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DIVERSITY AND CHARACTERIZATION OF EDIBLE FUTURE FRUITS OF UTTARA KANNADA AND NILGIRIS OF THE WESTERN GHATS IN SOUTH INDIA

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Abstract

Significant fruit crops have been growing in various countries by inhabitants but vast numbers of edible fruits are still there which are not cultivated in well-organized plantations, such fruit crops are referred to as underutilized or minor fruit crops. Many of these fruits are potential source of qualitative nutrition and high medicinal properties. The South Indian Western Ghats regions are the natural reservoir of a number of wild edible minor fruits. In spite of their potential, these fruits are less attended both at scientific and mass cultivation level. Due to lack of proper documentation, the traditional knowledge about the ethnobotanical uses of these fruits has been lost at an alarming rate. The present investigation was carried out during the period from 2016 to 2018. A total of twenty-four wild edible minor fruit yielding plants belongs to thirteen families were recorded and investigated for their pomological potential. The highest °Brix values were recorded in Garcinia talbotii - 18.50 ± 0.15, Glycosmis pentaphylla - 17.43 ± 0.18 followed by moderate °Brix values were recorded in Prunus serotina - 11.33 ± 0.24, Passiflora mollissima - 10.50 ± 0.23 and less °Brix values were noticed in Berberis tinctoria - 6.93 ± 0.08, Rosa moschata - 6.76 ± 0.18. Significant variations were also observed in various morphological and pomological characteristics. The present investigation more focuses on characterization of fruits with high °Brix values as these fruits further be utilized for their potential in the food and beverage industry as alternate to major fruit crops.

Key words*: °Brix value, minor fruits, pomological characterization, Nilgiris, Uttara Kannada, Western Ghats.*

INTRODUCTION

The underutilized, minor or neglected fruits are appellations often given to the edible fruit yielding plants that are endemic rather than adapted introductions or non-native and which often transformed as a integral part of the culture and nutritional source of the indigenous people (Padulosi et al., 2002). The wild edible minor fruits have the essential roles in the development of food security that encompass being part of attentive effort to assist the poor for nourishment and reduce risk of over-reliance on limited source of major fruits. Considering these facts, nowadays, wild fruits are gaining increased attention throughout the world as potential source of food and cheaper alternatives to the conventional major fruits (Mayes et al., 2012; Mudasir, 2014). India is the centre of origin for many tropical fruit tree species, most of which are not commercially cultivated but provide a significant source of livelihood support for many rural and tribal communities. Specific nutrient deficiency, malnutrition, and underweight of children are significant challenge in tribal areas. The most of tribal food resources are available but due to improper cultivation practices and lack of communication channel plenty of wild edible minor fruits have not been utilized to desired extent (Ajesh et al., 2012; Sarala and Krishnamurthy, 2014). Hence, tribal community rarely get considerable benefits from the abundantly available forest products. The solution of problem lies only in improving and development of techniques includes value addition, providing market, and educating tribals about the nutritional efficacy of underutilized commodities. Value addition of wild edible minor fruits into more reliable, digestive and convenient products may enhance the economic and consumption value of wild edible minor fruit commodities and develop nutritional security of tribals (Nandal and Bhardwaj, 2014).

Several studies have explored that indigenous wild fruits are essential for nutrition, food safety and economic welfare of rural populations in the developing countries and consuming such rich fruits helpful in

prevention of chronic and degenerative diseases (Saka et al., 2007; Adepoju, 2009; Magaia et al., 2013).

Since from past time, unscientific approaches towards usage of agricultural land and deforestation highly impacted on both cultivated and wild fruit crop diversity in India. Focusing on single variety of commercial fruit crops we could notice that drastic reduction in the wild fruit species diversity. However, in the wake of these threats, effective awareness towards usage and benefits of conventional organic farming practices and value addition of wild fruits enhances the species diversity and geographical indication of the particular fruit crops (Jeeva, 2009; Devi et al., 2012). Hence sustainable utilization and conservation of wild fruit plant genetic diversity in surrounding environment where the plants developed their potential adaptation with a significant character is one of the potential solutions which is necessary to look towards it (Mayes, 2012; Namera et al., 2014).

India is one of the seventeen mega biodiversity countries in the world. About 70 percent of the total geographical area surveyed by the Ministry of Environment and Forests in India, 45,500 plant species and representing about seven percent of the world's flora (Balasubramanian, 2017). The Western Ghats is one such hotspot which covers about 4.0 % of the total Indian geographical area comprises many underutilized, lesser known wild edible fruits that are consumed rarely and except few many of them are not explored to the commercial level. However, it is examined that these underutilized fruits may not constitute good source of antioxidants as observed in major cultivated fruits but they exhibit other essential nutrients and bioactive compounds. The ethnobotanical studies suggest that till today several rural communities are depending on the underutilized fruits for their nutritional requirements (Uthaiah, 1994; Narayanan et al., 2011; Nandal and Bhardwaj, 2014; Abhishek and Thangadurai, 2015; Kailash and Neeta, 2016; Kumar and Shiddamallayya, 2016; Abhishek et al., 2017).

The Western Ghats in South India mainly comprises of three main regions, central Western Ghats, Nilgiris and the southern Western Ghats. The Nilgiris, one of oldest mountain ranges, situated at the tri-junction of Tamil Nadu, Kerala and Karnataka. The topography in the Nilgiris District is rolling and steep. Nearly 60% of the agricultural land falls under the slopes. The rolling grasslands, dense shoals make the Nilgiris as one of the megadiversity hubs for indigenous fruit plants (Nayagam et al., 1993).

The Uttara Kannada a popular regional hot spot of central Western Ghats, witness wide range of species richness and distinct biodiversity. It includes several world-famous notable biodiversity conservation areas such as Dandeli Wildlife Sanctuary and Anshi National Park. In its 10.30 lakh hectares of total land, of which 8.30 hectares covers forest land. The Uttara Kannada District has diverse geographical features with thick evergreen forest and abundant floral and faunal diversity and a long coastal cover of about 140 km in length. This unique patch of Western Ghats also harbouring various rivers like, Kali, Ganagvali, Aghanashini, Sharavathi and Varada which promotes a wide range of biological diversity (Hebbar et al., 2010). These potential south Indian Western Ghats regions are the natural reservoir of a number of underutilized minor edible fruits. These naturally occurring fruits are not only nutritionally and therapeutically rich but also thrive well under adverse environmental conditions.

In spite of their potential, these fruits are less attended both at scientific and mass cultivation level. It is found necessary to look into the well-organized cultivation practices and improvement of underutilized minor fruit crops such as *Syzygium cumini*, *Syzygium jambos* *Syzygium caryophyllatum*, *Rubus ellipticus*, *Rubus niveus*, *Rhodomyrtus tomentosa*, *Ziziphus rugosa*, *Eleagnus conferta*, *Leea indica*, *Garcinia indica*, *Garcinia talbotii*, *Glycosmis pentaphylla*, *Bridelia retusa*, *Aporosa cardiosperma* and *Toddalia asiatica* so that their utilization can be maximized for the potential application in food and beverage industry. Therefore, an effort has been made during various flowering and fruiting season for collection, documentation and characterization of wild edible minor fruits of Western Ghats in selected area of the South India.

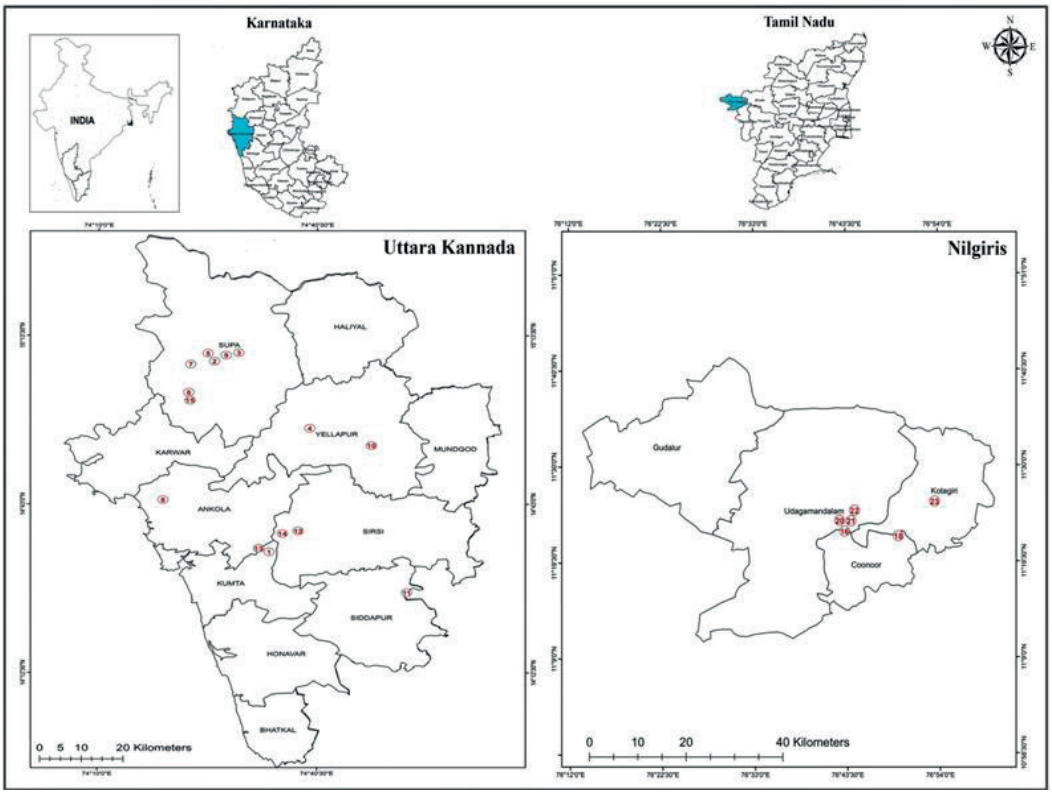

Figure 1. Maps of the study area depicting the fruit collection locations at Uttara Kannada and Nilgiris

MATERIALS AND METHODS

Collection and Identification

The study was carried out during the species-specific fruiting season from 2016-2018. The wild edible minor fruits were collected from the various regions of the Uttara Kannada District of Karnataka and the Nilgiris District of Tamil Nadu and all the fruit plant species were comprehensively identified by referring Flora of Madras, Flora of British India, digital herbarium and finally were authenticated by floral taxonomists. The study area was selected purposively due to the existence of adaptation for various underutilize minor edible fruits as these regions are very well known for their rich diversity for edible minor fruit plants. A total of twenty-four minor edible fruit plants were studied for their potential pomological features. The geographical locations of all fruit plants collected have been marked with digital devices for further visit and recollection. Figure 1 illustrates maps of the study area depicting the fruit collection locations at the Uttara Kannada and the Nilgiris.

Characterization of Wild Edible Minor Fruits

The wild edible minor fruits were characterized based on their morphological, pomological features and based on availability at various geographical locations of the Uttara Kannada and the Nilgiris Districts. The general field observations, status of edible minor fruits, indigenous knowledge on ethanobotanical aspects and consumption of edible fruits was observed during the field study. Information on technical knowledge regarding economic importance and ethnobotanical applications of these fruits was collected by personal interactions and group discussion with local people including street vendors, farmers, labours, tribals and forest officials. Figure 2 and 3 shows minor fruits collection at the Uttara Kannada and the Nilgiris. The data on plant attributes, local names, flowering and fruiting period, fruit utility was collected from

study areas. The fresh fruits samples were collected in sterile cloth bags. In the meanwhile, photographs and herbarium specimens were taken, wherever necessary. The key pomological characteristics such as the type of fruits, the color of skin and flesh, fruit shape, fruit surface texture, flavour, the fruit length, width and fruit weight values were recorded. The pH of the juice was observed using pH meter and ^{o}Brix values were recorded using analog hand refractometer as per the standard protocols and samples were analyzed in triplicates (Nawal et al., 2014; Prakash et al., 2015).

RESULTS AND DISCUSSIONS

Diversity and Distribution of Minor Fruits

A systematic survey was carried out on traditional and economic values of wild edible minor fruit plants and their geological distribution in various areas of the Western Ghats of the Uttara Kannada and the Nilgiris Region, India. The present investigation was carried out during the period from 2016 to 2018. It was noticed that both the study areas are enriched with various edible fruit yielding plants, especially the different locations of the Uttara Kannada dominate the Nilgiris regions by witnessing distinct endemic edible fruit plants. A total of twenty-four edible fruit yielding plants belongs to thirteen families were recorded from both the regions. Mainly juice yielding edible fruit plants were more concentrated as these fruits can be utilized for their potential in beverage industry as alternate to major fruit crops. The fifteen fruits from the Uttara Kannada and nine fruits from the Nilgiris have been collected and recorded for their pomological features. The wild edible minor fruits were season specific hence collected at various fruiting periods from January to December. A proper fieldwork plan and sound knowledge regarding study areas makes more comfortable during field visits and comprehensive observations and interaction with local people belongs to various tribal community, street vendors and elder persons helps in identify regional names, availability of fruits and also, they share knowledge regarding flowering and fruiting period of minor fruits and their economic utility. Further, species level identification performed by referring Flora of British India, Flora of Madras and Flora of South Kanara. It was observed that various locations of the Uttara Kannada region mainly Sirsi, Siddapur, Yellapur, Karwar, Supa, Mundgod, Haliyal and Ankola has rich diversity of minor fruit plants such as *Syzygium jambos*, *Leea indica*, *Glycosmis pentaphylla*, *Syzygium cumini*, *Elaeocarpus serratus*, *Syzygium caryophyllatum*, *Ziziphus rugosa*, *Carissa spinarum*, *Elaeagnus conferta*, *Bridelia retusa*, *Flacourtia montana*, *Garcinia talbotii*, *Ixora coccinea*, *Aporosa cardiosperma* and *Garcinia indica*. Whereas in the region of the Nilgiris, *Rubus ellipticus*, *Rubus niveus*, *Prunus serotina*, *Rhodomyrtus tomentosa*, *Berberis tinctoria* and *Toddalia asiatica* were dominated at different locations of Udhagai, Coonoor and Kotagiri. The list of wild edible minor fruits collected from the Uttara Kannada and the Nilgiris includes fruit local name, habit, distribution and are well illustrated in Table 1.

Pomological Characterization of Minor Fruits

The characterization based on morphological and pomological features of wild edible fruits was performed such as the type of fruit, fruit shape, skin color, surface texture, flesh color, taste and ^{o}Brix values. Among twenty-four fruits, thirteen fruits belong to berry, five belong to drupe, two belong to drupelet berry and one fruit as capsule was recorded. Fruit ripening is a natural irreversible process involves various physiological, biochemical and organoleptic changes that influence the development of an edible portion of fruit with potential attributes.

Figure 2. Wild edible minor fruits collected at various locations of the Uttara Kannada: 1-*Syzizium jambos*, 2-*Leea indica*, 3-*Glycosmis pentaphylla*, 4-*Syzizium cumini*, 5-*Grewia tillifolia*, 6-*Syzizium carophyllotum*, 7-*Ziziphus rogusa*, 8-*Carissa spinarum*, 9-*Eleagnus conferta*, 10-*Bridelia retusa*, 11-*Flocourtia montana*, 12-*Garcinia talbotii*, 13-*Ixora coccinia*, 14-*Aporosa cardiosperma*, 15-*Garcinia indica*

Figure 3. Wild edible minor fruits collected at various locations of the Nilgiris:
1-*Rubus ellipticus*, 2-*Rubus niveus*, 3-*Prunus serotiana*, 4-*Rhodomyrtus tomentosa*, 5-*Berberis tinctoria*, 6-*Toddelia asiatica*, 7-*Rosa moschata*, 8-*Elaeocarpus tectorius*, 9-*Passiflora mollissima*

The flavour profile of all the wild edible minor fruit exhibits notable flavours and aromas such as sweet, sour, astringent, bitter, fruity, aromatic as well. The increase in flavour and aroma during fruit ripening is attributed to the production of a complex mixture of volatile compounds such as ocimene and myrcene, and degradation of bitter principles involves synthesis of flavonoids, tannins, and related compounds (Cipollini and Levey, 1991; Malik et al., 2006; Senthilkumar and Vijayakumar, 2014). Table 2 represents the morphological features of wild edible minor fruits.

The ^{o}Brix values of all the fruit juices were recorded using analog hand refractometer and samples were analyzed in triplicates. Higher ^{o}Brix values (total soluble solids) were observed in *Garcinia talbotii* (18.50 ± 0.15), *Glycosmis pentaphylla* (17.43 ± 0.18), *Flacourtia montana* (17.36 ± 0.21) and *Elaeagnus conferta* (14.80 ± 0.05), followed by moderate ^{o}Brix values were recorded in *Prunus serotina* (11.33 ± 0.24), *Passiflora mollissima* (10.50 ± 0.23) and less total soluble solids were noticed in *Bridelia retusa* (7.23 ± 0.08), *Berberis tinctoria* (6.93 ± 0.08), *Rosa moschata* (6.76 ± 0.18). The fruit length and width (cm) values were measured as per the standard protocol. The highest length values were observed in *Passiflora mollissima* (6.90 ± 0.05), *Garcinia talbotii* (4.06 ± 0.08), *Syzygium jambos* (3.46 ± 0.08) and lowest values were observed in *Leea indica* (0.73 ± 0.03) and *Bridelia retusa* (0.66 ± 0.03). With respect to fruit breadth (cm) highest values were recorded in *Garcinia indica* (4.03 ± 0.14), *Syzygium jambos* (4.03 ± 0.11) and the lowest values observed in *Leea indica* (0.93 ± 0.03), were observed in *Bridelia retusa* (0.66 ±0.03).

Table 1. List of Wild Edible Minor Fruits Collected from the Uttara Kannada and the Nilgiris

Plant Name	Family	Fruit Local Name	Habit	Flowering and Fruiting Season	Sampling Location	Distribution
Syzygium jambos (L.) Alston	Myrtaceae	Jambu neerale, Pannerale (K)	Tree	Fl: March-April Fr: June-August	14°.55′ 57.59″ (N) 74°.54′ 72.94″ (E)	Sirsi, Siddapur (UK)
Leea indica (Burm. f.) Merr.	Vitaceae	Nedili, Karote (K)	Shrub	Fl: April-June Fr: July-September	15°.14′ 21.12″ (N) 74°.41′ 95.07″ (E)	Karwar, Sirsi (UK)
*Glycosmis pentaphylla (*Retz.) DC.	Rutaceae	Gurumani (K)	Shrub	Fl: February-April Fr: April-July	15°.15′ 69.83″ (N) 74°.47′ 59.81″ (E)	Supa, Yellapur (UK)
Syzygium cumini (L.) Skeels	Myrtaceae	Nerale, Dodda nerale (K)	Tree	Fl: January-March Fr: April-June	14°.92′ 89.84″ (N) 74°.64′ 12.56″ (E)	Sirsi, Yellapur, Mundgod (UK)
Elaeocarpus serratus L.	Elaeocarpaceae	Rudrakshi beejada mara, Athakunge (K)	Tree	Fl: February-May Fr: May-July	15°.15′ 48.43″ (N) 74°.40′ 44.94″ (E)	Supa, Yellapur (UK)
*Syzygium caryophyllatum (*L.) Alston	Myrtaceae	Kunta nerale, Kuntangila (K)	Tree	Fl: March-April Fr: June-August	15°.03′ 70.38″ (N) 74°.36′ 01.97″ (E)	Sirsi, Karwar (UK)
Ziziphus rugosa Lam.	Rhamnaceae	Kotte hannu, Chunna (K)	Shrub	Fl: December-January Fr: March-May	15°.12′ 15.84″ (N) 74°.36′ 44.14″ (E)	Supa, Yellapur, Karwar (UK)
Carissa spinarum L.	Apocynaceae	Kavale hannu (K)	Shrub	Fl: February-April Fr: April-July	14°.71′ 29.98″ (N) 74°.30′ 10.05″ (E)	Haliyal, Mundgod, Ankola (UK)
Elaeagnus conferta Roxb.	Elaeagnaceae	Kerahuli, Hulige hannu, Medduka (K)	Shrub	Fl: November-February Fr: March-April	15°.14′ 93.86″ (N) 74°.44′ 67.18″ (E)	Siddapur, Yellapur, Sirsi (UK)
Bridelia retusa (L.) A. Juss.	Phyllanthaceae	Kove mullu, Mullu hone (K)	Tree	Fl: October-December Fr: January-March	14°.87′ 69.55″ (N) 74°.78′ 41.96″ (E)	Yellapur, Supa (UK)
Flacourtia montana J.Graham	Salicaceae	Champe hannu, Sampige hannu (K)	Tree	Fl: November-February Fr: March-May	14°.43′ 32.09″ (N) 74°.86′ 62.24″ (E)	Supa, Ankola, Yellapur (UK)
Garcinia talbotii Raizada ex Santapau	Clusiaceae	Taviri hannu (K)	Tree	Fl: November-January Fr: February-April	14°.61′ 89.39″ (N) 74°.61′ 46.58″ (E)	Sirsi (UK)
Ixora coccinea L.	Rubiaceae	Kepala, Kusumaale hannu (K)	Shrub	Fl: December-February Fr: February-April	14°.56′ 68.65″ (N) 74°.55′ 13.48″ (E)	Sirsi, Siddapur Yellapur (UK)
Aporosa cardiosperma (Gaertn.) Merr.	Phyllanthaceae	Sarole hannu, Salle hannu (K)	Tree	Fl: February-April Fr: April-July	14°.61′ 13.87″ (N) 74°.57′ 80.83″ (E)	Sirsi, Yellapur (UK)
Garcinia indica (Thouars) Choisy	Clusiaceae	Punarpuli, Murugalu (K)	Tree	Fl: November-February Fr: March-May	15°.01′ 98.95″ (N) 74°.36′ 28.57″ (E)	Ankola, Sirsi, Siddapur Yellapur (UK)

Table 1. List of Wild Edible Minor Fruits Collected from the Uttara Kannada and the Nilgiris *(continued)*

Plant Name	Family	Fruit Local Name	Habit	Flowering and Fruiting Season	Sampling Location	Distribution
Rubus ellipticus Sm.	Rosaceae	Mullu pazham (T)	Shrub	Fl: February-April Fr: June-September	11°.38′ 78.58″ (N) 76°.70′ 78.74″ (E)	Udhagai, Coonoor (N)
Rubus niveus Thunb.	Rosaceae	Mullu pazham (T)	Shrub	Fl: February-April Fr: June-September	11°.40′ 76.49″ (N) 76°.72′ 28.16″ (E)	Udhagai, Coonoor (N)
Prunus serotina Ehrh.	Rosaceae	Poorachi pazham (T)	Tree	Fl: January-April Fr: April-August	11°.35′ 82.76″ (N) 76°.80′ 96.35″ (E)	Udhagai (N)
Rhodomyrtus tomentosa (Aiton) Hassk.	Myrtaceae	Thavittu pazham (T)	Shrub	Fl: February-April Fr: June-September	11°.40′ 78.51″ (N) 76°.72′ 17.92″ (E)	Udhagai, Coonoor (N)
Berberis tinctoria Lesch.	Berberidaceae	Oosi kala (T)	Shrub	Fl: February-April Fr: April-August	11°.40′ 00.34″ (N) 76°.72′ 50.34″ (E)	Udhagai, Kotagiri (N)
Toddalia asiatica (L.) Lam.	Rutaceae	Siru kindu mullu annu (T)	Liana	Fl: January-April Fr: April-August	11°.40′ 69.58″ (N) 76°.72′ 01.44″ (E)	Udhagai (N)
Rosa moschata Herrm.	Rosaceae	Kattu rose annu (T)	Shrub	Fl: June-July Fr: September-November	11°.40′ 51.81″ (N) 76°.72′ 67.25″ (E)	Udhagai (N)
Elaeocarpus tectorius (Lour.) Poir.	Elaeocarpaceae	Vikki/Bikki pazham (T)	Tree	Fl: May-June Fr: July-September	11°.42′ 08.84″ (N) 76°.87′ 85.48″ (E)	Udhagai (N)
Passiflora mollissima (Kunth) L.H. Bailey	Passifloraceae	Odey annu/Vazha (T) passion fruit	Climber	Fl: May-June Fr: July-September	11°.41′ 63.97″ (N) 76°.68′ 92.58″ (E)	Udhagai (N)

*K-Kannada name, T-Tamil name, UK-Uttara Kannada, N-Nilgiris, Fl-Flowering, Fr-Fruiting

Table 2. Morphological Characterization of Wild Edible Minor Fruits of the Uttara Kannada and the Nilgiris

Fruit Name	Type of Fruit	Fruit Shape	Skin Color	Surface Texture	Flesh Color	Taste
Syzygium jambos (L.) Alston	Berry	Spheroid	Pale yellow or whitish, sometimes pinkish	Smooth	Pale yellow	Sweet
Leea indica (Burm. f.) Merr.	Berry	Globose	Purple black	Smooth	Pale purple	Sweet
Glycosmis pentaphylla (Retz.) DC.	Berry	Oblate	Pink	Smooth, Glossy	Pale pink	Sweet
Syzygium cumini (L.) Skeels	Berry	Globose-Oblong	Deep purple to black	Smooth, Glossy, Adherent	Deep purple	Sweet, Astringent
Elaeocarpus serratus L.	Drupe	Ovoid	Greenish yellow	Smooth	White	Sweet, Astringent
Syzygium caryophyllatum (L.) Alston	Berry	Globose	Blackish purple	Smooth	Deep purple	Sweet, Sour
Ziziphus rugosa Lam.	Drupe	High spheroid	Whitish brown	Smooth	White	Sweet
Carissa spinarum L.	Berry	Globose	Blackish red	Smooth	Dark pinkish purple	Sweet, Sour
Elaeagnus conferta Roxb.	Drupe	Ellipsoid	Pale pink covered with small white lenticels	Smooth, Shiny, Bumpy	Orange red	Sweet, Sour
Bridelia retusa (L.) A. Juss.	Drupe	Spheroids	Blackish red	Smooth	Pale brown	Sweet, Astringent
Flacourtia montana J. Graham	Berry	Globose	Bright red	Smooth, Shiny	Reddish orange	Sweet, Sour
Garcinia talbotii Raizada ex Santapau	Berry	Oblong	Greenish yellow, rind surface shows yellow resins	Smooth	Pale yellow	Sweet
Ixora coccinea L.	Berry	Globose	Red	Smooth	Bright orange	Mild sweet
Aporosa cardiosperma (Gaertn.) Merr.	Capsule	Globose	Aril-Orange yellow	Smooth, Shiny	Pale yellow	Sweet, Bitter
Garcinia indica (Thouars) Choisy	Berry	Globose	Purple or Wine brown	Smooth	Reddish purple	Sweet, Sour

Table 2. Morphological Characterization of Wild Edible Minor Fruits of the Uttara Kannada and the Nilgiris *(continued)*

Fruit Name	Type of Fruit	Fruit Shape	Skin Color	Surface Texture	Flesh Color	Taste
Rubus ellipticus Sm.	Drupelet berry	Obovate	Golden yellow	Rough	Yellow	Sweet, Sour
Rubus niveus Thunb.	Drupelet berry	Obovate	Pinkish purple	Rough	Deep pink	Sweet, Sour
Prunus serotina Ehrh.	Drupe	Globose	Bright Red	Smooth, Shiny	Pale red	Sweet, Sour, Astringent
Rhodomyrtus tomentosa (Aiton) Hassk.	Berry	Subglobose	Purple green	Smooth, Garbage	Pale purple	Sweet, Astringent
Berberis tinctoria Lesch.	Berry	Obovoid-oblong	Blackish purple	Smooth, Shiny	Dark purple	Sweet, Bitter
Toddalia asiatica (L.) Lam.	Berry	Globose	Orange	Smooth, Shiny	Pale yellow	Sweet, Bitter, Aromatic
Rosa moschata Herrm.	Rose hip	Subglobose	Orange red	Rough	Pale orange	Sweet, Astringent
Elaeocarpus tectorius (Lour.) Poir.	Drupe	Ellipsoid	Green	Rough	White	Sweet
Passiflora mollissima (Kunth) L.H.Bailey	Berry	Obovoid-oblong	Pale yellow	Smooth	Pale orange	Sweet

Table 3. Pomological Characterization of Wild Edible Minor Fruits

Fruit Name	Fruit Length (cm)	Fruit Breadth (cm)	Fruit Weight (g)	Fruit Juice pH	Brix Value
Syzygium jambos (L.) Alston	3.46 ± 0.08	4.03 ± 0.11	21.60 ± 0.15	4.30 ± 0.05	11.13 ± 0.03
Leea indica (Burm. f.) Merr.	0.73 ± 0.03	0.93 ± 0.03	3.56 ± 0.12	4.66 ± 0.08	15.20 ± 0.05
Glycosmis pentaphylla (Retz.) DC.	0.90 ± 0.05	1.20 ± 0.11	4.66 ± 0.08	4.46 ± 0.03	17.43± 0.18
Syzygium cumini (L.) Skeels	2.40 ± 0.11	1.50 ± 0.05	8.36 ± 0.14	3.80 ± 0.03	16.36 ± 0.08
Elaeocarpus serratus L.	3.23 ± 0.03	2.16 ± 0.06	10.16 ± 0.08	4.80 ± 0.05	7.60 ± 0.11
Syzygium caryophyllatum (L.) Alston	1.50 ± 0.15	1.36 ± 0.08	8.36 ± 0.14	4.20 ± 0.05	10.26± 0.06
Ziziphus rugosa Lam.	1.70 ± 0.05	1.20 ± 0.05	6.56 ± 0.17	5.13 ± 0.08	12.86 ± 0.03
Carissa spinarum L.	1.53 ± 0.03	1.46 ± 0.06	9.46 ± 0.20	3.53 ± 0.06	16.63± 0.08
Elaeagnus conferta Roxb.	3.30 ± 0.15	1.56 ± 0.12	11.46 ± 0.14	3.43 ± 0.03	14.80 ± 0.05
Bridelia retusa (L.) A. Juss.	0.66 ± 0.03	0.66 ± 0.03	3.50 ± 0.23	4.63 ± 0.06	7.23 ± 0.08
Flacourtia montana J. Graham	1.73 ± 0.06	1.56 ± 0.08	10.46 ± 0.20	3.70 ± 0.05	17.36 ± 0.21
Garcinia talbotii Raizada ex Santapau	4.06 ± 0.08	3.73 ± 0.12	42.00 ± 0.05	5.16 ± 0.03	18.50 ± 0.15
Ixora coccinea L.	1.40 ± 0.05	1.26 ± 0.03	5.63 ± 0.14	5.46 ± 0.06	7.26 ± 0.12
Aporosa cardiosperma (Gaertn.) Merr.	1.13 ± 0.03	1.00 ± 0.05	5.33 ± 0.18	4.30 ± 0.05	10.46 ± 0.24
Garcinia indica (Thouars) Choisy	3.36 ± 0.08	4.03 ± 0.14	33.40 ± 0.20	3.13 ± 0.04	15.46 ± 0.18
Rubus ellipticus Sm.	1.20 ± 0.05	1.00 ± 0.10	3.50 ± 0.17	3.80 ± 0.05	10.10 ± 0.05
Rubus niveus Thunb.	1.36 ± 0.03	1.16 ± 0.08	3.80 ± 0.05	3.66 ± 0.03	9.56 ± 0.14
Prunus serotina Ehrh.	1.13 ± 0.08	0.96 ± 0.03	4.30 ± 0.15	3.80 ± 0.05	11.33 ± 0.24
Rhodomyrtus tomentosa (Aiton) Hassk.	2.20 ± 0.05	1.93 ± 0.06	5.30 ± 0.11	4.13 ± 0.03	8.50 ± 0.20
Berberis tinctoria Lesch.	1.76 ± 0.08	0.83 ± 0.03	2.80± 0.15	3.80 ± 0.05	6.93 ± 0.08
Toddalia asiatica (L.) Lam.	1.73 ± 0.03	1.50 ± 0.05	6.63 ± 0.17	2.76 ± 0.06	8.26 ± 0.08
Rosa moschata Herrm.	2.10 ± 0.05	1.73 ± 0.08	7.50 ± 0.15	4.20 ± 0.05	6.76 ± 0.18
Elaeocarpus tectorius (Lour.) Poir.	2.73 ± 0.06	1.70 ± 0.05	10.46 ± 0.12	5.13 ± 0.08	8.33 ± 0.13
Passiflora mollissima (Kunth) L.H. Bailey	6.90 ± 0.05	3.23 ± 0.18	30.43 ± 0.23	3.63 ± 0.03	10.50 ± 0.23

*Values are represented as mean ± standard error of triplicate determination

The fruit weight is another essential parameter need to be considered for selection of desired fruits for value edition. The highest weight (gm) values were observed in *Garcinia talbotii* (42.00 ± 0.05), *Garcinia indica* (33.40 ± 0.20), *Passiflora mollissima* (30.43 ± 0.23) and lowest value was recorded in *Berberis tinctoria* (2.80± 0.15). Fleshy fruit acidity is an important component of fruit organoleptic character. It was observed that most of collected fruits show moderate to higher acidic level of pH. The pH values were recorded highest in *Ixora coccinea* (5.46 ± 0.06), *Garcinia talbotii* (5.16 ± 0.03), *Ziziphus rugosa*

(5.13 ± 0.08) and the acidic pH values were recorded in *Elaeagnus conferta* (3.43 ± 0.03), *Garcinia indica* (3.13 ± 0.04) and *Toddalia asiatica* (2.76 ± 0.06). Table 3 systematically represents pomological characters with ^{o}Brix values of wild edible minor fruits. Considering all the morphological, pomological features, it was observed that most of the collected wild edible fruits though they are common in both the region shown considerable difference in the fruit size, fruit juice yield, taste and ^{o}Brix values and noticed that drastic variation in flowering and fruiting season in both the study areas, this may be because of the seasonal changes in weather conditions and soil profile. It was observed that most of the local people expressed an opinion regarding consumption and value addition of these fruits by means of producing local alcoholic and non-alcoholic beverages. Sasi and Rajendran (2012) investigation towards ethnobotanical aspects and report on wild edible fruits of tribal regions by Narayanan et al. (2011) and Sathyavathi and Janardhanan (2011) emphasis more on utilization of wild fruits for value added products. The role of underutilized fruits in fulfilling nutritional and economic security of tribals was well illustrated by Nandal and Bhardwaj (2014). Hebbar et al. (2010) documented few wild edible fruits and their medicinal importance suggests the importance of domestication of wild edible fruits. In the meanwhile, many farmers and tribal people expressed vulnerability of such wild edible endemic fruit plants caused mainly by pollution, deforestation and climate change. Prakash et al. (2015) reported that depletion of forest cover and the increasing human interference resulted in losses of wild edible fruits of the Western Ghats especially in areas of Wayanad, Dakshina Kannada and Kodagu. Nayagam et al. (1993) reported wild edible fruit plants from the various regions of the Nilgiris and if compares to present status we can observe drastic decrease in the number fruits this may be the reasons above mentioned. In view of sustainable domestication of these wild edible minor fruits of the Nilgiris and the Uttara Kannada, it is necessary to make awareness program on conservation and proper utilization of future fruit crops in more effective strategies. Furthermore, in the present study the majority of collected wild edible minor fruits exhibits higher to acceptable ^{o}Brix values and other pomological features. Hence, these fruits can be explored for their potential nutritional profile and dietary supplements. The value addition of these fruits in terms of beverage production may definitely increase the consumer demand and mass cultivation of these minor fruits in domestic scale may boost the country's economy with respect to food and allied industries.

CONCLUSIONS

The distinct wild edible minor fruit diversity was observed in the various locations of the Uttara Kannada and the Nilgiris. The present investigation provides comprehension details on diversity, distribution and pomological features of wild edible minor fruits and as a result, a total of twenty-four fruits were collected from Sirsi, Siddapur, Supa and Yellapur of the Uttara Kannada and Udhagai, Coonoor of the Nilgiris witness a rich diversity of minor edible fruit plants. These fruits have great ability to relieve nutritional deficiency by exploring their potential with proper cultivation practices and further may enhance fruit production in challenging climate conditions. Although the accurate prediction of climate change combined with population growth is not well investigated, it seems high that horticulture in large areas of the world may need to undergo considerable changes over next few decades for us to have a chance of meeting diverse nutritional requirements. The demand of these wild edible minor fruits could be enhanced through effective awareness programs on nutritional and therapeutic importance and well-established marketing strategies help in exploring their potential benefits especially in food and beverage industries by means of improving the economy of farmers and indigenous people.

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REFERENCES

Abhishek, M., Thangadurai, D. (2015). Proximate composition, nutritive value and antioxidant activity of a wild fruit, *Flacourtia montana* J. Graham. (Salicaceae). *Vegetos - Inter J Plant Res*, 28(4), 181-187.

Abhishek, M., Thangadurai, D., Sangeetha, J., Shivanand, B., Ravichandra, H. (2017). Unexploited and underutilized wild edible fruits of Western Ghats in southern India. *Scientific Papers. Series A. Agronomy*, Vol. LX. 326-339.

Adepoju, O.T. (2009). Proximate composition and micronutrient potentials of three locally available wild fruits in Nigeria. *Afr J Agric Res*, 4(9), 887-892.

Ajesh, T.P., Abdulla Naseef, S.A., Kumuthakalavalli, R. (2012). Ethnobotanical documentation of wild edible fruits used by Muthuvan tribes of Idukki, Kerala-India. *Int J Pharm Bio Sci*, 3(3), 479-487.

Balasubramanian, A. (2017). Biodiversity profile of India. *Tech Rep*, doi: 10.13140/RG.2.2.10664.57601

Cipollini, M.L., Levey, D.J. (1991). Why some fruits are green whey they are ripe: Carbon balance in fleshy fruits. *Oecologia*, 88, 371-377.

Devi, N., Sarma, G.C., Baishya, S.K. (2012). Wild edible fruits of Pakke tiger reserve in Arunachal Pradesh, India. *Pleione*, 6(2), 348-352.

Hebbar, S.S., Hedge, G.M., Hedge, G.R (2010). Less known wild edible fruits and seeds of Uttar Kannada district of Karnataka. *Indian Forester*, 136, 1218-1222.

Jeeva, S. (2009). Horticultural potential of wild edible fruits used by the Khasi tribes of Meghalaya. *J Hort Fores*, 1, 182-192.

Kailash, C.P., Neeta, P. (2016). Ethnobotanical documentation of wild edible plants used by Gujjar community of Tarai west forest division Ramnagar, Nainital, India. *Curr World Environ*, 11(3), 808-818.

Kumar, G.M.P., Shiddamallayya, N. (2016). Survey of wild edible fruits in Hassan forest division, Karnataka, India. *J Bio Environ Sci*, 8, 57-66.

Magaia, T., Uamusse, A., Sjöholm, I., Skog, K. (2013). Proximate analysis of five wild fruits of Mozambique. *Sci World J*, 1-6.

Malik, S.K., Chaudhury, R., Dhariwal, O.P., Rajwant, K.K. (2006). Collection and characterization of *Citrus indica* Tanaka and *C. macroptera* Montr: wild endangered species of northeastern India. *Genet Resour Crop Evol*, 53, 1485-1493.

Mayes, S., Massawe, F.J., Alderson, P.G., Roberts, J.A., Azam-Ali, S.N., Hermann, M. (2012). The potential for underutilized crops to improve security of food production. *Genet Resour Crop Evol*, 63(3), 1075-1079.

Mudasir, Y.M. (2014). Documentation and ethnobotanical survey of wild edible plants used by the tribals of Kupwara, J& K, India. *Int J Herb Med*, 2(4), 11-18.

Namera, K.C., Vaast, P., Kushalappa, C.G. (2014). Bioinventory and documentation of traditional ecological knowledge of wild edible fruits of Kodagu - Western Ghats, India. *J Forestry Res*, 25(3), 717-721.

Nandal, U., Bhardwaj, R. (2014). The role of underutilized fruits in nutritional and economic security of tribals: a review. *Crit Rev Food Sci Nutr*, 54(7), 880-890.

Narayanan, R.M.K., Anilkumar, N., Balakrishnan, V., Sivadasan, M., Ahmed Alfarhan H., Alatar A.A. (2011). Wild edible plants used by the Kattunaikka, Paniya and Kuruma tribes of Wayanad District, Kerala, India. *J Med Plants Res*, 5(15), 3520-3529.

Nawal, A.R., Innam, A.I., ELrakha, E.B. (2014). Characterization of some sudanese edible forest fruits. *J Agri Food Appl Sci*, 2(2), 39-44.

Nayagam, M.C., Pushparaj, M.S., Rajan, S. (1993). Less known edible fruit yielding plants of Nilgiris. *Ancient Sci Life*, 12, 363-376.

Padulosi, S., Hodgkin, T., Williams, J.T., Haq, N. (2002). Underutilised crops: trends, challenges and opportunities in the 21st century. In: Engels J.M.M, Ramanatha Rao, V., Brown, A.H.D, Jackson, M.T., eds. *Managing plant genetic diversity*, Vol. 30. Rome: IPGRI, 323-338.

Prakash, C.T., Ganesan, K., Vadivel, S., Rathnam, S.K. (2015). Survey and conservation of indigenous fruits of Western Ghats. *J Agricul Sci Technol A*, 5, 608-615.

Saka, J., Rapp, I., Akinnifesi, F., Ndolo, V., Mhango, J. (2007). Physicochemical and organoleptic characteristics of *Uapaca kirkiana*, *Strychnos cocculoides*, *Adansonia digita* and *Mangifera indica* fruit products. *Inter J Food Sci Technol*, 42, 836-841.

Sarala, P., Krishnamurthy, S. (2014). Monkey jack: underutilized edible medicinal plant, nutritional attributes and traditional foods of Western Ghats, Karnataka, India. *Indian J Tradit Know*, 13, 508-518.

Sasi, R., Rajendran, A. (2012). Diversity of wild fruits in Nilgiri hills of the Southern Western Ghats - Ethnobotanical aspects. *Inter J Appl Biol Pharm Technol*, 3(1), 82-87.

Sathyavathi, R., Janardhanan, K. (2011). Wild edible fruits used by Badagas of Nilgiri District, Western Ghats, Tamil Nadu, India. *J Med Plant Res*, 8(2), 128-132.

Senthilkumar, S., Vijayakumar, R.M. (2014). Biochemical, physiological and horticultural perspectives of fruit colour. research and reviews: *J Agric Alli Sci* 3(1), 9-16.

Uthaiah, B.C. (1994). Wild edible fruits of Western Ghats - a survey. In: *Higher plants of Indian subcontinent* (Additional Series of Indian Journal of Forestry), Volume 3, Bishen Singh Mahendra Pal Singh, Dehra Dun, India, 87-98.


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