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Blueberries: Medical Benefits and Environmental Needs: Article Review

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I. ABSTRACT

The increasing challenges of the modern era, such as psychological stress, environmental pollution, and climate change, have increased the need for increased awareness of returning to nature. Scientific research has increased on the natural compounds found in plants that hav

e a positive impact on human health. Among these plants, which are of great importance at the present time due to their positive health effects and high economic benefits, is the blueberry fruit, which has effects on cardiovascular health, brain health, immunity, blood sugar regulation, digestive health, skin benefits, prevention of chronic diseases, and combating signs of aging. This positive effect results from its high content of flavonoids, phenols, vitamins, fiber, and minerals. All of these compounds reduce the toxic effect of free radicals in the body resulting from modern living conditions. The economic factor is no less important than the health factor, especially in light of the increasing population density, the lack of job opportunities, and the weak financial returns of most plant crops. This plant is characterized by a high selling price and abundant yields if the necessary cultivation conditions are provided. This is the second aspect that will be focused on in this article. This review highlights the medical importance of blueberries and discusses the key environmental requirements for their successful cultivation, particularly in non-traditional and arid regions.

II. INTRODUCTION

Fruits are primarily classified as foods and their medicinal value is often not highlighted. However their importance to human health in general is noted. Historically research has focused on medicinal herbs known in folk medicine. in recent years interest in so-called functional fruits has increased. Numerous studies are being conducted on fruits to demonstrate the role of their compounds in the prevention and treatment of some chronic diseases, particularly pomegranates (Jurenka, 2008) red grapes (Baur and Sinclair, 2006) blueberries (Joseph, et al., 1999)

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kiwifruit (Stonehouse, et al., 2013) almonds olives and cherries. Blueberries are referred to as superfoods and functional foods due to their rich content of beneficial and health promoting substances primarily polyphenols (Li, et al., 2021; Yang, et al., 2022; Stull, et.al.,2024).

PLANT DEFINITION

Blueberries belong to the Ericaceae family, the genus Vaccinium, and the scientific name is *Cyanococcus*. Blueberry cultivars are diverse and grow in different environments, including lowbush (*Vaccinium angustifolium*) and highbush (V. corymbosum and V. virgatum). These two types tall and short are the most widespread and most widely used in food and processing (Padmanabhan et al., 2016). Blueberries are native to North America where they grow wild near swamps (Wild Blueberry Fact Sheet). Pollination is generally mixed. lowbush plants grow in colonies attached to special underground stems. Their roots are shallow utilizing organic waste and nutrients in the upper soil layer. The taller bushes used for commercial fruit production are deciduous reaching a height of 2–4 meters. Their flowers are bell shaped and white or pink (Canadian blueberries: a true taste of nature). In 1911 the plant was domesticated in collaboration between Elizabeth White and Frederick Coville and from them developed the varieties that formed the basis of the modern blueberry industry (Rodriguez-Saona, et al., 2019).

ACTIVE COMPOUNDS IN BLUEBERRIES

Blueberries are a fruit rich in nutrients including sugars glucose and fructose, vitamins A, D, and E, organic acids such as fulvic, hydroxycinnamic, and hydroxybenzoic acids, and minerals phosphorus, potassium, and magnesium. Blueberries are also very rich in biologically active substances such as flavonoids (Ashique, et. al. 2024). The most common flavanols found in blueberries are quercetin, myricetin, and kaempferol while flavanols are represented by catechin, epicatechin, and gallocatechin (Lavefve et al., 2020; Pertuzatti, Barcia et al., 2016; Pertuzatti, Hermosín-Gutiérrez, et al., 2016; Silva et al., 2020).

Table 1. Bioactive Compounds in Blueberries and Their Associated Medical Effects

Active compounds	Medical Effect	References
Anthocyanins	Strong antioxidant activity; reduce oxidative stress and inflammation; improve cardiovascular health	Kalt et al., 2020
Flavonoids	Neuroprotective effect; improve cognitive function and memory	Spencer, 2010
Polyphenols	Anti-inflammatory and anticancer properties; support immune system	Seeram, 2008

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Vitamin C (Ascorbic acid)	Enhances immune response; promotes collagen synthesis; antioxidant effect	USDA, 2019
Vitamin K	Supports blood clotting and bone health	Manach et al., 2004
Dietary Fiber	Improves digestive health; regulates blood glucose levels	Slavin & Lloyd, 2012
Chlorogenic Acid	Reduces blood glucose levels; supports metabolic health	Williamson, 2017
Resveratrol (trace amounts)	Cardioprotective and anti-aging effects	Baur & Sinclair, 2006

NUTRITIONAL AND MEDICAL IMPORTANCE

It is considered one of the five most important healthy foods for humans. It has recently gained significant attention for its use in plant probiotics, as well as for its pleasant taste and its components of organic acids, phenols, minerals, and vitamins with multiple therapeutic values antioxidants, anti-inflammatory, anti-cancer, nerve protection, and improving eyesight (Kalt, et. al. 2020). Due to its high production and packaging costs and its high perishability, it has been incorporated into many manufacturing processes, such as juices, wine, vinegar, jam, dried fruits, dried powder, colorants, flavorings, biscuits, bread, yogurt, and jelly (Duan, et al., 2022).

SUITABLE ENVIRONMENT FOR PLANT GROWTH

Blueberries grow in subtropical and temperate regions as they are a fruit of the cold temperate zone They require sufficient cold hours to break the dormant phase of the flower buds, and the duration varies depending on the variety (Pinzon, et. al. 2025). They require a moderate climate in winter and a warm climate in summer. The plant grows well in light, well-drained soil, and soil acidity is a determining factor for its success (Zhou, et.al. 2022). The most suitable pH level is between 4.5 and 5.5. The plant does not grow in alkaline soils and requires acidity-reducing treatments in neutral soils (Li, et.al. 2024). As for light, the plant requires at least 6 to 8 hours of sunlight per day to achieve normal growth (a planting guide for establishing a tropical fruit project).

SCIENTIFICALLY PROVEN HEALTH BENEFITS

The first one is cardiovascular health, because who are a higher intake of anthocyanins had the presence 25% lower risk for diseases coronary artery (mortal and non-mortal myocardial-infarction, MI) (Margarethe et al 2016; Aedín et al., 2016; Wood et. al. 2023). Increased consumption of blueberries, strawberries and total anthocyanins were linked to a 32 percent reduced risk for heart attack independent of other known risk factors. (Cassidy et al., 2013). Five cohort studies (Cassidy et. al 2007; Hurst et. al 1993; Mozaffarian et. al., 2011; Lajous et. al., 2016; Grosso et. al., 2018). A cross-section of 1898 carefully phenotyped twins measures vascular stiffness and one other biomarker. This is particularly relevant since clinically meaningful changes in vascular modulation, as assessed by pulse wave

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velocity, have been previously shown to be positively correlated with increasing anthocyanin consumption (Jennings, et. al., 2012).

They compared the consumption of 16 common fruits in terms of obesity and weight-control. In a non-simulated analysis of >>130,000 men and women followed for 24 years, the highest blueberry consumption was related to the least weight gain (–0.64 kilo during 4 years) (Bertoia et al,). al.,2015). Among six types of flavonoids, increased consumption of anthocyanins had the strongest inverse relationship with weight gain (0.1 kg per 10 mg of anthocyanin intake) in a cohort study among greater than 100K participants (Bertoia, et. al.,2016).

On insulin resistance: In a placebo-controlled study in obese, insulin-resistant adults (Stull, et. al., 2010). Anthocyanin extract from cranberry and blackcurrant (80 mg/d) improved insulin sensitivity (HOMA-IR), plasma lipid levels, and some markers of oxidative stress in a pilot study with patients suffering from type 2 diabetes

[82]. In diabetic participants the consumption of blueberry and cranberry reduced fasting blood glucose and glycosylated hemoglobin levels, high certainty of the evidence (Felipe, et. al., 2022). Blueberries also improved neurological performance. analytic thinking improved in older adults who consumed blueberries daily for 12 weeks. Researchers found that healthy older adults who took blueberry as supplement for a duration of 90 days showed improvements in task switching and memory confusion. In 39 older adults with cognitive impairment, blueberry powder led to mild improvements in memory performance and subjective daily functioning. These gains reflected improved executive function. Note: The slightly lesser benefits were observed in older adults with no cognitive disability versus the effect sizes obtained for participants with mild cognitive disability (Krikorian, et. al., 2010; Krikorian, et. al., 2010; Miller, et. al. 2018; McNamara, et. al. 2018)

THE POSSIBILITY OF GROWING BLUEBERRIES IN ARID REGIONS AND THE MIDDLE EAST

Blueberries can be grown in warm semi-arid environments like the Middle East but not in the traditional way; to achieve this, we need several requirements.

Growing in raised beds or containers with the use of a special acidic, well-aerated growing medium is a scientifically proven approach and is used commercially in non-traditional areas (Smrke, et. al. 2021). Selecting Low-chill Southern Highbush and Rabbiteye varieties: Varieties such as Sharpblue, Misty, O'Neal, Emerald, Jewel have proven suitable for warmer regions and are successfully grown in temperate countries (Lyrene, 2008). Controlling the pH of irrigation water: Using an acidifier for irrigation water (e.g., diluted sulfuric acid or phosphoric acids) or an ammonium nitrogen source (ammonium sulfate) helps maintain an acidic growing medium, especially when using pine bark beds (Krewer and Ruter, 2012). Salinity management: Test irrigation water (EC) before planting and avoid using untreated, highly saline water. Recent research shows differences in varietal tolerance to Cl^- and Na^+; therefore, selecting a resistant variety or reducing irrigation salinity is essential (Molnar, et. al., 2024). Shading and greenhouses: Reducing heat stress and evaporation during the summer improves fruit quality and reduces water consumption; these practices are used in trials and farms in Eastern Mediterranean countries and Morocco (Fang, et. al., 2020)

BIOSAFETY AND EFFECTIVE DOSAGES OF BLUEBERRY IN CLINICAL STUDIES

Clinical studies have shown that blueberries have a high biosafety profile with no serious adverse effects reported at dietary or therapeutic doses used in clinical trials. Double blind trials involving healthy adults and individuals with metabolic syndrome have shown that daily blueberry consumption was not associated with serious adverse events and good tolerability was observed over periods of up to six months (Curtis, et. al., 2019; Wang, et. al. 2022).

Effective doses of blueberries in clinical studies have ranged from 150-300 g/day of fresh berries or the equivalent in dried powder 22–45 g/day. These doses have shown positive effects on cardiovascular health including improved

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vasodilation and reduced systolic blood pressure. Doses equivalent to one cup 150 g per day have also been used successfully to improve metabolic markers without any reported toxicity (Curtis, et. al., 2022; Wood, et. al. 2023)

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