

# Blueberry Cultivation in India: Past, Present, and Future

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# Abstract

Blueberries, known as superfoods, are small, nutrient-rich fruits high in antioxidants, particularly anthocyanins. With increasing global demand for health foods, blueberry cultivation holds significant market potential. The domestication of blueberries began in the early 1900s. Native to North America and requiring acidic soils, they include highbush, lowbush, and rabbit eye types. Rising blueberry demand in India drives cultivation for market growth, export potential, and reduced import reliance. The diverse agroclimatic conditions, leveraging unique soil properties provide potential for cultivation of both low-chill and highchill types. Concerted efforts by universities, institutes, and public organizations highlight the increasing emphasis on blueberry cultivation as a means of agricultural diversification. Institutions like Dr. Y.S.P.U.H.F. Nauni, C.S.K.H.P.K.V. Palampur, ICAR-CITH Srinagar, and S.K.U.A.S.T. J&K are at the forefront of this initiative. Additionally, the introduction of several blueberry accessions by ICAR-NBPGR underscores the proactive steps being taken to establish a thriving blueberry industry in India.

# Introduction

Blueberry (*Vaccinium* spp.), is native to North America and belongs to the family Ericaceae. The basic chromosome number of the genus *Vaccinium* is x = 12, with the occurrence of species with different ploidy levels. There are generally three types of blueberries i.e. Highbush '*Vaccinium corymbosum*', Lowbush '*Vaccinium angustifolium*', and rabbit eye '*Vaccinium ashei*'. High bush types are cultivated ones whereas lowbush are the wild types. Another class, half-high types, are developed from a cross between highbush and lowbush species. The berries are traditionally cultivated in countries with cool subtropical or temperate climates. The remarkable story of the domesticated blueberry began 100 years ago in the early 1900s through the collaboration of Elizabeth White and Frederick Coville. The former, a cranberry grower, started research on wild highbush blueberries in the 1890s, while Frederick Coville, USDA botanist, was the first person who initiated the world's first blueberry breeding program in 1906, and in 1910, showed that plants must be grown in moist, acidic soils (pH 4.5-4.8). In 1911, he made the first successful cross between highbush 'Brooks' and lowbush 'Russell' blueberries.

Categorized as 'superfoods', blueberries are small (5-16 mm), round, and blue/purple-colored fruits. Its cultivation holds significant potential in the world market due to increasing global demands for health-promoting foods packed with antioxidants and other bio-active compounds. Fruits are known for being rich in multivitamins, minerals, and antioxidant compounds, particularly anthocyanins (105-236 mg CGE/100g), a large class of polyphenols. The fruits are highly suitable to be transformed into several products such as jams and preserves, beverages, jellies, etc., due to their rich nutritional profile, distinct flavor, and versatile physical properties.

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According to the International Blueberry Organization (IBO), in 2023, global highbush blueberry production reached 1789590 MT from an area of 248548 hectares, with China (525310 T), followed by Peru (299670 T), and the USA (277630 T) being the leading producers. However, Peru is the world leader supplier of blueberries with export volumes of 227480 T.

## Nutritional and medicinal properties

Blueberries are a powerhouse of several health-promoting compounds including vitamins, carbohydrates, minerals, fibers, and polyphenols. Despite their rich nutrient profile, blueberries are low in calories (57 kcal/100 g fruit), making them a great addition to a balanced diet. Owing to their richness in bioactive compounds and immuno-boosting actions, blueberries possess several medicinal properties including neuroprotection, anti-inflammatory, anti-cancer, anti-obesity, and anti-aging properties. Besides, the consumption of blueberries improves bone health, controls blood pressure and cholesterol levels, and can help patients suffering from cataracts and macular degeneration. Several health properties are due to the free-radical scavenging properties of anthocyanins, found abundantly in the berries.

## **Climatic requirements**

Blueberries thrive well in cooler climates fulfilling chill requirements ranging from 400-1100 hours. The optimum temperature during the growing season for successful blueberry cultivation ranges from 15-25oC. Extreme heat can reduce the quality of berries, whereas late spring frosts can damage flowers and young fruitlets. Higher humidity can lead to the development of fungal diseases. However, species varied for agro-climatic conditions: cold regions (Northern highbush blueberries); warmer areas (Southern highbush blueberries); and wide adaptability (Lowbush blueberries). Crucial for their growth is the soil, which must be acidic (pH 4.5 to 4.8) retaining sufficient moisture. Waterlogged conditions are detrimental to plant growth.

## Growth stages of berries

Blueberry flowers are typically bell-shaped, hermaphrodite, self-compatible, and white, pale pink, or reddish in color. The fruit is a 'false berry' with an inferior ovary and can contain many tiny seeds. The berries, covered with a protective covering called 'bloom', are light greenish initially, followed by reddish-purple, and the last stage ripe one shows a deep purple color with variable acidity. BBCH scale, a two-digit code, helps to identify phenological stages in various plant species. In the case of blueberries, developmental phases can be categorized into three ranges i.e. BBCH 0-60 (dormancy to initiation of flowering), BBCH 61-70 (initiation of flowering to end of flowering stages), and BBCH > 70 (initiation of fruit growth to harvest).

#### Varieties

In India, some cultivars of blueberry have been introduced in hilly areas such as 'Jewel', 'Gulf Coast', 'Misty', 'Blue Crop', 'Star', 'Biloxi', 'Sharp Blue', and 'Legacy'.

### Prospects of blueberry cultivation in India

The demand for blueberries in India is on the rise due to increasing health consciousness among consumers, and the country is one of the top importers of fresh or dried forms of blueberries globally. Fruits are abundantly available in rural areas during summer from May to August. The need to increase blueberry cultivation in the country arises from several compelling reasons including high domestic market demand and export potential, health and nutritional benefits, and minimizing import dependency on western countries. The export of berries can contribute to the country's agricultural exports and overall economic growth. Also, the diversification of crops can enhance food security and sustainability in the long term, especially in hilly regions where traditional agriculture faces challenges. The southern highbush blueberries which require less chilling hours are a viable option for cultivation in the non-hilly areas of the country. However, the paucity of quality planting materials and dependence on imported materials is a significant challenge. In order to lower the production costs of imported planting materials, several tissue culture laboratories have been set up in India,

specializing in auxiliary bud cuttings.

#### States under blueberry cultivation

Many private stakeholders have successfully introduced blueberries in the Indian states of HP, Uttarakhand, and J&K, as these areas offer sufficient chilling hours with acidic soil conditions. Moreover, the lower hills of the Himalayas and the northeastern states, with higher soil organic carbon content, offer potential areas for organic blueberry cultivation, particularly highbush varieties that provide satisfactory production with minimal inputs.

The National Youth Project (NYP) has initiated a blueberry cultivation project of 45 lakh in the hilly border districts of Arunachal Pradesh, aiming to benefit farmers by providing a lucrative cash crop option and offering consultancy and buy-back services to support interested farmers. The Ministry of Agriculture and Farmers Welfare (MoA&FW) provides financial assistance to expand blueberry cultivation under the MIDH scheme.

## **Research activities**

In India, several universities and public organizations are actively engaged in the cultivation and research of blueberries. Institutions such as Dr. Y.S.P.U.H.F. Nauni; C.S.K.H.P.K.V., Palampur; ICAR-CITH, Srinagar; and S.K.U.A.S.T., J&K, are exploring the possibilities of blueberry cultivation as a new fruit for diversification. Adaptation trials are being conducted to assess the viability of this crop in various regions. A study on flowering behavior of introduced blueberry genotypes at C.S.K.H.P.K.V., Palampur indicated that cultivar 'Jewel' is earliest in flowering, and rabbit eye cv. 'Alapaha' and 'Austin' were last to flower. ICAR-NBPGR has introduced several accessions of northern highbush blueberries from 2009-2012 i.e., EC638060 (Elliott), EC638061 (Northland), EC638062 (Duke), EC638063 (Bluecrop), EC638064 (Patriot), EC638065 (Chippewa), EC732189 (Austin), and EC732190 (Briteblue). An indigenous collection, IC558366 has also been maintained at ICAR-NBPGR, collected from West Kameng, Arunachal Pradesh. Through continued research and innovation, these institutions are laying the groundwork for a sustainable and profitable blueberry sector.

## Summary

India is well-positioned to become a major player in the global blueberry market, driving economic growth and improving the livelihoods of its farmers. By investing in advanced agricultural practices and infrastructure, India can enhance its blueberry production capabilities, ensuring a consistent and high-quality supply. This strategic focus will not only fulfill domestic demand but also position India as a competitive player in the global blueberry market. Through collaborative efforts between government bodies, researchers, and farmers, the country can overcome current challenges and achieve a sustainable and prosperous future for its blueberry industry.

<b>a</b>	DDCH	
Growth stages	BBCH	Description
	Scale	
Tight Bud	-	Bud scales are tightly closed and no visible swelling.
Bud swell	51	Visible swelling of buds, as the outer scale begins to separate.
Early green tip	-	Green leaf tissues (2-5 mm) emerging from tips of buds.
Bud break	53	Individual flowers can be seen between bud scales.
Late green tip	-	Occurs around flower bud burst when 6-13 mm green tissues are visible.
Tight cluster	55	Individual flowers are distinguishable.
Shoot expan-	-	Multiple leaves from leaf buds emerge and unfold.
sion		
Early pink bud	57	Short, closed corolla tubes/petals are pink in color.
Late pink bud	59	Corollas are white in color but still closed.

Early bloom	-	Most of the flowers are closed but some corollas have opened.			
Full bloom	65	The maximum number of flowers have opened.			
Petal fall	67	The most vulnerable stage to freezing injury is when petals are off exposing small			
		green fruits.			
Early green	71	Berries growth is by cell division and are pea-sized.			
fruit					
Late green	78	Pale-green fruits with reddish blush.			
fruit					
Shoot tip set	-	Shoot tip growth ceases and no new leaves emerge from the shoot tip.			
Fruit Coloring	81	Berries growth is by cell expansion, and the largest fruit in the cluster begins to			
		change color from green to pink/blue.			
10% blue	-	Some of the berries in the fruit clusters are ready to harvest.			
25% blue	85	Initial hand-harvesting should be done at this stage.			
75% blue	87	Mechanical harvesting can be done at this stage.			

Table 1: Various growth stages of blueberries.

Common name	Scientific name	Characteristics/Traits		
Northern High-	Vaccinium	6-12 feet in height, and limited to cold temperate areas.		
bush blueberry	corymbosum	Donor species for cold hardiness, fruit size, and early ripening.		
Southern High-	Vaccinium Resulted from interspecific hybridization between northern h			
bush blueberry darrowii		and other Vaccinium species, suitable for less acidic soil conditions.		
Lowbush blue-	Vaccinium	They are commonly found in pastures and have wider adaptability.		
berry	angustifolium			
Rabbit eye blue-	Vaccinium ashei	More tolerant to drought and heat, and suitable for warmer climates.		
berry		Self-incompatible in nature and have low chill requirements.		
Elliott blueberry	Vaccinium elliottii	Source of resistance to stem blight.		

Table 2: Characteristics of different species of blueberries.

Nutrients	Quantity	Vitamins	Quantity	Minerals	Quantity
Water	125 g	Vitamin A	79.9 I.U.	Calcium	8.88 mg
Energy	84.4 kcal	Vitamin B1	0.055 mg	Phosphorus	17.8 mg
Carbohydrates	21.50 g	Vitamin B2	0.061 mg	Sodium	1.48 mg
Dietary fiber	3.55 g	Vitamin B3	0.619 mg	Zinc	0.237 mg
Lipids	0.488 g	Vitamin B5	0.184 mg	Iron	0.414 mg
Protein	1.1 g	Vitamin B6	0.077 mg	Potassium	114 mg
Ash	0.355 g	Vitamin B9	8.88 µg	Magnesium	8.88 mg
Starch	0.044 g	Vitamin C	14.4 mg	Copper	0.084 mg
Total sugars	14.7 g	Vitamin E	0.844 mg	Selenium	0.148 µg
Glucose	7.22 g	Vitamin K	28.6 µg	Manganese	0.497 mg
Fructose	7.36 g	Amino acids	Quantity	Amino acids	Quantity
Sucrose	0.163 g	Tryptophan	0.004 g	Methionine	0.018 g
MUFA	0.07 g	Isoleucine	0.034 g	Cystine	0.012 g

PUFA	0.216 g	Leucine	0.065 g	Phenylalanine	0.038 g
Choline	8.88 mg	Lysine	0.019 g	Tyrosine	0.013 g
betaine	0.296 mg	Valine	0.046 g	Arginine	0.055 g
Beta-carotene	47.4 μg	Histidine	0.016 g	Alanine	0.046 g
Lutein + zeaxanthin	118 µg	Aspartic acid	0.084 g	Glutamic acid	0.135 g
α-tocopherol	0.844 mg	Glycine	0.046 g	Proline	0.041 g
γ-tocopherol	0.533 mg	Serine	0.033 g	Threonine	0.03 g

Table 3: Nutritional profile of 1 cup (148 grams) of blueberries.

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