

***Corylus jacquemontii* Decne: a review on its taxonomy, distribution and cultivation practices**

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ABSTRACT

The endemic people, that live in Indian Himalayan region (IHR), are largely depending on plant resources for their livelihood. There are various economically significant plants out of which wild edible plants are used for oil, spices and other seasonal materials such as jams, pickles, flowers, etc. *Corylus jacquemontii*, also known as the Himalayan hazelnut, is a species of hazelnut native to the western Himalayas. It is a large deciduous tree species that belongs to the family Betulaceae. The Himalayan/Indian hazelnut is valued chiefly for its nuts which are beneficial for health purposes and are used in many pharmaceutical industries. Due to its high nutritional value, locals harvest fruits completely that results into poor natural regeneration. Despite its limited distribution, *C. jacquemontii* has gained recognition as a potential alternative to the traditional European hazelnut (*C. avellana*) due to its high yield, resistance to pests and diseases and unique flavour profile. Due to its various uses as food, fuel, fodder and medicine, this species is under extensive threat. The birds, wild animals, insects and also local people feed on the seed of this species. The present study aims at providing an in-depth analysis of the species through a review of available literature and field observations. Results indicate that *C. jacquemontii* has a limited distribution range but it plays a crucial role in the local ecosystem as a food source for wildlife and as a source of income for local communities. Additionally, the taxonomic classification of the species is still debated, highlighting the need for further studies to clarify its relationships with other *Corylus* species. This research paper aims at providing a comprehensive overview of *C. jacquemontii*, including its botanical description, distribution, morphology and cultivation practices.

Keywords: Hazelnut; nutritional value; cutting; grafting; antifungal activity; antibacterial activity

INTRODUCTION

The mountain ecosystems play an immense role in maintenance of aesthetic, cultural and spiritual values and other important resources such as food, timber, fiber, medicine and other services such as regulation of climate, fresh air etc (Gret-Regamey et al 2019). The rich ecosystem of the Himalayas is associated with the economic status of the people of this region.

Among 8,000 plant species found in Indian Himalayan region, 30 per cent of them are endemic, 10.2 per cent are trees, 8.44 per cent are wild edibles and over 15 per cent are medicinal herbs (Samant and Dhar 1997). The *Corylus* genus of the family

Betulaceae represents a distinct group of advantageous woody plants ranging from small, multi-stemmed shrubs to tall, stately trees, all of which produce edible nuts. Among these, *Corylus jacquemontii*, also known as Indian hazelnut, considered as the synonym of Turkish hazelnut (*C. colurna* L), is a deciduous tree of temperate forests and has wild edible nut growing up to a height of 25 m (82 ft).

It is distributed in different countries of the world such as Turkey, north Europe, Iran, Azerbaijan, China and India. The weather of Indian Himalayan region (IHR) is suitable for the regeneration of this species. In India, they are spread over northwestern region of temperate Himalaya from Kashmir to Kumaon at an altitude of 3,000-7,000 ft (Brummitt 2001). It

mainly occurs in the inner dry tracts of the western temperate Himalaya, especially in Kinnaur, Chamba, Kullu and Lahaul and Spiti districts of Himachal Pradesh (Paul et al 2019). It is commonly known as Thangi in Pangi valley of Chamba district, Bhotiya Badam in Shimla, Urmuni in Kullu, Sharoli in Lahaul and Spiti valley and Sharod in Kinnaur district of Himachal Pradesh.

It is found associated with oak, fir, spruce, deodar, betula, maple and walnut in natural zone (Gupta et al 2019). Turkey has long dominated the world supply and has an oversized effect on global hazelnut prices. Lies (2023) reported that in 2020, Turkey produced 62 per cent of the global production of slightly more than 1 million tonnes. Italy, the second highest producer, accounted for 13.1 per cent of the world production in 2020.

In IHR region, hazelnut plays crucial role as a food for tribal communities such as Pangwals and Bhots (Gupta et al 2017).

The Indian hazelnut has hard dark grey colour bark and alternate, long acuminate and irregular-lobed leaves. The nuts are compressed, globose, hard-sheathed by much enlarged lobed, toothed, glandular-hairy, spiny and deep brown bracteoles. The leaves and young shoots are also used for cattle fodder. The nuts are edible and used for various purposes (Chauhan et al 2014).

The kernels of hazelnuts are a rich source of proteins, carbohydrates, vitamins, poly-unsaturated fatty acids, other minerals, iron, calcium, potassium etc (Table 1).

The hazelnut tree is adapted for wide variety of soils and climates and requires very less care or

inputs which have made it ecologically and economically important crop. Indian hazelnut is self-incompatible tree species found in scattered groups in its natural habitat. Various studies show that regular consumption of these nuts reduces the risks of heart stroke, cancer and other chronic health issues.

Distribution

The origin of hazelnuts is firstly derived from Europe and southeast Asia. Due to favourable weather condition of Indian Himalayan region, it is primarily grown in regions of Himachal Pradesh, Jammu and Kashmir, Uttarakhand and the northeastern Himalaya of India. *C wangii* Hu has only been reported in northwestern Yunnan province.

The specimens collected from eastern Sichuan and deposited in PE were recently identified as *C wangii*. Although *C wangii* is sometimes synonym under *C jacquemontii*, found it to be morphologically and molecularly distinct (Whitcher and Wen 2001). It is mainly found in the western temperate Himalayas, especially in Kinnaur, Chamba, Kullu and Lahaul and Spiti districts of Himachal Pradesh (Paul et al 2019) (Fig 1).

Chemical composition

Hazelnut is the antecedent of different valuable compounds, such as oils, proteins, carbohydrates, mineral substances and vitamins. The hazelnut core accommodates oil 55-72 per cent, protein 12-22 per cent, carbohydrates about 14 per cent, sugar 2-10 per cent and mineral matter of 1.8-3 per cent (Oparnica et al 2017) (Fig 2). The total oil content of the hazelnut is between 54.6 to 63.2 per cent, whereas, the crude protein is between 14.3 to 18.2 per cent. Dietary fibers range from 9.8 to 13.2 per cent, while the starch and free glucose content together make <5 per cent of the kernel (Fuso et al 2021).

Table 1. Nutritional value of hazelnut per 100 g

Element	Total quantity	Element	Total quantity
Energy	2,629 kJ (628 kcal)	Dietary fiber	10 g
Fat	61 g	Potassium	680 mg (14%)
Saturated fat	4 g	Phosphorus	290 mg (41%)
Mono-unsaturated fat	46 g	Folate	113 mg (28%)
Poly-unsaturated fat	8 g	Calcium	114 mg (11%)
Carbohydrates	17 g	Iron	4.7 mg (38%)
Protein	15 g	Niacin/vitamin B3	1.8 mg (12%)
Thiamine/vitamin B1	0.6 mg (46%)	Riboflavin/vitamin B2	0.11 mg (7%)

Source: USDA Nutrient Database

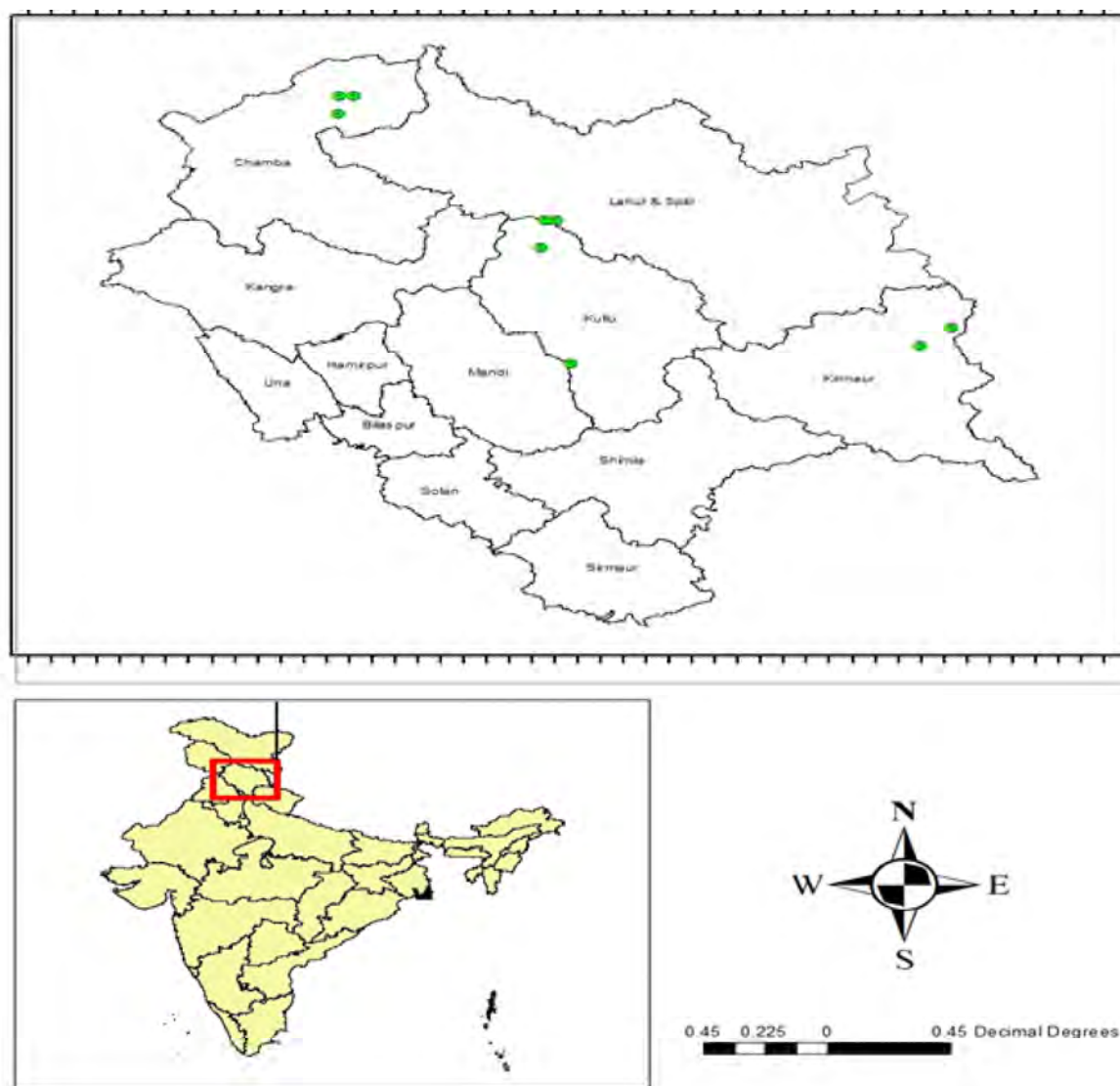


Fig 1. Distribution of hazelnut in Himachal Pradesh

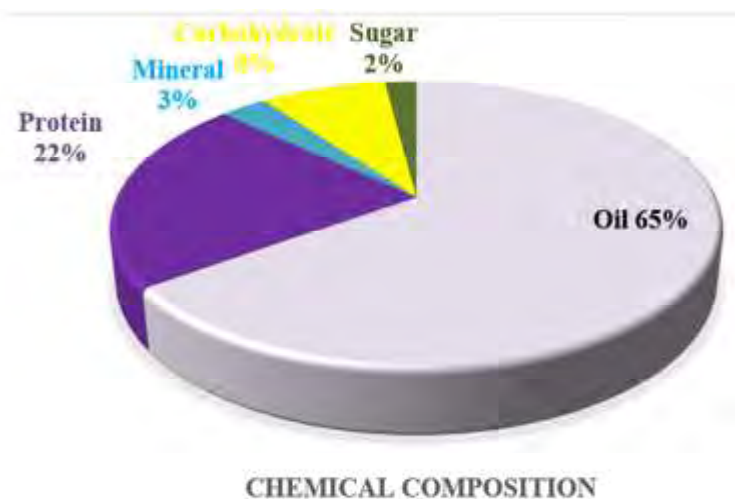


Fig 2. Chemical composition of hazelnut

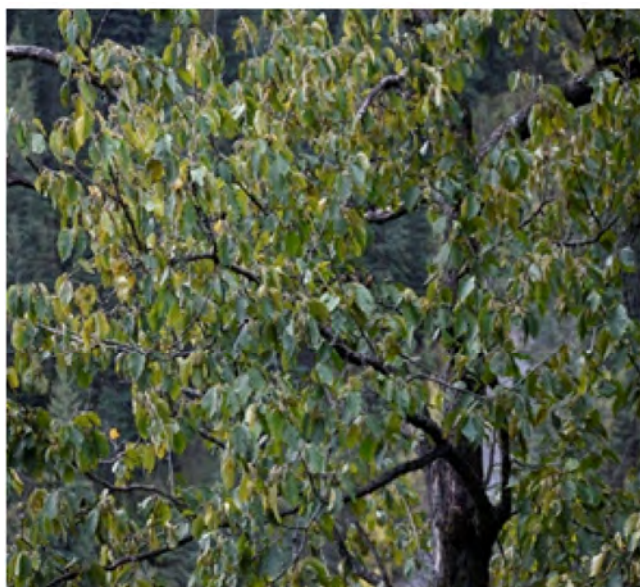


Plate 1. Hazelnut tree



Plate 2. Hazelnut fruits



Plate 3. Hazelnut nuts

Physiological description

Hazelnut is a deciduous tree with alternate, serrate, obovate and hairy leaves (Plate 1). The height of plants ranges between 3 to 36 meters (10 to 120 feet). The hazelnut is usually multi-stemmed shrub or small tree having double-serrated margin leaves which are round in shape.

The female flowers are smaller in size and have bright red stigmas which protrude from the bud. The male flower has catkin which is pale yellow in colour and is about 6-12 cm (2-5 inches) in length (<https://plantvillage.psu.edu/topics/hazelnut-filbert/>

infos). In late winter season, pale yellow catkin of male flower and red clusters of female flower are found on the same tree. The nut is round in shape and brownish in colour ranging between 1 to 4 cm (0.5 to 1.5 inches) and is partly or wholly enclosed inside a husk (Plate 2).

The plants are deep-rooted and grow well in shaded area and the fruit grows premium in well-drained soil. The catkin of the hazel tree opens in the spring season. The catkins are fully developed into clusters which have clusters of 3 to 5 nuts which are found under the serrated green leaves (Boccaccio et al 2008). The shell of the hazelnut is brown in colour,

glossy and roughly ovoid in shape. Once husked, the hazelnut has bitter dark brown skin which people remove before cooking the nuts.

The inner part of hazelnuts is whitish and slightly sweet because the outer skin is absent. The hazelnut without any shriveling on outer surface and with one month of freezing period is best nut (Plate 3) for use. To choose the best nuts, one should look for the nuts with smooth and glossy shells which have no signs of cracks or holes on their outer shell. The average viability of hazelnuts is about 30-40 years.

Habitat and growth conditions

The bark of the hazelnut tree is quite hard in nature and produces favourable crops under moderate climate conditions. The pistillate and staminate flowers do not develop well when -10 to -12°C of temperature is followed by wind (Boccaccio et al 2008). The chilling treatment which is good for the development of hazelnut should be same as that of the most commercial cultivars.

Therefore, this species is grown successfully in the apple growing regions of Himachal Pradesh, Jammu and Kashmir, Uttarakhand and northeastern Himalayan regions of India. The hazelnuts are more shallow-rooted than most fruit or nut trees and do not grow well in wet soils. The tree does not tolerate excess of heat and hot winds and thus does not grow in tropical areas.

The soil with pH 4.5 to 8.5 is well for germination of hazelnut but pH 7 is optimal. The hazelnut grows in all types of soils, but the soil with modest fertility shows gentle growth of the plant. It grows well in loamy soil. The alkaline soil is opposite for the growth of nuts.

It can grow in semi-shade (light woodland) or no shade. Hazelnut grows in deep, fertile and well-drained soils. The soil should be well aerated and have good depth. It requires a cool climate and long cool summer. The cool climate is more favourable for the development of the nuts than longer warm summers.

Methods of propagation

Root cuttings: The propagation of tree from cutting is a smooth, brisk and modest method (Hartmann and Kester 2002). This method is impelled by environmental

conditions (Bush 1953, Shreve 1974), physiological age of the cuttings (Perry and Vines 1972, Rhodes 1968) and chemical treatments (Barry and Sachs 1968, Doran 1957, Kawase 1965). Due to several factors, the smooth propagation is difficult. Mainly there are two types of cuttings in case of hazelnut propagation:

Softwood cuttings: The first-year shoots are taken in the month of June and treated with 1,000-3,000 ppm IBA (Kantarci and Ayfer 1994). After that, these are treated with 1,000 ppm IBA in mid-July (Solar et al 1994).

Hardwood cuttings: Hardwood cuttings are taken at the end of winter season and treated with 3,000-5,000 ppm IBA (Kantarci and Ayfer 1994). Other important factors for the proper growth of roots of hazelnut are highly aerated soil media (Lagerstedt 1968), ample light and low foliar temperature (Gonderman 1971, Hess 1965).

Seeds: The rate of germination of the hazelnuts directly from the seeds is very low. The locals and animals collect nuts directly from the ground when the nuts get ripened and fell from the tree. For the purpose of propagation, the nuts are directly collected from the trees when they start to turn slightly brown in color.

The outer seed coat of the hazelnut is hard in nature (Aiello and Dillard 2008). To overcome this dormancy, the half-brown nuts are harvested in August and refrigerated. The nuts are drenched in water for about 2 to 4 days in the month of November and then flaked in moist vermiculite at 4°C for 3 to 5 months. After 2 to 3 months, the seeds are subjected to heat treatment for about 5-6 days and the seeds with visible root tips are planted directly in the greenhouse beds.

The second method to break down the dormancy of the seeds is to bathe them in gibberellic acid (GA_3). The hard-outer shells are expunged and the kernels are drenched in 25-50 ppm GA_3 for about 16-24 hours. Then the treated seeds are directly transferred to the greenhouse beds or planted into the moist filter paper and then placed in the germinating boxes. The latter method is most suitable because the GA_3 treatment can stimulate the seeds that fail to germinate initially. The seeds which are freshly harvested and treated with GA_3 show the high rate of germination as compared to the stored seeds in which the germination is enhanced.

Layering: The most common and acknowledged method of propagation in the case of hazelnut is layering (Baron et al 1985, Howes 1948). The trees produced by this propagation are large and well-rooted (Hubert 1977). The layering is of two types:

Simple layering: In this layering, the stems are angled down about 20-25 cm into the deep trough and then covered with soil. Three to four buds remain outside the soil (Anon 2007). About 26,000-29,700 layers are attained per hectare (Achim et al 2001).

Mound layering: The breeders choose the stem from the already well-grown tree, bend down the stem and cover them with the soil so that the roots grow in the sucker. The breeders who used to commercialize the layering method, chose the low height trees in winter so that layering could be done easily and 10-15 new shoots are developed in next spring (Hubert 1977).

For mound layering, shoots are selected in the early summer season and girthed at above 2-3 cm base. The shoots are treated above the girthed area with IBA, IAA or NAA. To moisturize the girdled area, the shoots are covered with sawdust so that roots develop easily. The roots are developed in the girdled area and the plants are ready to germinate in other places (Braun 2010).

This method is most successful because the propagated area is still attached to the mother plant and withdraws its whole nutrition directly from the mother plant until it develops its own rooting system. This method is effective and produces a high survival rate (Hubert 1977).

For layering, breeders need to have good knowledge about the plant and plant hormones. This method needs a large area for layering practices. In this method, the mother plant is in good condition and disease free (Hartmann and Kester 2002).

Suckering: The suckers are developed by the hazelnut near the base of the tree. The soil is removed around the trunk; suckers are cut carefully and transferred to another places. Once the sucker is cut from the trunk, it initiates more suckers.

Grafting: The grafting method is used mainly for commercial purposes (Anon 2007), but this propagation method is not used in the case of Indian hazelnut

(Fideghelli and De Salvador 2009). In the grafting method, there are two parts: one is scion and the other is stock. Scion is the desirable part whose properties are developed on the stock part (Pollack 1998). *C. colurna* and *C. chinensis* are commonly used as rootstocks. *C. colurna* is resistant to drought and frost conditions (Ninic-Todorovic et al 2008, Miletic et al 2009). It is desired that the scion part is disease free and dormant. There are some places where machine grafting has been tried but the success rate is very less as compared to hand grafting (Hubert 1977).

Flowering and seed collection

Flowering period: March to April

Seed collection time: August to September

The species is monoecious ie both the flowers (male and female) are found on the same tree. The pollination is anemophily. The plant is androgyny (self-fertilizing).

Cultural practices

Hazelnut requires a cool climate and long cool summers. Plants can be propagated by tip layering, grafting and budding. *C. jacquemontii* is recommended rootstock for cultivated hazelnut (*C. avellana*). Planting is done at a distance of 4 m × 4 m in the pits of 1 m × 1 m × 1 m size. Pruning is done in December-January when trees are dormant. In autumn, doses of FYM 20-25 kg and 500 g NPK in the ratio of 1:2:1 may be applied per tree per year to harvest a good crop (Chauhan et al 2014).

Hazelnut plant requires limited water and it is rarely irrigated if planted on fertile soil with good water holding capacity. On the bearing tree, the lateral branches on main branches should be pruned every year for good plant canopy. The removal of suckers from the base is a common practice in hazelnut cultivation. However, the suckers can be reduced by root pruning at the time of planting. The male catkins emerge during June month. Pistillate flowers are born in tight clusters. Nuts are usually borne in lateral and terminal buds on previous season growth. Self-incompatibility is common in hazelnut cultivars which makes inter-planting necessary to provide cross-pollination. The blooming in hazelnut is dichogamous and, therefore, the appearance of staminate and pistillate flowers may not be synchronized.

Harvesting

The fruits are developed on the newly planted trees after 2-3 years. The full capability of the tree reaches up to 20-25 years after planting. The nuts are collected 2 to 3 times from a single tree in a single harvesting season.

Nutritional value and uses (Fig 3)

Medicinal value: The extract obtained from the buds, flowers, leaves, nuts and bark by isolation and purification technique can moisturize skin and can be used to mobilize fluid in skin tissue and drain the fluid from such tissues (which can reduce puffy eyes) when applied to the skin (Rani et al 2013). The massage of oil is very much beneficial in case of muscular pain (Samant et al 1996, Rani et al 2013).

Different studies show that nut of the *C jacquemontii* has lesser cholesterol content and also has antioxidant property. The nuts of Indian hazelnut have oleic acid and mono-unsaturated acid which help to lower the cholesterol level (Alasalvar et al 2008). The nuts have arginine which helps to relax the blood

vessels which lowers the chance of cardiac blockage (Alasalvar et al 2008). The nuts are rich in Vitamin A which has anti-oxidant properties (Caglarirmak and Batkan 2005). Among several nutraceutical foods, hazelnuts are considered an excellent anti-inflammatory and hypolipidemic food being the second richest source of monounsaturated fatty acids among nuts and because they are rich in vitamins, minerals, and phenolic compounds (Di Renzo et al 2019). They are rich in folate content which lowers the risk of neural tube related problems (Alasalvar et al 2008). Consuming hazelnuts may be helpful as they contain several phytochemicals which have been proven to be able to prevent urinary tract infections (Anon 2023).

Edible properties: Hazelnut has a high nutritional value, containing, generally 65 per cent oil, 14 per cent protein and 16 per cent carbohydrates. More than 90 per cent of its oil consists of unsaturated fatty acids, especially oleic (80%) and linoleic (6-12%) acids (Choden and Bornare 2021). The nuts are used as an ingredient in the parched rice (Samant et al 1996, Chauhan et al 2014). Due to their taste, nuts are a major ingredient in most of the confectionary industries

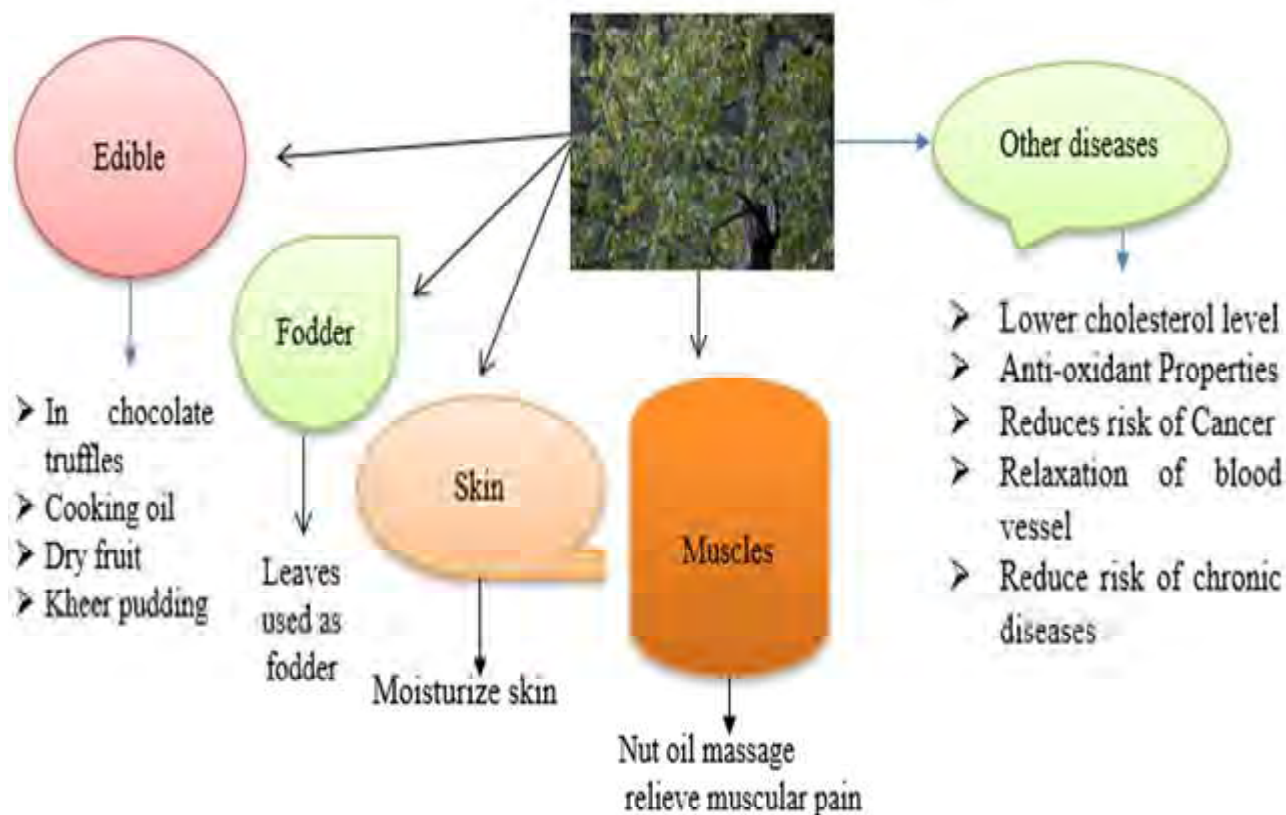


Fig 3. Uses of *Corylus jacquemontii*

and are used in different products as raw material (Vikram 2014, Chauhan et al 2014).

Other uses: The nuts have various nutritional values, therefore, by selling these nuts the villagers enhance their economic condition (Samant et al 1996, Samant 1998, Rana and Samant 2011, Rana 2007, Sharma 2008, Samant 2015) and floras (Stewart and Brandis 1874, Gaur 1999). Its leaves are used as fodder for animals (Samant et al 1996, Chauhan et al 2014). The wood of the tree is used by the villagers as fuel.

CONCLUSION

The comprehensive examination of *C jacquemontii* presented in this review study offers a deeper understanding of its taxonomy, distribution and cultivation practices. This information serves as a valuable resource for botanists, horticulturists and conservationists, ultimately aiding in the conservation and sustainable management of this unique plant species. Moreover, the paper has highlighted the potential benefits of cultivating *C jacquemontii*, such as its ornamental value, edible nuts and medicinal properties. By providing these insights, this review study contributes to the growing body of knowledge surrounding this species and encourages further research and conservation efforts. Continued research and practical applications of these findings will undoubtedly contribute to the protection and utilization of *C jacquemontii* Decne for the benefit of both human societies and the natural environment.

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