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Bioprospecting of *Rhododendron arboreum* for Livelihood Enhancement in Central Himalaya, India

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Abstract

Non-timber forest products (NTFP) are extensively extracted from Indian forests, and their role in rural and forest economies is immense. A number of wild plants used by rural and tribal population contributing significantly to livelihood and food security have escaped recognition and scientific inquiry in many developing countries. The wild edibles are gaining increased attention as potential food supplement or cheaper alternative of commercial fruits across the world. The Himalayan region is comprised of a large variety of wild-growing plants that are used for food and other subsistence needs by the local communities. *Rhododendron arboreum* is a wild plant species possesses high ecological importance and the flower of the species having unique medicinal and nutritional value. The flowers of the tree are edible and are used in the preparation of a refreshing drink in mountain region of Central Himalaya. The paper highlighted medicinal, nutritive and potential of *R. arboreum* for bioprospecting by making value added products to improve the livelihood of hill farmers in Himalaya region.

Key words: Bioprospecting, Livelihood, Conservation, *Rhododendron arboreum*

Introduction

Food and nutritional securities are key issues for developing world as low food intake and poor access to food in underdeveloped countries continues to be an unresolved concern (Adebooey and Phillips 2006). Wild food and natural products are significant in this context as it contributes to human and animal food web and often the means to survival for millions of poor rural households (Fisher 2004; Belcher *et al*. 2005). Uses of non cultivated foods, of which wild fruits form a part, as a diet supplement, and as coping mechanisms at times of food shortage, seasonally as gap filler, or in times of emergency provides an important fallback option or safety net for rural poor world over. The Indian

Himalayan region covers approximately 18% of the geographical area of the country, but accounts for more than 50% of India's forest cover and harbors 40% species endemic to the Indian subcontinent (Maikhuri *et a*l., 2000). The Himalayan region is characterized by undulating terrain, sparse human population, small and fragmented land holdings, rain-fed subsistence agriculture, fragile ecosystem and low risk bearing capacity of farmers yet rich in plant and animal diversity (Chandra and Rao 2007; Chandra *et al*., 2009). The rich plant diversity of the Indian Himalaya is utilized by the native communities in various forms as medicine, edible/food, fodder, fuel, timber, agricultural tools, etc. Among these, wild edible plants form an important source as a supplement food in times of scarcity and traditional medicine for traditional communities. Wild plants are gathered in the form of fruits, shoot, leaves, twigs, flowers, roots, tubers stems etc., and these plants still share a good proportion of tribal dishes world over (Samant and Dhar 1997; Samant *et al*. 2001). Forest based resources have played a key role in the sustenance of human civilization since time immemorial and till now deeply associated and serving a large number of human population throughout the world (Murphy *et al*. 2005; Mamo *et al*. 2007). For centuries, wild fruits of many plant species have played a prominent role in the diet and medicine of human beings, particularly in the tribal and rural areas of the Himalaya, for thousands of years (Negi 1986; Samant and Dhar 1997; Maikhuri *et al*. 1994, 2004, 2009; Maikhuri *et al*. 2007; Sundariya and Sundariyal 2003; Gairola and Biswas 2008, Dhyani *et al*. 2010; Negi *et al*. 2011). Consumption of fruits and vegetables is known to lower risk of several oxidative stresses, including cardiovascular diseases, cancer and stroke (Willett 2002). Evidences of the health benefits of wild edible fruits, in addition to established role in nutrition are available (Meda *et al*. 2008).

In the Indian Himalayan Region (IHR) over 675 wild edibles are known (Samant and Dhar 1997) of which *Rhododendron arboreum*, commonly known as "Burans", is amongst highly valued wild edible flower growing between 1500 and 2400 m asl. The genus forms dominant combination of forest types in the high altitudes (above 1500 m) of the of Garhwal region having ecological significance and economic importance in addition to its graceful flowers. A total of 72 species, 20 subspecies and 19 varieties have been listed from India (Mao *et al*., 2001). The Eastern Himalayan region is a hot spot for *Rhododendron* diversity (75 species, 4 subspecies, 5 varieties), whereas only 6 species are reported from the Western Himalaya (Sastry and Hajra 2010). Among all the species in India, *Rhododendron arboreum* Smith (1805: 9) has the widest elevational range, while other species are confined to high altitude regions which mainly form *krummholz* vegetation and alpine scrubs (Naithani 1984).

Among all Indian rhododendron species, *R. arboreum* is widely distributed, occurring from western to eastern Himalayan region and other neighbouring countries (Giriraj *et al*., 2008). Apart from their worldwide aesthetic and ethnic uses, several species have commercial and medicinal values (Leach 1986). Rhododendron species with high levels of phenols, promising antioxidant and free radical scavenging activities may be utilized in the development of healthcare products (Dhan *et al*. 2007). Antioxidants play a key role to scavenge free radicals and are associated with reduced risk of cancer and cardiovascular diseases (Willcox *et al*. 2004). Among various attributes of functional

foods, antioxidant property is considered the best, as it reduces the oxidation processes in the body (Krishnaih *et al*. 2007) and plays an important role in maintaining health by protecting against reactive oxygen species (Lan *et al*. 2007). *R. arboreum* is one of the most impressive rhododendron species, common in the western Himalayas in association with *Quercus species, Myrica nagi, Neolitsea pallen, Alnus nepalensis, Viburnum mullaha* and *Pinus roxburghii.* Still of having good medicinal value and tremendous potential for bioprospecting, the species not got much attention for its conservation and management in the western Himalaya. The present study, therefore, attempts to evaluate the potential of *R. arboreum* as source income to rural people and discuss the conservation status of the species.

Study area and Methodology:

The present study was conducted in Garhwal region of Uttarakhand (28° 43' and 31° 28' N latitude and 77° 49' and 81° 03' E longitude) which is a newly formed hill state located in the central part of the India, shares an international boundary with China in the north and with Nepal in the east. The recorded forest area of the state is 34662 km^2 which constitute 64.79% of its geographic area (GoI 2004). More than 8000 species of flowering plants grow in the Himalayas, with nearly 4000 species identified from the Garhwal Himalayan region along with great diversity (Kandari and Gusain 2001). Vegetation varies according to altitude and climatic conditions, from tropical deciduous forest in the foothills to Himalayan temperate forest at middle altitudes, coniferous, sub-alpine and alpine forest at higher altitudes, giving way to alpine grasslands and high altitude meadows.

Indigenous knowledge and ethnobotany

A rapid rural appraisal survey of the region was carried out to collect the baseline information of *R. arboreum*. The information was collected through formal and informal discussion with knowledgeable people of the region as well as members of the families so as to collect authentic data regarding traditional medicinal uses of the flower and edible products.

Cost-benefit analysis and economic potential

The cost-benefit analysis of different value added products prepared from *R. arboreum* was calculated in Rs/day which includes labour charges for male and female workers in different areas for flower collection and materials/items required for preparation of different value added products such as sugar, preservatives, packaging materials. The monetary output includes the yield of the products and based on current market rate. The average economic benefit of different villages, NGOs and Governmental food processing unit is collected by personnel meetings and repeated survey.

Preparation methods of value added products

The juice prepared by separating the stamens from petal and ground into small pieces. The petal mass is retained in the water, and boiled for at least one hour. The slurry

thus obtained left to cool at room temperature and then filtered through cheesecloth. The filtered solution is the pure juice of flower. For the preparation of squash from the pure juice, about 2 kg of sugar is boiled in 1 litre of water. Now 1 liter of pure juice and a small quantity of citric acid (10 g/2kg sugar used) is added into the solution. The mixture is boiled again for 30 half an hour and then left to cool at room temperature. The solution obtained, is known as squash, which again filtered through cheesecloth and yield into product and stored into containers for marketing.

Results and discussion

Traditional Medicinal value of *Rhododendron*

Rhododendron arboreum is a wild plant species possesses high ecological importance and the flower of the species having unique medicinal and nutritional value. The flowers of the tree are edible and are used in the preparation of a refreshing drink in mountain region of Central Himalaya. It is used for making household goods, accent, fuelwood and agricultural implements by the local people of the region. Leaves are traditionally applied to the forehead to relieve headache. Anthocyanins and antioxidants from flowers and leaves of *R. simsii* and other species have been reported (de Loose 1970; Takahashi *et al*., 2001) but still not from *R. arboreum*. Kashiwada *et al* (2001) reported daurichromanic acid, rhododaurichromanic acid A and B from its leaves and twigs; the first two showed anti-HIV activity. Leaf composition of 206 species, subspecies and varieties showed simple phenols in 55 species, with a relatively uniform flavonoid pattern (Harborne and Williams 1971; Harborne 1986). Bark juice of *R. arboreum* is used to cure coughs and dysentery by local inhabitant of the region. Flowers are sour-sweet and are eaten raw and a decoction of the flowers is used to check vomit, especially if there is also a loss of appetite. In recent years the fresh flowers have been used for the preparation of juice and squash by local inhabitant of the Garhwal Himalaya. The juice and squash are gaining high popularity not in the Uttarakhand but all over the country due to its medicinal property. Flower juice & squash is given to the patient suffering from sugar/diabetics, used as heart tonic and believed to cure many heart diseases. The juice of the flowers is also used in the treatment of menstrual disorders.

Economic potential of edible products

Within the last few years the rhododendron squash has been gaining a high marked increase due to its bioprospecting potential. The changed have been found throughout the mountain region of Uttarakhand State, Central Himalaya. More than 87 villages of different district of the hill state viz. Chamoli, Tehri, Pauri, Uttarkashi and Rudarparyag of Garhwal region have adopted the local value addition of wild edibles as small household activity for self consumption (Table 1). There are many NGOs and government food processing centers that are fully harnessing the potential of bioprospecting of *R. arboretum* for economic benefits by preparing value added products viz. juice, sauce and squash. A number of NGOs have adopted this entrepreneur at large scale for sustaining their livelihood and earning very high economic benefit beside many governmental juice extraction and food processing unit also engaged in this venture

(Table 2). Government processing units not selling the squash of the rhododendron but they are earning economic benefit by taking charges for extraction of juice from raw material (flower) and preparation of squash to be available by local people (Table 3). There are number of stakeholders in Garhwal region who have adopted this venture as a small entrepreneur to serve the livelihood during the peak flowering (Feb-April) beside engaged in various others activities of income generation (Table 4).

Unemployment in Uttarakhand is currently an acute problem. There are not enough public sector jobs for all educated and uneducated young people. The threat of unemployment certainly reduced as some of educated as well as uneducated and unemployed youths in this region engaged themselves fully in the preparation of quality products of wild edibles (Negi *et al*., 2011). Total output and net return are very high for its products, because this plant grow abundantly in the wild and no further inputs are required, except collecting the flowers. The Central Himalaya, particularly Uttarakhand, is an important religious and tourist center, visited by millions of pilgrims and tourists every year (Maikhuri *et al*, 2004) which make available the market demand of the product very high. Many entrepreneurs have linked this venture to the eco-tourism and gaining high economic benefit through marketing their products during peak tourist season. Continuing prospects of wild edibles based value added products as a source of income are quite good and their demand is increasing and liking is growing in the region.

Table 1 Adoption of value addition of *R. arboreum* in various villages of Garhwal region, Uttarakhand

Name of district	No. of villages	Monetary equivalent (Rs/family/year)
Tehri Garhwal	13	636 ± 18.0
Pauri	11	512 ± 17.4
Chamoli	21	720 ±1 9.6
Rudraparyag	17	660 ± 18.2
Uttarkashi	15	530 ± 17.9

A shift in lifestyle of mountain people

Many of the wild fruits, flowers, twigs etc gathered by local people, are attaining high market value in recent years. A drastic change has been found in the people of mountain region for their preference to consumption of local food drink ((Maikhuri *et al*. 2007; Negi *et al*. 2011). Consumption of branded cold drinks (i.e. pepsi, limca, coca-cola etc) in urban, semi-urban and local communities is being gradually replaced by the squash prepared from *R. arboretum* flowers. Most of the families in rural villages have shifted toward the choice of juice prepared from wild edibles bioresource particularly of *Rhododendron*, even it is gaining wide attention by high class family in the urban centre and high class cities due to its refreshers quality and medicinal properties. There are many NGOs and local entrepreneurs who are sustaining their livelihood through this venture. The products prepared from bioprospecting of *Rhododendron* are also gaining

national popularity due to high nutritional and medicinal value. Entrepreneurs are supplying the products direct to the open shop in local and urban market and have created marketing network through various NGOs and different fair organized in the state, Expo-International Trade fair Delhi beside various regular fair or trade organized time to time in the state and country. Proper processing and selling through organized channel have enhanced market value of their products and these platforms enable them to access quicker benefits.

Table 2 Number of NGOs adopted bioprospecting of *R. arboretum* and its monetary equivalent in Garhwal Himalaya, Uttarakhand

Name of district	No. of NGOs	Average quantity of squash prepared	Monetary equivalent
Tehri Garhwal	4	2500 ± 27.2	150000 ± 1620.4
Pauri	3	2000 ± 22.6	120000 ± 1320.2
Chamoli	6	4000 ± 45.7	240000 ± 2546.9
Rudraparyag	5	3500 ± 38.5	210000 ± 1912.1
Uttarkashi	5	3000 ± 32.6	180000 ± 1641.3

Table 3. Income of government food processing unit through bioprospecting of *R. arboretum* in different district of Garhwal Himalaya, Uttarakhand

Name of district	No. of govt. food processing unit	Average quantity of squash prepared (Liter)	Monetary equivalent of squash (Rs)	Benefit of processing unit (Rs)
Tehri Garhwal	4	2140 ± 19.3	128400 ± 1765.3	12840 ± 248.5
Pauri	3	2750 ± 37.5	165000 ± 2247.1	16500 ± 356.1
Chamoli	5	3420 ± 42.1	205200 ± 3118.4	20520 ± 521.9
Rudraparyag	3	3250 ± 37.4	195000 ± 2636.7	19500 ± 486.4
Uttarkashi	4	2400 ± 22.8	144000 ± 1526.2	14400 ± 310.2

Table 4. Cost-benefit analyses of squash (*R. arboreum*) adopted by small entrepreneurs in Garhwal Himalaya, Uttarakhand

Particulars	**Name of district**				
	Tehri Garhwal	Pauri	Chamoli	Rudraparyag	Uttarkashi
No. of small entrepreneur	04	03	06	05	04
Average quantity of squash marketed (liter)	585 ± 18.7	420 ± 16.5	1015 ± 24.4	1570 ± 22.4	540 ± 17.7
Monetary equivalent (Rs)	35100 ± 523	25200 ± 395	60900 ± 864	94200 ± 1345	32400 ± 465
Net monetary return (Rs)	17550 ± 352	12600 ± 254	30450 ± 496	47100 ± 673	16200 ± 265
Average income/entrepreneur/year	3510 ± 65.8	3150 ± 54.1	4350 ± 72.6	7850 ± 95.4	4050 ± 68.6

Conservation issue and strategies for management

Rhododendrons require specialized habitat conditions and specific plant associations to survive. The impact of the rhododendron species on other species has its significance to ecosystem processes, succession and forest management, thus rhododendron is considered a 'Keystone element' in the Himalayan context (Singh *et al*. 2003). It is a keystone element so that if disturbed may degrade habitats that threaten associated biodiversity (Singh *et al*. 2009). The degradation of rhododendron habitat is due to lack of appropriate policy, institutional and operational infrastructure. Restoration of rhododendrons and their conservation in nature promotes the existence of other biodiversity components (Singh *et al*. 2009). It is expected that information on phytosociological analysis and associated vegetation will be helpful to solve ecological problems such as, biological conservation and management. Improved efforts of protection with community participation and *in situ* and *ex situ* conservation methodologies need to be administered in order to conserve the species and ecosystems (Giriraj *et al*., 2008). Rhododendron is the only group of plants that has continuum in the aforesaid ecotone and beyond doubt maintains the biological sustenance in this fragile zone (Singh *et al*. 2009). Nutrient and water fluxes between the associated species are filtered and possibly impacted by these genera (Swank and Crossley 1998). Maintaining viable population of wild edible species is a crucial factor in its conservation and this requires appropriate approaches/framework (Maikhuri *et al*. 2009, Negi *et al*. 2011) and conservation methods. Trees largely determine the architecture and microclimatic conditions of the forest and hence, the changes in tree community dynamics may strongly affect other forest species (Browkaw 1985) and ecological processes in a stand (Singh and Singh, 1986; Kharkwal *et al*. 2005).

In many parts of the Himalaya, these resources are critical, especially for the poor, in securing subsistence needs in times of hardship and emergencies when quick cash is required or when casual food stores run out (Sundriyal *et al*., 2003; Maikhuri *et al*. 2004). Bioprospecting of *R. arboreum* open up wide scope for livelihood options to rural inhabitants of the region but at the same time also exerted anthropogenic pressure on the species since it is widely used for fodder, fuelwood and for preparation of agricultural equipments in the region. Therefore, sincere efforts are needed to promote its conservation through domestication and sustainable harvesting. Very little information is apparently available on the germination of rhododendrons. The rhododendron species are propagated by vegetative means as well as through seeds (Singh *et al*. 2009). The rate of vegetative propagation is very slow in many rhododendron species and seed germination in nature is also very poor (Singh *et al*. 2003, 2009). Research activities may mitigate the impasse to a certain degree by developing nurseries and their subsequent planting, but overall success depends on the conservation by the local inhabitants through sustainable harvesting and conservation. Picking of flowers from single tree should be amounts to about 60% only and the rest of the blooms are left out on the tree to mature into seeds for conservatives measures (Singh *et al*. 2003). Educating NTFP collectors about distribution and vulnerability of different species encourage them to adopt non destructive sustainable harvesting methods of collection. Awareness and capacity building programme of local communities regarding the sustainable extraction of forest resources to be organized

regularly through involvement of *Van Panchayat*, various NGOs and *Gram Sabha* since they can play an important role in developing community organizations.

A. Flower of *Rhododendron arboreum*, B & C. Bioprospecting of *Rhododendron arboreum* at village level, D. Small entrepreneurs at village level involved in bioprospecting of wild edibles

Conclusion

Underexploited and underutilized natural resources with potential economic significance are crucial in maintaining subsistence lifestyles in traditional mountain societies. The ability of a given wild bioresources to continue meeting both subsistence and market needs however, largely depends upon sustainable harvesting and appropriate management practices for their conservation. The wild edibles of the area need to be promoted as a horticultural crop and the farmers/local people need to be encouraged to develop/establish nurseries of these wild edibles. Efforts are required for value addition and create awareness about their high nutritive and medicinal value as a health food drink among rural, urban and semi-urban consumers for solving malnutrition on one hand and

economic development on the other. The information on such plants may help adding variety to the monotonous diet so that requirements of minerals and vitamins etc. are easily met and help in publicizing the hitherto less known resources of wild fruits to many naturalists, visitors, tourists, mountaineers, researchers and local population.

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