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Cultivation of "Badri Berry" (*Hippophae salicifolia* D. Don) for multiple profit with special reference to natural demographic surveys of Uttarakhand Himalayas

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Abstract
Sea buckthorn, the "Badri Berry" (*Hippophae salicifolia* D. Don) of Uttarakhand, is an important medicinal plant that is grown naturally in extremely cold conditions in cold desert areas of this Himalayan state. The plant has high medicinal importance but was unknown to the general public till the recent past. With general awareness of its modern traits recently, it has gained global attention due to its nutritional and therapeutic properties. It is one of the most important underutilized plants at high altitudes in the cold desert region of the Himalayas, including J&K, Himachal, and Uttarakhand. It has immense industrial, medicinal, cosmetic, and pharmaceutical importance and has a lot of potential as a bio-resource for land reclamation because of its ability to bind soil, provide rapid surface cover, fix nitrogen, and endure cold and drought. However, research on sea buckthorn is still limited due to recent awareness among people in general. This brief review and research data summarize the demographic status, economic potential, multiple uses, and properties, consequently, which may lead to its large-scale conservation, cultivation, and utilization within the state and country. Sea buckthorn, which will give momentum to recognize it as an exceptional plant in the state of Uttarakhand.

Keywords: Sea buckthorn, Badri Berry, *Hippophae salicifolia*, Pharmaceutical, Super fruit, Demographic Status, Nutritional properties, Soil Conservation.

1. Introduction
Sea buckthorn is locally known as 'Chuk,' 'Ames,' and 'Ameel' in Uttarakhand. The second author of this article proved it as "Badri Berry" on the basis of the ancient literature of Skanda Purana and Srimad Bhagavatam. Hence, further in this paper, we will mention sea buckthorn (*Hippophae salicifolia* D. Don) as "Badri Berry." Badri berry is a hardy, spiny, and thorny shrub thriving in Uttarakhand's high altitudes. It is famous for its tiny, bright orange-yellow berries, which are very rich in vitamin C and antioxidants. Yellow berries are used traditionally for health and now for their juices, oils, and supplements. Multiple uses of the plant make it a valuable "green gold" for local livelihoods and ecological balances for the whole Himalayas.

The natural variety of sea buckthorn, i.e., "Badri Berry" of the Uttarakhand Himalayas, is scientifically known as *Hippophae salicifolia*, while in Himachal and Jammu Kashmir, it's another species, *H. rhamnoides*, which is common. The berries of *H. rhamnoides* are bright orange in color, and the berries of *H. salicifolia* are bright yellow. It is a dioecious and deciduous shrub belonging to the family Elaeagnaceae. It is widely recognized as a "multipurpose wonder plant" due to its rich nutritional profile, extensive health benefits, and significant ecological value in cold-temperate regions of the Himalayas, especially in Uttarakhand.

Hippophae salicifolia D. Don, known as willow-leaved sea buckthorn, is a significant wild species in the Uttarakhand Himalayas, thriving in riverine areas (for example Alaknanda and Yamunotri) from 1500 to 3500 m, valued for its nutritious fruit and soil stabilization, with key habitats in Uttarkashi, Chamoli, and Pithoragarh, often forming dense stands on sandy/gravelly slopes. Local names include 'Chuk' or 'Ameel,' and studies highlight its importance for bio-fencing, fuel, fodder, and medicine, with research focusing on its genetic diversity and ecological roles[1].

Figure 1. 'Badri berry' (*H. salicifolia*) plant with fruits

Sea buckthorn is a resilient, nutrient-dense shrub known for its bright orange/yellow berries profoundly rich in vitamins (C, E, and B12), antioxidants, and healthy fatty acids (omega 3, 6, 7, and 9). It has been used for centuries in traditional medicine (Ayurveda and Tibetan) for glowing skin, skin protection from cold, digestion, inflammation, and many more ailments. It is a 'super fruit' gaining modern use in juices, supplements, and cosmetics and as a restorative plant for harsh environments, valued for its potential health benefits and unique nutritional profile. It is exceptionally rich in a diverse array of nutrients and bioactive compounds, which vary depending on the plant part, origin, and processing method. It is often called a "natural vitamin treasure house" due to the presence of nearly 200 components with potential nutritional and medicinal value[2].

In Uttarakhand, the Herbal Research and Development Institute, Mandal-Gopeshwar, is working on multiplication and conservation through cultivation of suitable varieties of this plant in farmers' fields. Promotion of farmers for its cultivation and nursery development activities is being done for its mass-scale cultivation and multiple profits, which may uplift the farmers' socio-economic status in the near future.

2. Cultivation and Management

The plant of 'Badri berry' has significant and abundant wild growth in high hills of Pithoragarh, Rudraprayag, Chamoli, and Uttarkashi districts. The plant thrives in cold, high-altitude deserts, tolerating harsh conditions but needing well-drained soil. It grows on hill slopes in well-drained, sandy soil having pH 6.5-7.5, ensuring at least one or more male plants in 12 to 15 female plants for good fruiting and spacing them adequately 2 to 3 m apart for air[3].

In Jammu & Kashmir, Ladakh aims to be the Sea Buckthorn Capital with vast natural reserves, though production needs modernization. Uttarakhand and Himachal Pradesh also have significant wild growth and government institutions; universities and non-governmental organizations are working on this plant on a project-based management basis.

Large-scale 'Badri berry' cultivation requires scientific farming in high-altitude cold regions, as it is very difficult to grow, care for, and harvest the crop in cold desert areas. At present basic need of large-scale cultivation of 'Badri berry' is

planned management of progressive farmers' awareness, large scale planting material production and sustainable cultivation of available planting material of this 'golden crop'.

In Uttarakhand, the Herbal Research and Development Institute (HRDI), Mandal-Gopeshwar, has previously worked on planting material, fruit juice extraction, jam, and herbal tea production with the assistance of financial support from the National Medicinal Plant Board (NMPB), Government of India, from 2016 to 2018. Under this project HRDI established a high-altitude nursery at Munsiyari, Pithoragarh, and managed it as the quality planting material production site of 'Badri berry' in 2018. Approximately 200 plants of *H. salicifolia* were raised in this nursery in 2018, out of which 91 plants survived well in the nursery, and flowering and fruiting have taken place in 10 to 15 plants since 2024. It shows that it takes 5 to 7 years for flowering and fruiting after cultivation of healthy samplings.

3. Demographic Surveys & Methodology

In view of data recording on demographic structure, fruit, dry fruit, seed, and juice extraction of this 'Badri berry,' various surveys were conducted in different years and seasons by the institute. Harshil, Har-Ki-Dun & Gangotri valleys in Uttarkashi, Badrinath hills & Mana valley in Chamoli, and Darma & Vyas valley and Munsiyari hills in Pithoragarh districts were surveyed during the project period in 2016 and 2017 and after the project period in 2025 as follows:

During the Project Period in 2016 & 2017: - Surveyed for juice extraction and data collection of 'Badri berry' in Darma & Vyas valley in Oct-Dec 2016 and 2017.

After Project Period in 2023: - Surveyed for juice extraction and data collection of plants in Mori, Osala, Gangad villages, and Har-ki-Dun valley in Oct 2023.

After Project Period in 2025: - Surveyed for juice extraction and data collection of plants in Joshimath and Badrinath hills in Nov 2025 and Munsiyari and Khaliyatop hills in Dec 2025.

During the surveys, local people known to this species were contacted and asked questions for data collection on multiple uses of fruit juice and plant parts, natural availability around their habitation, area distribution, and expected area around the regions. On average, 15 to 20 local people of each valley/village were asked questions for data collection on juice preparations, plant part use, distribution, growth behavior pattern of the plant, and available data were recorded for this species in different parts of Uttarakhand. Fruits were collected from different sizes (smallest to largest) of fruiting trees, and juice was extracted from the collected fruits. Fresh fruit dried in sunlight for 20-25 days and weighed. After extraction of juice from fresh fruits, the remaining seeds/residue were dried and weighed for data recording on seed availability, fresh fruit weight, dry fruit weight, and per-unit juice extraction.

4. Results and Discussions

4.1 *Area and Distribution*

During the different surveys at different intervals, data was recorded on the basis of local inhabitants except in the Niti and Yamunotri valleys. Data recorded on flowering and fruiting, average height of fruiting trees in different locations, approximate distributions of the species in the region, and altitudinal range of occurrence, which is shown in Table-1. During the surveys it was observed that only a maximum of sixty percent of people were aware of the species and its importance, but in tribal areas like the Mana, Darma, Vyas, and Chaudas valleys, one hundred percent awareness was found about the species and its valuable fruit juice extraction. It was observed during interrogation of the tribal community in these areas that the tribal community traditionally obtained and used the juice of the 'Badri berry.' The majority of old people of the tribal community used to boil the juice up to half the quantity and keep it for use for a long time, up to 20 years. It is seen in the field that boiled juice becomes black in color and is never perishable.

Survey works were not conducted by authors for Gaurikund in Rudraprayag district and Niti valley in Chamoli district, and available data were cited from the existing literature to have complete data on sea buckthorn distribution within the state.

Table 1. Growth behavior pattern and approximate distribution of 'Badri berry' in cold alpine areas of Uttarakhand Himalayas

Sl	District	Area Visited/ Villages Surveyed	Growing Altitude Range msl	Recorded Average Plant Height m	Flowering Period	Fruiting Period	Approximate distribution area (ha)
1.	Uttarkashi	Sankari, Taluka, Dhatmir, Osla and Gangad (Har-di-Dun Valley)	1500- 3500	3-7	June-July	Aug-Sept	300
		Gangotri, Mukhwa, Harshil, Bagoli, Dharali, Jhala, Sukhhi, Purali, Barsu and Raithal (Gangotri-Harshil Valley)	1700-4000	3-10	June-July	Aug-Sept	800
		Kharsali, Janki Chatti, Hanuman Chatti, Phool Chatti, Syanachatti and Bhairo Ghati (Ymunotri Valley)	1500-3700	2-8	June-July	Aug-Sept	1000
***2.**	Rudraprayag	Gaurikund, Sonprayag, Trijuginarayan along Mandankini River (Kedar Valley)	1800-2700	3-9	June-July	Aug-Sept	**300***
3.	Chamoli	Pandukeshwar, Govindghat, Hanuman Chatti and Mana Village (Mana-Badri Valley)	2700-3800	2-8	June-July	Aug-Sept	1200
		Malari, Gamshali, Bampa, Farkya, Lata, Tolma and Niti (Niti Valley)	2200-3500	3-9	June-July	Aug-Sept	**200** *
4.	Pithoragarh	Munsiyari, Darkot, Sarmoli, Laspa and Khaliya Top (Munsiyari Valley)	2200-3300	3-8	May-June	July-Aug	400
		Dugtu, Daatu, Baling, Sella and Nagling (Darma Valley), Garrijang, Budhi, Gunji, Nabi, Rongkang, Napalchu and Kuti (Vyas Valley) and Sridang and Sirkha (Chaudas Valley)	1500-4000	2-10	June-July	Aug-Sept	1000
Approximate distribution area of sea buckthorn i.e. 'Badri berry' in Uttarakhand Himalaya							5200
*Distribution data source of Kedar Valley and Niti Valley[4]							

It is recorded that approximate wild distribution of the highly important species in the state is about five thousand two hundred hectares, which shows sufficient planting material is available in the nature for enhancement of rapid conservation programs in farmer's field.

Naturally in cold desert/alpine areas of Uttarakhand Himalaya, 'Badri berry' plants are available from 1500 m to 4000 m elevation range. Plant height was recorded from 2 m minimum to 10 m maximum. It is observed that in extremely dry hill slopes plant populations are found sparsely distributed here and there. This may be due to plant growth checked by extreme dry conditions and less availability of soil moisture, while in shady and damp areas population growth found in herd of about 100 to 200 plants and height of plant found 7 to 10m. Plant growth and more height gain may be due to the availability of sufficient moisture for growth enhancement of the plant. It is already reported in literature that generally *H. salicifolia* is a shrub that could grow up to a tree size (4–10 m) at 1500–3200 m above mean sea level and is limited in its biogeographical distribution to the Himalayas[5, 6]

Indigenously, the ethno-botanical uses of *H. salicifolia* by the regional people of the Central Himalaya include animal feed, cosmetics, food, fuel, medicine, veterinary care, and bio-fencing, etc.[7, 8].

Generally, it was observed that the flowering period of the plant is June-July throughout the state, but it was recorded as May-June in the Munsiyari nursery in the cultivated nursery area of sea buckthorn plants. Fruit ripening of these cultivated plants was also observed two months early in August-September, while ripening of fruit in the wild is recorded from Oct to Dec in the naturally grown regions. The height of the Munsiyari nursery is 2300 m; therefore, there is a slightly higher temperature in comparison to the natural cold desert habitat of the plant, which may affect the flowering and fruiting of the plants. Early flowering and early ripening of fruit may be due to higher temperatures in cultivated areas in the Munsiyari nursery. These plants in the Munsiyari nursery were raised in 2018, and flowering and fruiting started during May to Sept in 2024. This shows that if 'Badri berry' is cultivated on farmers' land, flowering, fruiting, and ripening of fruits may take place early, from the end of August to September.

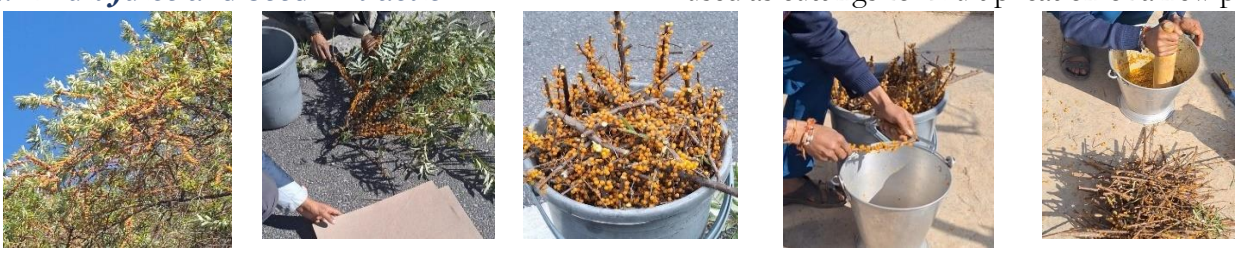
Fruits with small fruiting stems were collected from Har-ki-Dun, Harshil Valley, Badrinath Hills & Mana Valley, and Munsiyari & Vyas Valley from September to December in the years 2022, 2023, and 2025 to find out the data on juice extraction, seed availability per unit, and cuttings available per unit from wild collection, which is shown in Table 2. Tiny stems with fresh fruit and leaves were collected from the source in nature. Fresh fruits were separated from the tiny stems and collected in a fresh pot, weighed, and juice extracted. After extraction of juice, the weight of residue is taken and recorded, and the remaining tiny stems are cut down into 6-inch pieces for raising new plants as cuttings in nurseries.

It is observed that planting material in the form of seeds and cuttings may be gotten from the wild, by which no adverse impact on its natural population may occur. It is also seen that plucking of ripened fruit and extraction of juice from them left residue and small stem cuttings. In the remaining residue, seeds are available, which may be used as seed for multiplication, and the small stem after removing the fruit may be used as cuttings for multiplication of a new plant.

Table 2. Juice extraction, seed availability per unit and cutting available per unit from wild collection of 'Badri berry' from different locations

S.N	District	Sample collection area	Weight of fresh fruit Kg	Quantity of juice extracted kg	Weight of fresh residue after juice extraction kg	Weight of dry residue after juice extraction kg	Seed counts in dry residue	Available 6 inch cutting
1.	Uttarkashi	Sukhi Harshil	4 kg	1.1	2.95	0.750	18000	776
2.	Chamoli	Badrinath hills	5 kg	1.2	3.25	0.812	23000	975
3.	Pithoragarh	Munsiyari Nursery	3 kg	0.770	2.25	0.66	14100	580
		Darma Valley	4 kg	1.2	2.90	0.760	18500	796
Total Average			4 kg	1.06 kg	2.83 kg	0.745 kg	18400	3137
Per Kg Average			**1 Kg**	**0.265 kg**	**0.709**	**0.186**	**4600**	**784**
Average Percentage			**100 %**	**26.5 %**	**70.90 %**	**18.6 %**	**-**	**-**

4.2 *Fruit Juice and Seed Extraction*



Fruiting tree | Fruit collection | Fresh fruit with stem | Fruit separation from stem | Manual juice extraction

Figure 2: Fruit Collection of 'Badri berry' (*H. salicifolia*)

During the study fresh fruits with small stems were collected from the wild for extraction of juice manually, and average per-unit data on juice quantity, fresh residue quantity after juice extraction, dried residue quantity, seed counts in dried residue, and available stem cuttings for raising new plants were recorded.

It is observed that an average of 26.5 percent pulp juice may be extracted manually from one kg of fresh fruit, which may be enhanced if juice may be extracted mechanically. After extraction of juice from fresh fruits manually, 70.90 percent remaining residue is calculated, which included seed and fruit bark and other contents like small stem parts. When it dried, fresh remaining residue after extraction of juice, the average dried weight was 18.6 percent of fresh residue.

Based on the study, it may be concluded that from 1 kg of fresh fruit, 265 gm of juice may be obtained manually with 709 gm of fresh residue bearing seeds, which remains 186 gm after sun drying. It may also be concluded that in 1 kg of fresh fruits, approximately 4600 seeds are available, and from the stem part of 1 kg of fresh fruit, around 700 to 800 cuttings of 6 inches for new planting material may be obtained for raising in a nursery.

As per several studies, the reported moisture content of berries comes under the range of 84.9 to 97.6% for the sea buckthorn, and Uttarakhand's 'Badri berry' yields significant juice, with berries containing 60-80% juice, rich in nutrients.[9]. In the present study juice was extracted 26.5% in manual efforts; it may increase up to 60-80% mechanically. Therefore, it may be concluded that farmers who are involved in the cultivation of 'Badri berry' in Uttarakhand may extract 25 to 30 percent juice manually from one kg of fruits (Fig. 3).

4.3 *Dry Fruit and Seed Extraction*

During the study, whole fruit of 'Badri berry' is dried without juice extraction. It is taken from Badrinath hills and Munsiyari locations for dry fruit quality and quantity observation and seed count in dry fruits, and data were recorded, which are shown in Table-3.

Table 3. Dry fruit weight and seed count in 'Badri berry'

S.No.	District	Sample Collection Area	Weight of fresh fruit	Weight of dry fruits	Seed counts in dry fruits
1.	Pithoragarh	Munsiyari hills	1.0 kg	200 gm	4578
2.	Chamoli	Badrinath hills	0.20 kg	050 gm	918
Total			1.20 kg	250 gm	5496
Total Average per kg			**1.0 kg**	**208 gm**	**4580**

Fresh Fruit | Semi-dried fruit | Dry fruit | Dry residue after extraction of juice

Figure 3. Different stages of fruits of 'Badri berry' (*H. salicifolia*)

In Uttarakhand, dried 'Badri berry' fruit is a traditional super-food among tribal people, used for its potent vitamin C and antioxidants to boost immunity, fight colds/coughs, and heal skin ailments like cuts and burns, while they also use fresh juices and boiled juices traditionally. In view of exploring the difference in fresh and dry fruit weight, the data were recorded after drying of fresh fruits in sunlight for 20 to 25 days, and it was observed that 200 to 300 gm of dry fruits were obtained from one kg of fresh fruits.

As reported in the citation, 84.9 to 97.6% moisture content is available within the berries, so the weight of dry fruit is directly correlated to

the dryness of the fruit, and generally it ranges from 200 to 300 gm per kg of fresh fruit.

5. Conclusions

'Badri berry' in Uttarakhand offers significant ecological benefits, such as soil conservation and land reclamation, alongside extensive nutritional and medicinal advantages due to its rich composition of vitamins, antioxidants, and essential fatty acids. All parts of the plant are useful for the society, as fruits may be used for making juice, jam, jelly, pickle, and dry fruit; leaves may be used in herbal tea and other herbal preparations; and the plant has soil-binding capacity with nitrogen-fixing ability. Therefore, it is high time to promote conservation of the 'Badri berry' through cultivation for upliftment of the society of Uttarakhand.

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Author contributions

DSB: Conception, study and data collection and manuscript preparation. **AT:** Investigations, Formal analysis, conceptualization, manuscript writing.

Data Availability

All data included in this article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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