



A Review on the Distribution, Economic Importance and Nutritional Value of Underutilized Plants in Sikkim's Agricultural Scenario

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This literature review provides a brief reference to the current status and socio-economic importance of some of the selected underutilized crops of Sikkim. Some wild fruits show great potential for cultivation due to their high antioxidant content, good fat, medicinal biochemicals, and even higher fruit yield per tree compared to commercial plant varieties, making them horticulturally competent for cultivation. The use of these wild local plant species as a supplementary food reserve holds promise. The avocado crop is versatile and can be utilized in various ways, such as for

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producing processed goods, for export, for oil extraction, and as a raw material in the pharmaceutical and cosmetic industries, thereby generating high-value products. There is a significant interest in this crop in different parts of India, including Eastern India, as indicated by the high demand for information on avocados.

Keywords: Supplementary food; plant diversity; herbal material; floriculture.

1. INTRODUCTION

The Sikkim Himalayas, a region that exhibits more plant diversity than any region in the Indian Subcontinent, is a treasure trove of plant diversity that upholds an age-old tradition of use in wild habitats. This region is considered the origin of a large number of plant species [1]. Some wild fruits show great potential for cultivation due to their high antioxidant content, good fat, medicinal biochemicals and even higher fruit yield per tree compared to commercial plant varieties, making them horticulturally competent for cultivation. The use of these wild local plant species as a supplementary food reserve holds promise. They can be adjusted under our crop cycles for various uses such as fodder, food and floriculture. The available literature on wild edible plants of this region reveals that the utilization of edible wild fruits by ethnic communities is highest among all types of edibles [2,3].

Numerous studies in the past have highlighted the utility of edible plants from this region. Out of 175 wild edible plants documented, 64 % were edible as fruits/ seeds, followed by 18% leafy vegetables and so on (Sundriyal et al., 1998). Similarly, of the total 190 species of wild plants reported by [4], 70 of them were found to be fruits followed by vegetables and pickles (50 species), with the remaining being used as condiments and herbal material. Likewise, from the western district of Sikkim alone, out of 124 wild edible plants documented, the highest proportion of edibles (52 %) comprised of fruits/seeds (Tamang et al., 2017). A total of 190 species have been identified as edible, out of which nearly 47 species make their way to the market. Some of the fruits consumed by locals are believed to carry great nutritive value (Manju et al., 2003). These plants are used as food, herbs and for other subsistence needs by the various local communities. The abundant and untapped potential of these wild edible plants highlights the urgent need for their preservation and sustainable utilization [5-7]. This literature reviews and provides a brief reference to the current status and socio-economic importance of some of the selected underutilized crops of Sikkim.

1.1 Sikkim Cucumber (*Cucumis sativus* var. *Sikkimensis*)

Naudin [8] made the first mention of Sikkim cucumber, which Hooker [9] categorised as *Cucumis sativus* var. *sikkimensis* [8,9]. The Sikkim cucumber was widely cultivated in Sikkim and the Nepal Himalayas (at an altitude of ~ 1500 m) and was characterized by its large fruits (up to 38 cm long and 12 cm in diameter) and finely woven brown leather. Color of the peel and large cavity of the ripe fruit [10]. Cucumbers originating from Cucumbers originating from Sikkim are larger in size compared to those from other regions of the country and possess a distinct texture [11-13]. There is considerable diversity in this crop within the state, but the majority of farmers cultivate their own landraces to cater to their household or local market needs. This exotic cucumber is also found in nearby himalayan areas as well as neighbour countries like Nepal and Bhutan. The fruit weighing 1 kg exhibits no bitterness at all, even under suboptimal growing conditions. The fruit initially appears green and then slowly develops an unusual yet visually pleasing, deep brown and fissured skin. During development, the skin cracks extensively, resembling skin damage phenotypes found in other reticulated fruit species [14]. It offers a delightful taste when consumed fresh, in sushi, salad rolls, pickles, etc.



Fig. 1. Sikkim cucumber (*Cucumis sativus* var. *sikkimensis*)

Nutritional value: It contains vitamin A, which maintains the correct functioning of organs, vitamin C, which strengthens the immune system and vitamin E, which reduces inflammation. Cucumbers also contain antioxidants that protect cells from the damaging effects of free radicals, as well as minerals such as magnesium, phosphorus and potassium. In India, cucumbers are considered a cooling food as they reduce the heat given off by the body and are eaten in hot weather to soothe the throat and stomach.

Yacon (*Smallanthus sonchifolius*): Yacon, a plant that belongs to the Asteraceae family, is a perennial species that has its roots in the Andean region of South America. This plant is renowned for its tuberous roots which are characterized by their sweet flavor. These roots are not just known for their taste but also for their health benefits. They are rich in fructans, a type of carbohydrate that has various health benefits, making these roots a valuable health food. These roots can be enjoyed in their raw form or can be cooked, depending on personal preference. In addition to its native region, Yacon is also cultivated in other parts of the world. It has found a favorable environment in regions like Sikkim and West Bengal in India, as well as certain parts of Nepal. The cultivation of this plant is not just for its health benefits but also for its potential as a cash crop. It has been identified as a crop that could help address various issues that farmers in these rural areas face. One of the ways in which Yacon cultivation benefits farmers is through its supply to manufacturing companies. An example of this is the Shoten Group, a company based in Sikkim, India. This company uses Yacon to produce various products, one of which is Yacon syrup. Individual root weight can be quite variable even on the same plant, ranging from 200-500 g, although individual roots might weigh more than 1 kg each in optimal growing conditions [15]. The production and marketing of these products help in popularizing Yacon as a crop. This, in turn, creates a demand for Yacon, which benefits the farmers who cultivate it. The increased demand not only provides a market for the farmers' produce but also highlights the beneficial properties of Yacon, further increasing its popularity. This cycle of supply and demand creates a sustainable model for the farmers, the manufacturers, and the consumers, making Yacon a valuable addition to the agricultural landscape [16].



Fig. 2. Yacon (*Smallanthus sonchifolius*)

Nutritional value: In folk medicine, yacon's tuberous roots and infusions from dried leaves are used to treat diabetes and various digestive and renal disorders. Yacon is marketed as a cash crop and food supplement that can also be used to prepare home-based medicines and syrup, which can help in managing blood sugar, improving gut health and metabolism, and in weight management, highest concentrations of fructooligosaccharides (FOS) are found in yacon [17]. The above-ground part of the yacon plant is used as fodder for livestock and its young leaves are used to prepare herbal drinks. In the realm of conventional medicine, the roots of the yacon plant and dried leaf infusions are employed to manage diabetes and a range of digestive and kidney ailments. Yacon is sold as a commercial crop and it can be used to create homemade remedies and syrups that aid in regulating blood sugar, enhancing gut health and metabolism, and managing weight [18]. The part of the yacon plant that grows above the ground serves as livestock feed, and herbal beverages are prepared from its young leaves. It can also be used as a prebiotic because it contains fructooligosaccharides (FOS), which promotes the growth of health-promoting bacteria while lowering harmful bacteria [19].

Cape gooseberry (*Physalis peruviana*): Cape gooseberry (*Physalis peruviana* L.), a significant yet underutilized fruit crop, belongs to the Solanaceae family. It is referred to as golden berry in English-speaking nations, Fokfokey in Sikkim himalayas, uchuva in Colombia, Cape gooseberry in South Africa, rasbhari in India, uvilla in Ecuador, aguaymanto in Peru, and topotopo in Venezuela [20]. Although *Physalis peruviana* is indigenous to Peru and Chile [21], it

is also found in Asian and African countries. It has been cultivated in tropical, subtropical and temperate regions. The cultivation of *Physalis* began in the 1900s in the United Kingdom and subsequently spread to South Africa, Australia, and New Zealand. It is grown as a minor fruit crop throughout Asia, Africa, the USA, and the Caribbean [22,23,24]. In India, it is cultivated in states such as West Bengal, Punjab, Uttar Pradesh, Haryana, Madhya Pradesh, Punjab, the Nilgiri Hills, and other regions [25].



Fig. 3. Cape gooseberry (*Physalis peruviana*)

Nutritional value: The fruit, a berry, displays a brown calyx upon ripening, indicating the time of harvest. It is a rich source of vitamins, antioxidants, minerals, and flavonoids. Given its various nutraceutical and pharmaceutical values, the demand for this crop has been growing among health-conscious individuals. The fruit has a high ascorbic acid content (36 mg per 100 g of pulp) and is a rich source of vitamin A, iron and phosphorus [26]. Ramdan and Morsel [27] reported that the pulp of *Physalis* fruits contains high levels of Moisture (78.9 g/100 g), Protein (0.05–0.3 g /100 g), Lipid (0.15–0.2 g/100 g), Carbohydrate (19.6 g/100 g), Fiber (4.9 g/100 g), Ash (1.0 g/100 g), Calcium (8.0 mg/100 g), Phosphorus (55.3 mg/100 g)

Iron (1.2 mg/100 g), Carotene (1.6 mg/100 g), Thiamine (0.1 mg/100 g), Riboflavin (0.03 mg/100 g), Niacin (1.70 mg/100 g), and Ascorbic acid (43.0 mg/100 g).

Stinging Nettle (*Urtica dioica*): Appreciated for its medicinal attributes and as a prospective cash crop, the Nettle plant, part of the Urticaceae

family, is found in temperate regions worldwide, including Asia, Europe, North Africa, and North America. This annual and perennial herb is available in many South Asian countries and the Indian subcontinent and has long been recognized globally as a medicinal herb. In India, nettles grow in the temperate and sub-tropical Himalayas, from Kashmir to Sikkim, at elevations ranging from 1200 to 3500 M amsl. It thrives in the wild as undergrowth. In Sikkim, it is commonly known as Sisnu and is reported to be found on nearly all soil types. The leaves are covered with stiff hairs (trichomes) on both sides that produce a burning sensation when touched. It is notorious for causing dermatitis when touched, a reaction mediated by the release of biochemical mediators, such as histamine and acetylcholine from the hairs, which act like needles [28]. The plant is known for its versatility. A key feature of nettle is that the entire plant can be utilized for various purposes such as vegetable, fodder, medicine, cosmetics and textile production. Young leaves are cooked as a soup and consumed mainly in the winter time. The root part is a source of natural dye. It is an excellent source of natural fiber, and gaining popularity in the International market. Among all the nettles, *Urtica dioica* is the most popular and researched plant. Much research evidence is there regarding its medicinal properties study. But other nettle species seem to be ignored. To date, proper morphological differentiation and comparison of biochemical content among these species are difficult to find. In Sikkim mainly two genus of nettle is reported; *Urtica* and *Girardinia* with the following species *G. diversifolia*, *U. ardens*, *U. dioica*, *U. hyperborea*, *U. parviflora* (Flora of Sikkim, 2022). On review, study on their morphological description along with their biochemical properties was lacking.



Fig. 4. Stinging nettle (*Urtica dioica*)

Nutritional value: Enlightened about the various attributes of nettle that are utilized to manage arthritis, rheumatism and allergic rhinitis. Its foliage is rich in fiber, minerals, vitamins, and antioxidant substances such as polyphenols and carotenoids. Stinging nettle possesses antiproliferative, anti-inflammatory, antioxidant, analgesic, anti-infectious, hypotensive and antiulcer properties, along with the capacity to avert cardiovascular diseases [29].

Nakima (*Tupistra nutans*): The Eastern Himalayan regions of Sikkim and Darjeeling Himalaya were the sole place where Nakima (*Tupistra nutans*) was first identified. It has also been recorded from Meghalaya, Arunachal Pradesh, and Eastern Nepal recently. The researcher's field study reveals that this species is found in the Kalimpong area of West Bengal where it is cultivated. The vegetable nakima (*Tupistra nutans*), a species of the Liliaceae family, is native to South Asia and is commonly found from Sumatra Ambon Island to South China. It is commonly grown in cooler regions and is grown all throughout Sikkim. With long, strap-like leaves that can reach a length of one to two meters, this distinctive rhizome genotype from the eastern Himalayas forms a rising, high clump of evergreen foliage that resembles *Aspidistra*. The size, colour, and keeping quality of inflorescence are all pleasing. It is primarily found in damp, shaded areas and is sold in the local market in September through October. Its inflorescence is used for medicinally and as a spicy vegetable in stews. Suckers are utilized to propagate the nakima plant. The main importance of this work is to determine the nutritional value of this vegetable which is grown in Sikkim and is liked by local people also.



Fig. 5. Nakima (*Tupistra nutans*)

Nutritional Value: Rai et al. [4] reported the approximate values for the edible percentage, which were 91.5 moisture, 2.1 carbohydrate, 2.4 protein, 2.9 fat, and 1.1 ash and minerals like sodium (3.1), and potassium (292.1). Gurung et al. [30] determined the percentages as follows on a dry basis: reducing sugar–13.18, crude protein–11.18 %, fat–1.72 %, fiber–12.26 %, ash–8.73 %, and vitamin C–8.89 mg/100 g of edible portion. The recent rise in popularity of "Nakima" among consumers can be attributed to its medicinal benefits. The plant possesses a diverse range of traditional and native therapeutic use. Flowers that are dried and powdered root and flower decoctions are used as a tonic to ease body aches and to manage diabetes. They observed considerable variations in these values depending to various sets of collecting. By keeping in view, the above-mentioned points the present study was undertaken with the objective of analyzing various dietary nutrients present in the inflorescence of Nakima (*Tupistra nutans*). Flowers are a great appetizer and an excellent supply of secondary metabolites. The root extract's α -glucosidase inhibitory effect, antioxidant and antimicrobial activity, and phenolic compound estimated by Chung et al. [31] validated its use in traditional medicine and suggested its potential as an important bioresource for the food and pharmaceutical industries. The plant's inflorescence has been reported to have anti-diabetic properties and fetch a higher price on the market, however, this is not entirely confirmed. A significantly elevated nutrient profile was found in this analysis, with 22.59% crude fat, 6.55 % crude fiber, 0.36 % total protein, and 0.43 % ascorbic acid. Magnesium, phosphorus, and potassium were found to be abundant when essential and nonessential minerals were analyzed. The ratio of potassium to sodium was high. One of the most effective plants to investigate for nutraceuticals is *Tupistra nutans* wall as studied by khaton et al. [32].

Schezwan paper (*Zanthoxylum piperitum*): Sichuan pepper, alternatively known as Szechuan pepper, Chinese prickly ash, Chinese pepper, Mountain pepper, and mala pepper, is a spice that originates from the dried fruit husks of certain prickly ash plant species. This spice is a staple in Sikkim, where it is used to enhance the flavor of a wide range of dishes, including meat-based ones. The *Zanthoxylum* species, a member of the Rutaceae family. These species have a wide distribution, spanning across various

countries such as China, Nepal, Bhutan, Japan, Korea, Indonesia and India.



Fig. 6. Schezwan paper (*Zanthoxylum*)

Nutritional value: Sichuan pepper, a popular culinary ingredient, is known for its unique anti-diabetic properties. A study conducted by Li et al. in 2020 provided crucial phytochemical data on Sichuan peppers. This data could potentially be utilized in the treatment and management of type-2 diabetes mellitus. The study highlights the potential of Sichuan pepper as a natural remedy in the fight against diabetes, opening up new avenues for further research and development in this field."

Mullero/musledi (*Elaeagnus latifolia*): *Elaeagnus latifolia*, locally known as muslendi 'bastard oleaster', is a dense thorny shrub or small bushy tree found in the lower temperate zone. The fruit is long elliptical about 4 cm long, reddish with light freckles, and sour in taste. Fruits are commonly available in the markets during February-March [33]. The species is found in subtropical and temperate Himalaya from Kumaon through Sikkim, Darjeeling, Bhutan and Khasi hills in Meghalaya. It is a large ever green liana (woody climber) with rusty-shiny scales that are often thorny. The climber covers the neighboring trees, and it is difficult to estimate the length of the stems. Flowers appear during August-September, while fruits ripen during March-April when they are commonly seen in the market. Fruits are eaten raw or used as pickle. *E. latifolia* is collected either from the Community Forests or from the Private Forests with other wild edible plants and a small quantity is drawn from natural forests. The density was low in forest stands; however, in recent times few farmers have started domestication of this plant. Fruits are sold in the market at the rate of Rs 10-12 per kg. The mean fresh weight of the fruit is

recorded as 8.75 g. Total average fruit yield was recorded as 9-155 kg/plant in different girth classes. 'Chutney' of *E. latifolia* is sold in markets and can yield a net profit of Rs 17 per kg, which nearly double the price of the fruits (Rs 6-10 per kg). Leaves are also used as fodder for goat and cow [1].



Fig. 7. Mullero/musledi (*Elaeagnus latifolia*)

Nutrient content: The fruits of *Elaeagnus conferta* (muslendi) are rich in essential minerals, vitamins such as vitamin C, A, and E, as well as flavonoids and phenol compounds [34]. Many studies has done on nutritional value of its fruits which suggests that it contains high nutritive value, such as Rai et al. [4] found that the fruits of *Elaeagnus conferta* contains 91.7 ± 2.0 % moisture, 0.7 ± 0.1 % ash, 0.8 ± 0.2 % fat, 1.4 ± 0.5 % protein, 5.3 ± 0.5 % carbohydrate, 6.7 ± 0.3 mg/100 g sodium, 233.5 ± 2.3 mg/100 g calcium and 5.8 ± 0.3 mg/100 g of potassium with a high nutritive value of 34.0 ± 2.5 Kcal/100 g.

Avocado (*Persea americana*): The Avocado, also known as Phamfal and phumsi locally, is a subtropical, evergreen tree that belongs to the Lauraceae family and is scientifically known as *Persea americana*. This tree, which produces a pear-shaped, blackish-green fruit known for its high nutritional content and creamy texture, originates from a wide geographical area that spans from the eastern and central highlands of Mexico, through Guatemala, to the Pacific coast of Central America. The avocado crop is versatile and can be utilized in various ways, such as for producing processed goods, for export, for oil extraction, and as a raw material in the pharmaceutical and cosmetic industries, thereby generating high-value products. There is a significant interest in this crop in different parts of India, including Eastern India, as indicated by the high demand for information on avocados.

Furthermore, the soil and climatic conditions in the hilly region of Darjeeling and the neighboring states of India are conducive to the growth and development of avocados. Locally in Sikkim, it is sold for 10-20 rupees per piece. However, the cultivation of avocados in this region is minimal in homestead gardens and small, and marginal orchards due to the farmers' lack of scientific knowledge. Therefore, the identification and conservation of wild and farmer-cultivated avocado species is a major concern for all avocado growers and scientists [35].

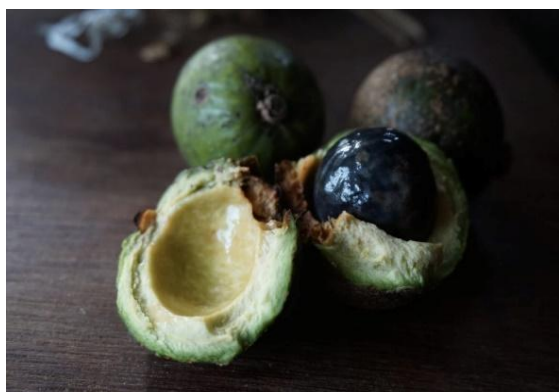


Fig. 8. Avocado (*Persea americana*)

Nutritional Value: Avocado fruits are characterized by a hard exterior, a soft middle, and a seed encased in a shell. The flesh of the fruit is a pale yellow-green color, with a smooth, buttery consistency and a slightly nutty taste, similar to a ripe banana. Unlike other fruit crops, avocados are rich in healthy fats. In a single serving of 3.5 ounces (100 g), avocados contain a variety of vitamins such as Vitamin K (26% of the DV), Folate (20 % of the DV), Vitamin C (17 % of the DV), Potassium (14 % of the DV), Vitamin B5 (14 % of the DV), Vitamin B6 (13% of the DV), and Vitamin E (10% of the DV). They also contain trace amounts of magnesium (Mg), manganese (Mn), copper (Cu), iron (Fe), Zinc (Zn), phosphorus (P), and niacin (vitamin B3) (Dreher and Devenport, 2013), (Fulgoni et al., 2013), and [36]. Avocado fruits have a higher potassium content than bananas, which are typically considered a high-potassium food. A 3.5 ounce (100 g) portion contains 14% of the recommended daily intake [36]. Avocados are high in fat, with 77 % of their calories coming from fat. They are particularly high in oleic acid, a monounsaturated fatty acid that is beneficial for heart health [36] and (Mendez Zuniga et al., 2019).

2. CONCLUSION

The crops of the Sikkim Himalayas, which are currently underutilized, possess vast potential for future agricultural development. They exhibit a wide range of genetic diversity in both qualitative and quantitative traits and demonstrate resilience to both abiotic and biotic stresses.

Some of these crops not only provide a significant source of nutrition but also have the capacity for year-round production. They constitute an important gene pool for future plant development, offering nutritional value and tolerance to stress. However, these crops have not received as much research attention as larger plants, suggesting a need for more concentrated efforts in identifying resources, farming, and conservation. The annual commercialization of wild plants as fruits, herbs, or vegetables in the local market is a testament to the region's rich biodiversity and the untapped potential of these valuable resources. This indicates that there is a great potential for market acceptance and monetary conversion, which will eventually encourage local communities to adopt these crops for cultivation in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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