Basic nutritional attributes of *Hippophae rhamnoides* (Seabuckthorn) populations from Uttarakhand Himalaya, India

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Nutritive value of *Hippophae rhamnoides* (Seabuckthorn) berries and seeds collected from a few prominent locations of Uttarakhand Himalaya were analysed. Fresh fruit berries and seeds were collected from randomly selected healthy mother plants (15 plants) from Mana, Niti, Bhyundar, Gangotri and Yamunotri valleys of Garhwal Hills for determining the various biochemical constituents. The nutritional value, biochemical constituent assessment (acidity, fat, lignin, carbohydrate, reducing sugar, starch, protein, etc.) and the mineral composition analysis (nitrogen, phosphorus, sodium, potassium, iron, copper, zinc, magnesium, arsenic, etc.) were carried out using standard analytical techniques. These analyses revealed that the fruits and seeds from the Gangotri valley possess higher nutritive value in terms of fat, protein, carbohydrate, reducing sugars and lignins, and those from the Mana valley possess higher starch and acidity content. The fruits and seeds of Gangotri valley are also rich in the macro and micronutrient element composition. These findings have important connotations in light of upcoming organic foods and nutriceutical industries in the state.

Keywords: Domestication and rural development, *Hippophae rhamnoides*, multipurpose, nutritive value.

SINCE time immemorial, traditional knowledge and indigenous evidences suggest that a variety of wild edible plant species in the Himalayan region have played a prominent role in providing food and medicine for human beings as well as animals[1]. Majority of the wild edible plants are a good source of nutrition being rich in proteins, minerals and vitamins. During the recent past, wild edibles have featured prominently in the discussions and framework of rural development and biodiversity conservation[2]. Poor rural and tribal people depend on a wide variety of plants, animals and fungi for their own consumption and for income generation. Some of these wild edibles have huge economic potential to generate income[3]. The ability of a given wild resource to continue meeting both subsistence and market needs however, largely depends upon its ability to provide diverse resources or services and sufficient production to meet the demands. Sustainable harvesting and appropriate management practices of *Hippophae rhamnoides* (Seabuckthorn) have been listed as one of the prominent bioresources from the Uttarakhand Himalaya for economic benefits. Though available distribution records indicate the genus is well represented in Uttarakhand at elevations 2500 masl, information on production of fruits which are the main source of food products is poor. While several suggestions were being put forward to enhance the area of this species through plantation, identifying the potential populations from the wild, and their production and biochemical constituents of food value should be understood before bringing such populations to cultivation on underutilized land/wastelands in the area. The present study is an attempt to assess biochemical composition of fruit berries and seeds of this species from five prominent populations of Central Himalaya. Such information is expected to help local communities improve their livelihood in an environmentally sustainable manner while harnessing the potential of this species to meet both short and long-term subsistence, social, economic, cultural and conservation needs.

H. rhamnoides, locally known as Ames in Chamoli district, Ameel in Uttarkashi district and Chook in Pithoragarh district, Uttarakhand belongs to the family Elaegnaceae. This deciduous shrub or small tree is widely distributed throughout the subtropical mountainous zones of Asia. In India, the plant is generally found in the higher Himalayan regions of Himachal Pradesh, Jammu and Kashmir, Northeast and Uttarakhand. In Uttarakhand it grows abundantly in the wild, mostly on river banks and sun-facing steep slopes between altitudes of 2000 and 3600 masl. It generally grows on sandy soil, exposed river bed, soil deposits near streams and even in forests. Morphologically, the plants show great plasticity to the environment, but typically grow 1.5–9 m in height. In China[4], it is also found to attain heights up to 18 m. *H. rhamnoides* is a fascinating species in the plant kingdom and well known for its multifarious virtues and multidimensional uses[5]. During the last decade, Seabuckthorn has attracted special attention of researchers, scientists and environmentalists from Asia, Europe and recently from North America because of its multiple uses. However, China has been the only country harnessing the full potential of this plant for food, medicine and cosmetics[4].

In recent times, the edible parts of Seabuckthorn are being significantly used in various life-saving drugs and health tonics. In China, Seabuckthorn oil is used as medicine for treating burns, gastric, skin radiations, cervical erosion and duodenal ulcer[6,7]. The role of Seabuckthorn

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on anti-oxidation, the immune system and circulatory system was analysed. These studies indicate that it has the potential and has proved useful in the treatment of AIDS[8].

Rural people of Central Himalaya traditionally use this fruit as food for preparing chutney (local jelly) and medicine. The Bhotiya tribe of Niti and Mana valley mix the fruit juice of *H. rhamnoides* with sugar cubes/gur and boil it for 2–3 h in an iron pan. The thick and dark brown to black-coloured cake produced is used as medicine to get relief from cold, cough and throat infection. Inhabitants of high altitude in general, and *Hippophae*-growing areas in particular, also use the fruit berries for veterinary medicine. The juice extracted from the fruits is known to reduce the poisonous effects of some plants grazed by livestock, mainly cattle, sheep and goat. Besides, the Bhotiya tribe of this region uses the juice and pulp of fruit berries as a substitute for tomato or curd during winters for vegetable and curry preparation. A small-scale production of squash locally called 'Himamesh' after value addition of *Hippophae* fruits, was produced by local entrepreneurs with technical inputs from us[5,9]. The nutrient composition of the leaves of *H. rhamnoides* suggests that it is a suitable fodder plant for livestock during winter[10].

Light orange to dark orange-coloured, pea-sized fruit berries are well known for their polyvitaminous properties; the most prominent feature is that the fruits of this species are one of the richest sources of vitamin C (780 mg/100 g). It is also reported that Seabuckthorn fruit berries and seed oil contain 190 and 106 kinds of bioactive substances respectively[6,7]. Seed oil contains vitamin K (about 109.8 to 230 mg/100 g) which promotes blood coagulation because of its catalytic role in forming prothrombin[4]. There are many mineral elements present in the fruit berries, fruit juice and seeds of Seabuckthorn.

Fresh, mature and ripe fruit berries and seeds were collected from randomly selected healthy mother plants (15 plants from each valley) from all the five valleys of Garhwal Himalaya, viz. Mana, Niti, Bhyundar, Gangotri and Yamunotri in mid-November 2004. The fruit juice was extracted using a simple hand-press method and sieved with the help of a muslin cloth for proximate mineral analysis. The remaining residue (pulp and seeds) was dried in the sun followed by oven-drying. The dried pulp and seed samples were made to fine powder using a plant grinder. Proximate and ultimate biochemical analysis was carried out following the standard methodologies[11–14].

The biochemical constituents and mineral element composition of samples collected from five prominent populations of *Hippophae* from Mana, Niti, Bhyundar, Gangotri and Yamunotri valleys of Garhwal Himalaya are given in Tables 1–3.

The moisture content of fresh fruit varied from 84.9 in Niti valley to 97.6% in Gangotri valley. Total soluble solid (TSS) content varied between 9.72% (Bhyundar population) and 8.86% (Mana population). The quantity of starch was highest (85.17%) in Mana population and lowest (29.42%) in Gangotri population, and acidity content was found highest (6.8%) in Mana population and minimum (6.3%) in Niti population. Fat content was highest (10.33%) in the fruit pulp of Gangotri population.

While the protein content was highest (7.13 and 28.33% respectively, in fruit pulp and seeds) in Gangotri population, it was only 5.42% in fruit pulp of Bhyundar population and 22.79% in seeds of Yamunotri population. Similarly, carbohydrate content in fruits was highest (0.40%) in Gangotri population and lowest (0.30%) in Bhyundar population. Reducing sugars was highest (6.0%) in the fruits of Bhyundar population and lowest (5.0%) in Yamunotri and Mana populations.

Table 1. Comparative account of biochemical composition of fruit pulp of *Hippophae rhamnoides* populations sampled from different valleys of Uttarakhand Himalaya and other areas

Valley/ country	Moisture (%)	TSS (%)	Acidity (%)	Reducing sugar (%)	Starch (%)	Lignin (%)	Fibre (%)	Fat (%)	Carbohydrate (%)	Total protein (%)	Source
Yamunotri	88.4	9.08 ± 0.05	6.6 ± 0.14	5.0 ± 0.16	37.04 ± 0.98	21.67 ± 0.67	12.0	9.00 ± 0.58	0.39 ± 0.02	6.38 ± 0.07	Present study
Bhyundar	85.3	9.72 ± 0.06	6.6 ± 0.01	2.3 ± 0.17	48.87 ± 1.01	26.33 ± 2.85	12.0	9.33 ± 0.33	0.30 ± 0.02	5.42 ± 0.11	Present study
Mana	86.4	8.86 ± 0.05	6.8 ± 0.002	5.0 ± 0.00	85.17 ± 1.03	17.67 ± 0.88	13.0	10.00 ± 0.58	0.37 ± 0.01	5.83 ± 0.22	Present study
Niti	84.9	9.28 ± 0.07	6.3 ± 0.01	2.1 ± 0.16	62.55 ± 1.21	18.00 ± 0.00	13.0	8.33 ± 0.67	0.34 ± 0.002	5.96 ± 0.18	Present study
Gangotri	97.6	9.28 ± 0.14	6.5 ± 0.003	6.0 ± 0.003	29.42 ± 0.97	21.33 ± 0.67	14.0	10.33 ± 0.88	0.40 ± 0.01	7.13 ± 0.64	Present study
Yamunotri	88.4	9.08 ± 0.05	6.6 ± 0.14	5.0 ± 0.16	37.04 ± 0.98	21.67 ± 0.67	12.0	9.00 ± 0.58	0.39 ± 0.2	6.38 ± 0.07	Present study
Northern area of Pakisthan	Nd	Nd	3.9	Nd	Nd	Nd	12.7	18.6	Nd	18.3	Sabir *et al.*[27,28]

Nd, no data.

Table 2. Comparative account of nutrient composition in fruit pulp and seeds of *H. rhamnoides* populations from different valleys of Uttarakhand Himalaya and other areas

Valley/ country	Fe (ppm)		Mg (ppm)		Cu (ppm)		Zn (ppm)		As (ppm)	
	Pulp	Seed	Pulp	Seed	Pulp	Seed	Pulp	Seed	Pulp	Seed
Yamunotri	1.127 ± 0.093	0.593 ± 0.153	0.72 ± 0.050	2.487 ± 0.321	0.133 ± 0.007	0.097 ± 0.044	0.92 ± 0.092	0.817 ± 0.294	0.06 ± 0.004	0.099 ± 0.012
Bhyundar	0.727 ± 0.086	0.46 ± 0.017	0.62 ± 0.1	2.996 ± 0.114	0.11 ± 0.006	0.043 ± 0.003	1.3 ± 0.075	0.827 ± 0.044	0.077 ± 0.014	0.145 ± 0.007
Mana	0.753 ± 0.074	0.36 ± 0.006	1.703 ± 0.534	1.806 ± 0.209	0.133 ± 0.022	0.023 ± 0.0067	0.817 ± 0.247	0.497 ± 0.0088	0.16 ± 0.006	0.078 ± 0.002
Niti	0.703 ± 0.023	0.573 ± 0.007	0.78 ± 0.035	3.04 ± 0.081	0.09 ± 0.006	0.057 ± 0.018	1.14 ± 0.645	2.83 ± 0.373	0.064 ± 0.013	0.063 ± 0.007
Gangotri	0.81 ± 0.090	0.647 ± 0.013	1.92 ± 0.727	2.843 ± 0.339	0.103 ± 0.003	0.043 ± 0.003	2.74 ± 0.383	1.943 ± 0.514	0.231 ± 0.012	0.095 ± 0.004
Northern area of Pakisthan[27,28]	0.04–0.225	Nd	0.139–0.249	Nd	Nd	Nd	Nd	Nd	Nd	Nd
China[29]	0.064	Nd	0.41–0.56	0.47–0.73	0.0115–0.04	0.038–0.12	0.08–0.12	0.088–0.27	Nd	Nd
Finland[29]	0.022	Nd	0.34–0.53	0.56–0.79	0.0113–0.014	0.06–0.095	0.089–0.13	0.14–0.27	Nd	Nd

Table 3. Comparative account of nutrient composition in fruit pulp and seeds of *H. rhamnoides* populations from different valleys of Uttarakhand Himalaya and other areas

Valley/country	Sodium (%)		Potassium (%)		Phosphorus (%)		Nitrogen (%)	
	Pulp	Seed	Pulp	Seed	Pulp	Seed	Pulp	Seed
Yamunotri	0.63 ± 0.07	0.39 ± 0.11	11.62 ± 0.7	10.38 ± 0.34	0.67 ± 0.01	0.61 ± 0.003	1.02 ± 0.01	3.65 ± 0.03
Bhyundar	0.47 ± 0.07	0.41 ± 0.03	10.12 ± 0.9	10.90 ± 0.17	0.63 ± 0.01	0.65 ± 0.03	0.89 ± 0.01	3.74 ± 0.01
Mana	0.51 ± 0.07	0.49 ± 0.11	12.07 ± 0.2	10.12 ± 0.32	0.66 ± 0.05	0.66 ± 0.003	0.93 ± 0.04	3.73 ± 0.08
Niti	0.59 ± 0.11	0.31 ± 0.03	13.21 ± 0.3	9.33 ± 0.28	0.60 ± 0.02	0.63 ± 0.02	0.95 ± 0.03	4.09 ± 0.05
Gangotri	0.53 ± 0.07	0.05 ± 0.01	14.84 ± 0.2	13.42 ± 1.47	0.63 ± 0.007	0.69 ± 0.00	1.14 ± 0.10	4.53 ± 0.07
Northern areas of Pakisthan[27,28]	0.065–0.8		2.8–7.2		0.11–0.133		Nd	
China[30]	Nd	Nd	1.5	0.34	Nd	Nd	Nd	Nd

Nitrogen content in the fruit pulp varied between 1.14 (Gangotri population) and 0.89% (Bhyundar population) and in seeds between 4.53 (Gangotri population) and 3.65% (Yamunotri population). While the fruit pulp of Yamunotri population contains 0.67% of phosphorus, it is only 0.60% in the Niti population. In seeds it varied between 0.69 and 0.61% for the populations studied.

Potassium plays an important role in the ionic balance and helps in maintaining the tissue excitability of the human body[14]. Concentration of potassium is more abundant among all the elements investigated in the fruits and seeds of *H. rhamnoides*. It varied between 14.84 (Gangotri population) and 10.12% (Bhyundar population) in fruit pulp and between 13.42 (Gangotri population) and 9.33% (Niti population) in seeds. Other macro and micronutrients, viz. sodium, magnesium, iron, copper, zinc, etc. are found to be present in less to moderate quantity in fruit pulp and seeds of *H. rhamnoides* (Tables 2 and 3). The estimated nutritive value of *H. rhamnoides* fruit pulp varied between 110 and 120 cal/100 g (Figure 1).

The present biochemical studies reveal that fruit berries and seeds of Seabuckthorn are an important source of valuable nutrients, minerals and several other bioactive substances for the local population. Among the different populations studied, the one at Gangotri valley seems to have slightly higher nutritive value and is rich in mineral content followed by those at Mana, Yamunotri, Bhyundar and Niti valley. Biochemical analysis of fruit and seed samples collected from different populations revealed that the fruit and seed of Gangotri population contain good quantity of fat, protein, carbohydrate, reducing sugars and lignin, whereas starch and acidity content were found higher in the fruit pulp of Mana population. The fruit of Gangotri population is also rich in macro and micronutrient composition, i.e. iron, potassium, nitrogen, phosphorus and arsenic in both fruit pulp and seeds compared to the other populations.

The production potential of this species and sustainable harvest of edible and other useful parts can boost the local economy. On an experimental basis, local value addition was attempted by preparing squash from the pure fruit juice of this species and sold locally as Himamesh (Figure 2). This technology was demonstrated to the people to encourage them to adopt it in the form of a small village-level cottage industry[5,9]. Seabuckthorn fruit juice was also introduced to the market by the National Agricultural and Marketing Federation (NAFED) under the brand name 'Leh Berry' and priced at Rs 10 per 100 ml pack/bottle. About 300 people from Leh and Ladakh are getting part- or full-time employment from the Seabuckthorn-based cottage industry, which manufactures juice, jam and sauce[15]. We have conducted awareness camps and training workshops in these valleys of Uttarakhand Himalaya during 2002–04. As a result of such outreach programmes, about 54 households in 11 villages of five valleys from the Garhwal region have begun extracting juice to meet the requirements of the local entrepreneurs or pharmaceutical companies, in addition to their own consumption. At present these household entrepreneurs sell fresh fruit juice at the rate of Rs 160/l. On an average a household could earn about Rs 2000 for 3–5 days they spends during November when the fruits are ripe[16].

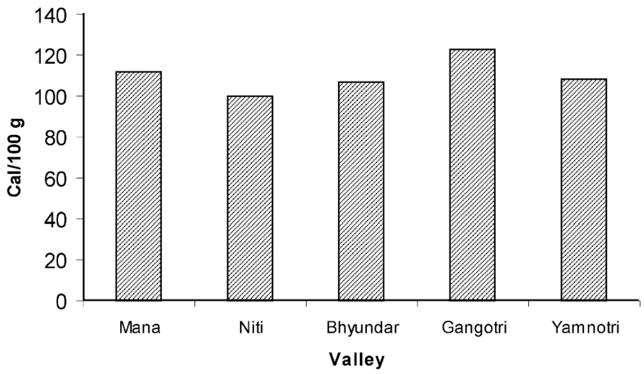

Figure 1. Nutritive value of fruit berries (without seeds) of *Hippophae rhamnoides* in five valleys of Uttarakhand Himalaya.

Figure 2. *Hippophae rhamnoides.* ***a***, Full blooms of ripened plant; ***b***, Fruit berries; ***c***, Juice extraction; ***d***, Locally prepared juice.

Seabuckthorn provides ecological stability to fragile land checking soil erosion, conservation of soil moisture, enhancing soil fertility through biological nitrogen fixation (*Hippophae*-dominated forest can fix 180 kg N/ha/yr) and provide health benefits/nutritional security[4,17–20]. The economic potential of this species could be utilized for local development by domestication and large-scale multiplication of this species on underutilized/wasteland. *Hippophae* being a dioecious plant, selection of proper male and female plants as source material for area expansion and positioning of 6–10% male trees as pollinators in the wind-flow direction are basic requirements to have good yields. As such, requirements could be met only by manpower capable of identifying sexes of plants, and planting design keeping wind direction during pollination is critical for the success of the programme. The present basic nutritional assessment in addition to sophisticated analyses from other regions[21–25] is expected to provide sufficient guidelines to the Uttarkhand government in developing a viable action plan for *Hippophae* resources and bioindustrial potential. Exploitation of this important resource is also suggested by other workers[26].

The recent increase in interest in potential wild bioresources has been a consequence of shift in development focus. Increasing unemployment in the rural sector in mountains in particular, is likely to have serious ramifications on socio-economic and environmental balance. In spite of numerous laudable developmental programmes and huge investments, the reality of rural livelihood in mountains is rather alarming. With the growing concern and commitment to hill-area development and poverty alleviation, untapped and underutilized wild bioresources such as *Hippophae*, where disturbances to ecosystem are minimal (only fruits are harvested and not the total plant biomass), could contribute to a household's food and livelihood security. Within this approach, local value addition in potential wild edibles has begun to attract attention as being one of the income-generating components of the non-farm part of rural economy.

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