a moderately fleshy and astringent mesocarpserves as restorative and an analgesic to mitigate pain from backache and in the buttocks. Dates contain a good amount of dietary fiber which facilitates the evacuation of the bowels. Dried dates help to remove the cholesterol from the arteries and improve cardiovascular health. It has high calcium content and hence improves bone health. In general, the juice of *P. sylvestris* is consumed as a cooling beverage.[144]

Phyllanthus embilica

The *P. emblica* belongs to the family *Phyllanthaceae*; locally it is called Kadu nelli (K). It is consumed as fresh, and also jam, juice and wine are also prepared. It has a unique taste. It has abundant amounts of Vitamin C and superoxide dismutase[145] It is used in many traditional medicinal systems, such as Chinese herbal medicine, Tibetan medicine, and Ayurvedic medicine.[146] *P. emblica* fruit is reported to have hypolipidemic[147-150] and hypoglycemic activities[147,151] and found to have hepatoprotective properties.[152-154] It is also used as an antimicrobial,[155-157] and anti-inflammatory agent.[158-160] *P. emblica* fruit is used in food, cosmetics and pharmaceutical preparations. The fruit contains numerous phytoconstituents such as, the higher amount of polyphenols such as gallic acid, ellagic acid, and flavonoids such as rutin and quercetin.[161]

Rhodomyrtus tomentosa

It belongs to the family of *Myrtaceae. R. tomentosa* has been used as a folk medicine in Asian countries. Locally it is called Thavutegida (K). Fruits are edible, consumed fresh and are well known for their sugar, vitamin, and mineral contents. In Vietnam, the fruits are used to produce a wine called routusim.[162] *R. tomentosa* fruits have been traditionally used to treat diarrhea and dysentery. It has the potential to boost the immune system[163] Piceatannol is considered to be an important phenolic component in *R. tomentosa* fruit that significantly contributes to its anticancer activity.[51,164]

Rubus ellipticus

It belongs to the family *Rosaceae*. *R. ellipticus*, commonly called Yellow Himalayan Raspberry.[165,166] Locally it is called as Kadumulli hannu. The fruit is consumed fresh. Phytochemical screening of fruit yields flavonoids, glycosides, steroids, phenols, tannins, anthocyanins, ascorbic acid, and resin.[47,167] Due to high content of fiber, fats, minerals, proteins, 200 g of fruit is sufficient to fulfill the daily nutritional requirement of an individual.[167] The fruit of *R. ellipticus* is a rich source of natural antioxidants, which helps in reducing the oxidative stress and thereby protects the body against degenerative diseases, including cancer, on direct consumption. The fruit acts as antidiabetic, antioxidant; anti-proliferative, nephroprotective activity.[168-170] It is eaten during indigestion while the fruit juice has been given as medicine during fever to bring down the body temperature.

Semecarpus anacardium

It belongs to the family *Anacardiaceae*. Locally it is called Gerrhannu (K). The dried fruits are consumed. It is also distributed in the sub-Himalayan region, tropical, and central parts of India. This plant is well-known for its medicinal value in Ayurvedic and Siddha systems of medicine. The most significant components of the *S. anacardium* Linn. are bhilwanols, phenolic compounds,[171,172] bioflavonoids,[173] sterols, and glycosides.[172,174] The extract from the fruit and nut demonstrates various activities including anti-atherogenic, anti-inflammatory, hypoglycemic, and anti-carcinogenic.[175,176]

S. americanum

It is an important medicinal plant belonging to the Solanaceae family and the fruit locally called ganike and the fruit is also known as black nightshade. In Asian countries, the nightshade plants have been widely used in the ethnomedicinal system from ancient age.[177,178] The plant *S. americanum* is used in ailments of the respiratory tract, wounds, skin eruptions, cuts, and trachoma.[179] The fruits contain different important steroidal glycoalkaloids such as β-solamargine, α-solamargine, solasonine, α-solanine, solasodine, and solanidine.[180] In recent times, the anticancer activities of solasodine were proven on several cancer cell lines.[181]

S. pinnata

It is an evergreen to deciduous tree distributed across India and the countries of South-East Asia. It belongs to the *Anacardiaceae* family and also known as *Spondiasmangifera* (Linn. F.) The fruit is also called Jangliaam in folkloric medicine, also locally it is called as vrikshamla. The ripe fruits are consumed fresh and also used for making pickles. Fruit juice is a useful antiscorbutic. Fruit pulp cures rheumatism and is used for bilious dyspepsia.[182] The fruit may be a valuable source of Vitamin C. The fruit and root serve as an anti-thirst remedy,[183] while the unripe fruits are used as an aphrodisiac.[184]

Tamarindus indica

Tamarind is a versatile and nutritious fruit. It belongs to the *Fabaceae* family. It is commonly called Hunsehannu (K). This is found to be a perennial fruit.[11] The tamarind pulp is eaten fresh, often made into juice and is also used for seasoning to flavor confections, curries and sauces.[185-187] Conventionally, the pulp is applied on inflammations, used as a gargle for pharyngitis when mixed with salt, as a cream for rheumatism. Sunstroke, Datura poisoning, and alcoholic intoxication can be treated with this fruit. The pulp is claimed to assist the restoration of sensation in cases of paralysis. It exhibits high antioxidant capacity that appears to be related to its high phenolic content.[187] Tamarind fruit pulp was reported to have a higher amount of the Vitamin B complex (thiamine, riboflavin, and niacin) as well as trace amounts of carotene and Vitamin C.[186,188] The fruit pulp is a vital source of calcium and phosphorus[186] and trace amounts of iron.[25,189] Tamarinds have a rich source of all minerals

available, especially magnesium, copper and potassium. The fruit pulp showed molluscicidal activity against *Bulinus truncatus*snails and this is probably due to the presence of saponins in the fruit.[187] Tamarind fruit is considered to possess carminative, laxative, digestive, and expectorant properties.[190] Furthermore, Tamarind fruits possess anti-bacterial and anti-fungal properties.[187]

Ziziphus rugosa

It belongs to the *Rhamnaceae* family. *Z. rugosa* Lamk is locally called as kotemullu and Bilichurimullu. The plant is found predominantly in the deciduous and semi-evergreen forests of Western Ghats. Traditionally, the people from the Western Ghat region eat the raw and ripened fruit as a nutritional source[191] Natives prepare dosa by grinding the ripe fruit. The fruit acts as a demulcent in the treatment of throat and broncho-pulmonary irritation. Powdered dried fruit and leaves are applied topically in the treatment of boils.[192] The fruits are used for wounds and diarrhea.[193] The people from the villages (central-western ghats of Karnataka) use this fruit as a coolant to keep the body hydrated. The phytochemical components of the fruit have alkaloids, saponins, flavonoids and glycosides, fiber, protein, and carbohydrates.[194] There are reports, methanol extract of fruit pericarp of *Z. rugosa* has antibacterial, insecticidal, and antioxidant activities.[195]

CONCLUSION

Wild edible fruits are important sources of an array of nutrients and medicines. In addition, wild edible fruits are used as food, fiber, fuel, etc. Fruits are rich sources of micro and macronutrients and play an important role in a healthy and balanced lifestyle of humans. There are 28 wild edible fruits we listed from Western Ghat and most of the fruits are commonly consumed by the local and rural people. These fruits are explored for potential food supplements and remedies for various diseases. Therefore, the wild edible fruits can be cultivated for edible purposes, medicinal purposes, also for the income generation and livelihood improvement. This type of study could contribute to educating the younger generation about the importance of wild fruits. However, this is not a comprehensive list of medicinally significant wild edible fruits, still many needs to be explored in terms of their medicinal importance, phytochemicals composition, and usage.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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