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Nutraceutical potential of selected wild edible fruits of the Indian Himalayan region

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ABSTRACT

Wild edible fruits contribute significantly to the nutritional security of mankind across the globe. However, detailed analyses of health promoting bioactive compounds and antioxidants are lacking, especially in Himalayan wild edible fruits. Bioactive compounds and antioxidant potential of 10 wild edible fruits reveal that *Terminalia chebula*, *Phyllanthus emblica* and *Myrica esculenta* are the richest source of total phenolics; *Pyaracantha crenulata*, *Terminalia chebula* and *Berberis asiatica* for flavonoids; *Phyllanthus emblica*, *Morus alba* and *Ficus palmata* for ascorbic acid, anthocyanins, and *Morus alba* for β-carotene. Phenolic compounds, i.e. Gallic acid, catechin, chlorogenic acid, caffeic acid and p-coumaric acid varied among species and found the maximum in *Terminalia chebula* and *Phyllanthus emblica*. Antioxidant activity showed the significant relation with total phenolics, flavonoids and phenolic compounds. Results indicated that these species should be promoted as a natural source of antioxidant/nutraceuticals so that these antioxidants can be used for supplementing dietary foods of mountain people.

1. Introduction

The earth is filled with overwhelming plant diversity and efforts have been made to categorise them based on their structural and functional features to interpret the relationship among the plants (Bajpai et al., 2014; Feng, Lu, Gao, Liu, & Wang, 2014; Mishra, Ram, & Kumar, 2015; Nemli, Kianoosh, & Tanyolaç, 2015). Among the functional features, the health benefits of bioactive compounds and their incorporation in the food has stimulated wider interest and demand across the globe. This becomes much relevant when a large proportion of world population, especially in mountainous and other marginalised ecosystem, are facing the problem of low food intake and poor access to healthy food (Esquinas-Alcazar, 2005). Therefore, quality food intake to supply essential nutritional bioactive compounds has become central to achieving food and nutritional security (Bharucha & Pretty, 2010; Toledo & Burlingame, 2006).

In spite of the fact that a number of initiatives are ongoing to enhance the productivity of few domesticated crops, nutritional security remains a concern. In this regard, use of under-utilized wild edible fruit species have been suggested as an alternative (Bharucha & Pretty, 2010; Bhatt, Rawal, & Dhar, 2000; Chivandi, Mukonowenzou, Nyakudya, & Erlwanger, 2015). This recognition has prompted investigations on bioactive compounds in selected wild edible fruits in the Himalayan region, where diversity of under-exploited and under-utilized natural resources, with potential economic significance, are reported to have a decisive role in maintaining subsistence lifestyles of the region and may have a key role in nutritional security (Toledo & Burlingame, 2006). For example, many plant species such as *Sorbus domestica*, *Rosa canina*, etc., have been identified with their commercial potential as the functional food (Egea, Sánchez-Bel, Romojaro, & Pretel, 2010). However, Himalayan plants, in spite of their proven potential as natural antioxidants (Bhatt, Rawat, & Rawal, 2013; Rawat et al., 2014), have not received such attention. Among others, fruits are the richest source of natural antioxidants and widely known to prevent degenerative and cardiovascular diseases (Genkinger,

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Platz, Hoffman, Comstock, & Helzlsouer, 2004; Ness & Powles, 1997; Reddy, Sreeramulu, & Raghunath, 2010).

The Himalaya, one amongst the biodiversity rich area, supports over 675 species of wild edible plants (Samant & Dhar, 1997). The diversity of wild edible plants in the Indian Himalayan Region (IHR) has traditionally been known to play significant role in meeting nutritional, minerals and antioxidant requirement of indigenous communities (Andola, Rawal, & Bhatt, 2008; Maikhuri, Rao, & Saxena, 2004; Rawat et al., 2011). However, the systemic investigation on nutritional and antioxidant potential of the wild edibles in the region are meagre (Badhani, Rawat, Bhatt, & Rawal, 2015; Belwal, Dhyani, Bhatt, Rawal, & Pandey, 2016; Sundriyal & Sundriyal, 2001). The present study, therefore, attempts to: (i) screen 10 wild edible fruits for nutritional bioactive compounds, (ii) evaluate health-promoting antioxidant activity using different *in vitro* assays, and (iii) develops the relationship between bioactive compounds and antioxidant activity. The outcome of this study will help in developing baseline data on the nutraceutical potential of wild edible fruits of IHR, which can further be utilized in the preparation of dietary supplement and functional food or processed food products.

2. Materials and methods

2.1. Plant material collection

Reconnaissance survey of the nearby forest of district Almora, Uttarakhand (West Himalaya) was conducted and wild edible fruits consumed by local people were listed. Based on availability of the fruits, and their uses in the literature (Table 1), ten species [*Berberis asiatica* Roxb. ex. DC. (Kilmora), *Celtis australis* L. (Khareek), *Ficus palmata* Forsk. (Bedu), *Fragaria indica* Andr. (Kiphalia), *Morus alba* L. (Sahtoot), *Myrica esculenta* Thunb. (Kaphal), *Phyllanthus emblica* L. (Anwla), *Prunus armeniaca* L. (Chuli), *Pyaracantha crenulata* D. Don. (Ghingaroo) and *Terminalia chebula* Retz. (Harad) were selected for this study. The common name of these species are given in the bracket. Fresh mature and ripened fruits (500 g) from 5 to 8 plants of each species were collected from different locations, e.g., Katarmal (N 29°38′25″; E 79°37′20″; 1250 m asl), Kosi (N 29°38′25″; E 79°37′20″; 1150 m asl) and Kalika (N 29°39′51″; E 79°29′03″; 1750 m asl) during May to July 2009. Care was taken not to inflict damage to the fruit during harvest and transport, in order to prevent the wounding response. Fruits of the each species were randomly mixed and brought to the laboratory in a cool dark chamber for further analyses. The maturity of the fruits was determined on the basis of colour and shape of the fruits in which condition they are consumed (Fig. 1). Fruits were then thoroughly cleaned and washed with running tap water. The edible parts of the fruits were considered for analysis. Samples were analysed within 2 days after harvesting to avoid any post harvesting effect. Fruits were botanically identified at Biodiversity Conservation and Management theme of the G.B. Pant National Institute of Himalayan Environment and Sustainable Development, Kosi-Katarmal, Almora.

2.2. Chemicals and reagents

2,2-Diphenyl-2-picrylhydrazyl (DPPH) radical (% purity – 98%), Gallic acid (<97.5%), ascorbic acid (99%), chlorogenic acid (<95%), caffeic acid (<98%), *p*-coumaric acid (<98%), 3-hydroxybenzoic acid (98%), catechin (<98%) and quercetin (<98%) were procured from Sigma–Aldrich (Steinheim, Germany). 2,2-Azinobis-3-ethylbenz thiazoline-6-sulphonic acid (ABTS), 2,4,6-tri-2-pyridyl-1,3,5-triazin (TPTZ), methanol and ethanol were procured from Merck Co., (Darmstadt, Germany). For high-performance liquid chromatography (HPLC) analysis all solvents were HPLC grade. All other reagents were analytical grade.

2.3. Extraction

Fresh fruit samples (20 g) of each species were used for the preparation of extract in three replicates. The edible part of the

Table 1
Details of selected wild edible fruits of the Indian Himalayan Region. Name in the parenthesis under the species name is common name.

Name of the species	Family	Fruit characteristics	Medicinal uses	References
Berberis asiatica (Kilmora)	Berberidaceae	The fruits are juicy with a acid flavour; eaten raw	Given to children as mild laxative, and juice used in gums and teeth trouble	Arora and Pandey (1996), Andola et al. (2008)
Celtis australis (Khareek)	Cannabaceae	Pulp of fruits is sweetish; consumed by rural community	Decoction of fruit is used in treatment of amenorrhoea, heavy menstrual and inter-menstrual bleeding, diarrhoea, dysentery and peptic ulcers	Arora and Pandey (1996), Demir et al. (2002)
Ficus palmata (Bedu)	Moraceae	Fresh figs. are known for their taste and flavour; very popular among mountain inhabitants	Fruit is demulcent, emollient and laxative; used as a part of the diet in the treatment of constipation and diseases of the lungs and bladder	Arora and Pandey (1996), Iqbal et al., (2014)
Fragaria indica (Kiphaliya)	Rosaceae	Juicy fruits like strawberry, eaten raw	Fresh leaves and fruit can also be crushed) and be applied as a poultice to treat boils and abscesses, swellings, weeping eczema, ringworm, snake and insect bites and traumatic injury	Arora and Pandey (1996), Bhatt and Dhar (2000)
Morus alba (Sahtoot)	Moraceae	Consumed fresh as well processed products such as jam, jelly, etc.	Used in kidney troubles and purification; treat weakness, fatigue, anemia, and premature greying of hair	Arora and Pandey (1996), Ercisli and Orhan (2007)
Myrica esculenta (Kaphal)	Myricaceae	Eaten raw, delicious taste, used in preparing refreshing drinks, jam, jelly, etc.	Pectoral, sedative, fruit wax is used externally for ulcers	Bhatt et al. (2000), Rawat et al. (2011)
Phyllanthus emblica (Anwla)	Phyllanthaceae	Fruits eaten raw and used for processed products such, jams, jellies, pickles, etc.	Used as aperients, carminative, diuretic, aphrodisiac, laxative, astringent and refrigerant. Useful in anaemia, jaundice, dyspepsia, haemorrhage disorders, etc.	Arora and Pandey (1996), Anila and Vijayalakshmi (2002)
Prunus armeniaca (Chuli)	Rosaceae	Large fleshy, juicy and sweet fruits; eaten fresh and as canned products	Fruits are used as a laxative, anti-carcinogenic and astringent; fruit, seeds and bark are used to prepare herbal remedies	Arora and Pandey (1996)
Pyracantha crenulata (Ghingaroo)	Rosaceae	Red sweetish fruits; eaten raw by rural community	Powdered dried fruit, combined with yoghurt is used in the treatment of bloody dysentery	Arora and Pandey (1996)
Terminalia chebula (Harad)	Combretaceae	Fruit is edible and used medicinally	Astringent, purgative, stomachic and laxative and used in asthma, piles and cough	Barthakur and Arnold (1991), Suchalatha and Shyamaladevi (2005)