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FRUITS AND VEGETABLES IN HUNGARY: FROM CULTIVATION TO NUTRITION

Judit Molnár[a], Zoltán Varga[b], Tamás Szakál[c], Ottília Vámos[d], Dávid Vasas*
Department of Soil, Water and Natural Sciences, Albert Kázmér Faculty of Agricultural and Food Sciences of Széchenyi István University in Mosonmagyaróvár, Vár Square 2. H-9200 Mosonmagyaróvár, Hungary
vasas.david@sze.hu

The consumption of fruits and vegetables is a key component of a healthy diet worldwide. In Hungary, the past and present of horticultural education, as well as the cultivation of vegetables and fruits, are of notable importance. Researchers and educators have played a significant role in advancing these areas. Numerous scientific disciplines contribute to the understanding of the role and value of fruits and vegetables. Therefore, it is essential to prepare a comprehensive review that highlights Hungarian vegetable and fruit cultivation, as well as related collections. Given the current phase of climate change - and more broadly, complex environmental transformations - it is increasingly necessary to integrate knowledge on the ecological requirements and nutritional value of horticultural crops with environmental trends and future projections. This approach is essential for improving the resilience and adaptability of the sector. An extensive literature review was conducted using Google Scholar, Medline, and PubMed databases, covering the fields of agriculture, engineering, food science, and nutritional sciences. Relevant scientific books were also examined. Based on this research, we selected the most pertinent sources to inform our review. Our publication focuses on the key characteristics of commonly cultivated vegetables in Hungary- including cultivation practices, environmental requirements, nutritional content, and culinary relevance. The vegetables covered include tomato, pepper, long pepper, potato, cucumber, zucchini, watermelon, green pea, green bean, onion, garlic, carrot, celery, radish, beetroot, horseradish, head lettuce, cabbage, cauliflower, and sweet corn. Fruits such as apple, pear, peach, apricot, plum, walnut, cherry, and sour cherry are also analyzed based on similar aspects. Fruits and vegetables, along with their beneficial components, play a crucial role in disease prevention and maintaining good health. We hope that our manuscript contributes to a deeper understanding of Hungarian fruit and vegetable production, offering readers valuable and engaging insights into Hungarian gastronomy.

1. Introduction

About 25-35 types of vegetables are grown in Hungary. Of these, 9-10 plants account for 90 % of production and consumption. Both globally and in Hungary, vegetables are grown on 2-3 % of arable land. Vegetable production can take place in arable land, in greenhouses, in film-covered growing equipment, or in arable land with temporary film covering. About 120 ha of greenhouse area is used for vegetables. The areas covered with film can be estimated at 6-8 kha (Hodossi et al., 2004). In our country, almost one-third of greenhouse vegetable production consists of peppers, tomatoes, and cucumbers, according to data published in 2004 (Hodossi et al., 2004). Vegetarian, vegan, and flexitarian diets are associated with reduced intake of animal-based proteins, which, in addition to their environmental and health benefits, contribute positively to sustainability (Szalai et al., 2024). All three diets share a common foundation in valuing natural food sources and adhering to nutritional guidelines aimed at maintaining health (Molnár et al., 2023).

In addition to vegetable production, fruit production is also of outstanding importance in our country. Even the conquering Hungarian ancestors found a significant supply of wild fruits, including wild sour cherries, wild apples, wild pears, blackberries, and blueberries. Conscious fruit production began in monastery gardens in Europe as well as in Hungary (Sipos, 2002).

The ongoing phase of climate change - or, more broadly, complex environmental transformation - necessitates the collection, systematization, and critical evaluation of knowledge concerning the cultivation, ecological requirements, and nutritional value of horticultural crops in Hungary. These efforts must be aligned with both the current and projected future conditions of environmental change, as well as with its potential consequences. Such a synthesis is essential for enhancing the adaptability of the horticultural sector and reducing its vulnerability. Food systems face critical challenges from climate change, hunger, malnutrition, and social inequities, but also present opportunities for producing healthy, sustainable, and equitable food (Fanzo et al., 2022).

This article presents the initial steps of this complex undertaking. It builds upon a previous manuscript from 2008, which examined the impacts of climate change on horticultural production in Hungary. That study emphasized that extreme weather events represent the greatest challenge, as they reduce yields and compromise crop security. It proposed cultivar-specific adaptation strategies, reevaluation of production sites, and the implementation of technological innovations - particularly in vegetable and fruit production, as well as in medicinal plant cultivation (Varga and Varga-Haszonits, 2008). Nearly two decades later, a renewed assessment is required - this time also addressing the issue of nutritional value. Fruits and vegetables, due to their high vitamin content and immune-supporting properties, play a crucial role in health maintenance, disease prevention, and the preservation of physiological balance (Pal and Molnar, 2021).

Many fruit species were introduced to Hungary from Asia Minor and Southern Europe in the 15th-18th centuries, and from Western Europe in the 19th century. In the 20th century, new varieties and cultivation techniques were introduced to Hungary from America (Sipos, 2002). The systematization of the results of the examination of variety collections became part of the fruit breeding work from the 20th century (Szabó and Vaszily, 2017). The introduction of specialized horticultural education is attributed to Ferenc Entz, while domestic fruit breeding is attributed to Máté Bereczki. Gyula Magyar, János Horn and Mátyás Mohácsy, who dealt with the theoretical knowledge of fruit cultivation (Sipos, 2002). Among the founders of Hungarian fruit production, Sándor Nagy, Sándor Fejes, Aladár Porpáczy, Jenő Liszka, Gyula Szakátsy, Pál Maliga, and Iván Okályi can be mentioned, whose work was outstanding and honorable (Sipos, 2002). Fruit and vegetable production, particularly small-scale farming, plays a pivotal role in achieving sustainable development goals. The promotion of sustainable farming practices contributes significantly to food security (FAO and CIRAD, 2021). Fruit and vegetable wastes, which constitute about 16 % of total food waste

and contribute approximately 6 % to global greenhouse gas emissions, present valuable opportunities for valorization within the Circular Economy framework (Cassani and Gomez-Zavaglia, 2022). During the 2024 data collection, 108 vegetable farmers were surveyed in the Mymensingh district. The majority of respondents (74.07 %) perceived sustainable farming practices to be moderately effective. According to the findings, the perceived effectiveness was significantly influenced by extension contact and knowledge related to agricultural practices. Most vegetable producers (59.25 %) reported facing substantial challenges in the implementation of sustainable agricultural practices, with the most frequently cited issue being the high incidence of pests and diseases (Hasan et al., 2025). Another study highlighted that Sustainable and Circular Production Models (SCPMs) represent a viable alternative to conventional fruit and vegetable production systems (Duque-Acevedo et al., 2022). Sustainable vegetable production plays a key role in both current and future agroecological systems. Unfortunately, in the southern African region, land scarcity and the decline of genetic diversity in vegetable crops are anticipated (Mazibuko et al., 2023).
Vegetables and fruits are indispensable components of a healthy diet, as their valuable nutritional content contributes significantly to the maintenance of health (Rodler, 2005). Experts have formulated recommended intake levels in various forms (Okostányér, 2025; HARVARD.EDU, 2025). Dietary and lifestyle changes were examined during the active phase of the COVID-19 pandemic. The study indicates that pandemic-related restrictions contributed to trends of decreased vegetable consumption, contrary to recommended guidelines (Molnár et al., 2022).

Most vegetables and fruits have a low energy content, with the exception of dry legumes and nuts. Their fat content is minimal -again, with the exception of nuts- and the carbohydrate content of most varieties is also negligible, apart from certain exceptions such as dry legumes, potatoes, chestnuts, bananas, and some types of nuts (Rodler, 2005). Among their beneficial components are dietary fibers, which inhibit the absorption of fats and cholesterol (Rodler, 2005). The vitamins found in vegetables and fruits -primarily B1, B2, B6, C, K, and E- as well as various micro- and macroelements and phytochemicals, also exert significant physiological effects.

In addition, dishes prepared from vegetables and fruits (e.g., apple and sour cherry pies, jam-filled pancakes and sweet rolls, walnut and poppy seed bejgli, stuffed cabbage, and stuffed peppers) are prominent elements of Hungarian gastronomy. Furthermore, traditional beliefs and folk customs associated with vegetables and fruits also hold cultural importance. In Hungary, for example, it was customary to predict the weather using blossoming fruit branches in winter. The apple has long symbolized love and knowledge, as reflected in both Greek mythology and the Christian Bible (Sipos, 2002). The most important environmental conditions of Hungarian fruit and vegetable production is described first in this paper and then the importance of some Hungarian fruits and vegetables is presented. As a continuation, in our article we summarize the nutritional properties of several domestically grown vegetables and fruits, along with their roles in healthy nutrition and gastronomy.

2. State-of-the-art analysis

Vegetable and fruit production remains a cornerstone of sustainable agriculture worldwide, reflecting ongoing efforts to enhance yield stability, nutritional quality, and environmental resilience under rapidly changing climatic conditions. Recent studies emphasize that despite advances in horticultural practices and cultivar development, substantial challenges persist in adapting to climate variability, maintaining biodiversity, and ensuring nutritional security. Recent environmental challenges require a rethinking of adaptation strategies, especially regarding extreme weather events and shifts in agroecological zones.

Global trends show a growing demand for plant-based diets, which are key to achieving health and sustainability goals. Food loss and waste continue to pose significant challenges in terms of greenhouse gas emissions and resource efficiency, which circular economy approaches seek to mitigate through the valorization of horticultural by-products.

Current literature gaps include insufficient region-specific analyses of the interactions between climate adaptation, crop nutritional value, and socio-economic factors affecting smallholder farmers. There is a lack of systemic evaluations that integrate ecological, agronomic, and nutritional traits based on future climate scenarios.
Our study aims to address these gaps by providing a comprehensive synthesis that presents the environmental conditions influencing Hungarian fruit and vegetable production, while also offering an updated evaluation of their nutritional value and their roles in health and gastronomy.

3. Method

During our research, primarily electronic information in the Google Scholar, Medline and PubMed databases was collected. In addition, we paid special attention to textbooks, notes and other recommended literature related to the topic. The searched works included knowledge about characteristics of vegetables and fruits, healthy nutrition, cultivation, environmental conditions, functional foods and nutritional values, Hungarian gastronomy, dietary fiber, vitamins, macroelements, microelements, and phytochemicals. The manuscripts, after being summarized and critically analyzed, include information on the environmental requirements and nutritional properties of several important domestic vegetables and fruits, along with their roles in healthy nutrition and their beneficial components. We included a total of 87 references (Okostányér, 2025; HARVARD.EDU, 2025), and their distribution by year of publication is illustrated in Figure 1.

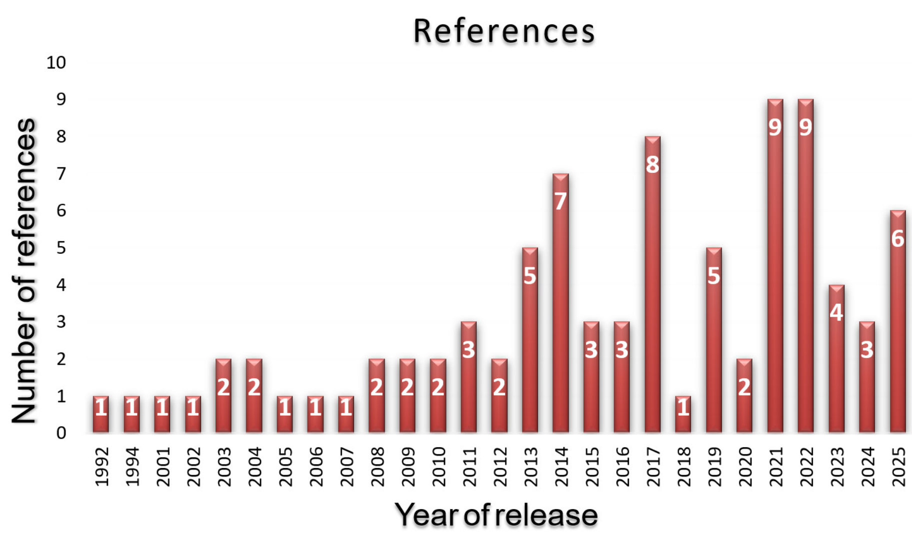

Figure 1: References cited by year of publication

4. Results

The environmental conditions of vegetables and fruits are analyzed in the first section.

4.1 Environmental conditions for vegetable cultivation

Processes occurring in plants, which can be biological, biochemical, and physical, are temperature-dependent. Their occurrence, speed, and direction are significantly influenced by temperature (Hodossi et al., 2004). In addition, light also plays a decisive role in the organic matter building of plants. Light also has an effect on most biochemical and physiological processes (growth, development, morphological and anatomical changes). In addition, it plays a significant role in transpiration and mineral nutrition. Thus, the appropriate amount of light also causes significant qualitative changes in vegetables (Hodossi et al., 2004). Nearly forty elements that make up the organism of plants come from the air, water, and mostly from the soil. According to their origin, they can be elements that can be absorbed from water, such as oxygen and hydrogen, elements that can be absorbed from the atmosphere, such as carbon, and elements that can be absorbed from the soil, such as nitrogen.

Horticultural crops, including vegetables, have higher demands on soil structure and nutrient content than field crops (Stangl, 1994). Medium-density, deep soil with good structure and adequate water management, crumbly, rich in humus, and easily absorbed nutrients is ideal for almost all vegetable crops (Hodossi et al., 2004). The principles of sustainable agricultural cultivation and information on the nutrient supply of cultivated plants have been formulated in several manuscripts (Kalocsai et al., 2022). The practical implementation of the underlying principles is closely linked to the reliability and comparability of soil testing methods, which form the basis of nutrient management recommendations and support the sustainability of soil use (Vona, 2021).

The role of water in the life of plants is also essential. Approximately 90 % of the mass of vegetables is water, which is part of the cell sap and is the medium for dissolving and transporting plant nutrients. In addition, water is an important plant nutrient, playing a decisive role in the formation and regulation of turgor and osmosis in the plant and in the plant's energy management. The water requirements of cultivated vegetable species can vary significantly. Some are drought-tolerant (such as chicory salad), while others require continuous, large-scale irrigation (such as pepper). The water use of vegetable plants depends on temperature, air humidity, light conditions and soil nutrient supply, among other things (Szabó, 2001). Both more and less water than optimal can be harmful to the plant. The rate, method and timing of irrigation also affect successful water supply (Hodossi et al., 2004).

4.2 Environmental conditions for fruit cultivation

The environmental conditions of fruit cultivation can also be read in several manuscripts (Stangl, 1994). The success of cultivation was founded on favorable geographical factors, human resources, and the concentration of species within specific cultivation regions and zones (Surányi, 2011). Among the indirect factors of organic fruit production, the following elements were highlighted: site selection, soil nutrient-supplying capacity, rootstock, cultivar, planting material, planting density, canopy shape, phytotechnical practices, irrigation, soil cultivation, mulching, and nutrient management. (Dremák, 2010). The weather has a significant impact on fruit production. Summer heat combined with drought can cause just as much damage as late spring frosts. Temperature fluctuations can also lead to winter freezing of flower buds. Preventing damage caused by weather poses a challenge for producers. These can be mitigated mainly by cultivation techniques, appropriate selection of the growing site, and planting domestically bred fruit varieties (Sipos, 2002). Sunlight plays a prominent role in the environmental conditions of fruit production. Green plants produce nutrients from carbon dioxide and water with the help of sunlight energy, and they use these nutrients for their growth, flowering, and life activities. In the absence of light, several damages occur in the plant, such as a few developing flower buds, the fruiting surface is shifted to the edge of the crown, or the fruit does not color (Sipos, 2002).

Precipitation must be supplemented by irrigation in our country. In some cases, this can be replaced by water-conserving soil care methods. Hail, on the other hand, can cause significant damage to fruits, against which the most reliable protection is the use of ice protection nets (Sipos, 2002). Strong winds can also cause damage to fruit trees. This damage can be prevented by installing windbreaks. With moderate wind movement, pollination of flowers is more complete, and the fruits are healthier (Sipos, 2002). Some plants (for example, apricots, almonds, peaches, and walnuts) are particularly sensitive to spring frost. This can be either transported frost (cold air currents) or radiant frost (ground frost) (Sipos, 2002). Fruit production is also highly dependent on topographic factors. The most important of these are the degree of slope, the orientation of the slope, and even the altitude (Sipos, 2002). Good soil is also very valuable. A well-chosen soil and knowledge of its most important properties play a prominent role in fruit production. Fruit varieties have different soil requirements. Therefore, rational soil care and/or nutrient management are important. This can reduce or completely eliminate the adverse properties of the soil (Kalocsai et al., 2022). The most important soil properties include humus content, pH, friability, soil structure, and soil type (Sipos, 2002).

4.3 The most important beneficial components of vegetables and fruits

Diets rich in fruits and vegetables not only provide a gastronomic experience but also contribute to the maintenance of health due to their beneficial components. In this context, we discuss the properties of dietary fibers, vitamins, minerals, and phytonutrients (Du et al., 2025). Research findings suggest that short-term fruit juice consumption may have a negative impact on the gut microbiome, likely due to reduced dietary fiber intake and the increased sugar and carbohydrate content (Sardaro et al., 2025).

Dietary fibers are the components of vegetables and fruits that are not broken down by the human body -these are indigestible complex carbohydrates, also known as polysaccharides. They are classified into two groups: water-soluble fibers (with fruits and vegetables as their primary dietary sources) and water-insoluble fibers (primarily found in cereals and oilseeds). Fibers serve as essential nutrients for the gut microbiota, stimulating various physiological functions within the body, such as vitamin synthesis and immune defense mechanisms. Fiber intake has been shown to reduce the risk of cardiovascular diseases, certain types of cancer, obesity, and type 2 diabetes (Nishi et al., 2023). In recent decades, the diet has undergone radical changes compared to that of our ancestors, which has also affected the gut microbiota (Barber et al., 2020). In the majority of Western countries, approximately 90 % of the population consumes only about half of the recommended daily intake of dietary fiber (Dreher, 2018). It is noteworthy that over 60 % of fruits and vegetables worldwide contain pesticides, compounds that bioaccumulate in adipose tissues (Bansal, 2025).

The vitamins found in vegetables and fruits are essential for growth, vitality, and overall physical well-being. Vitamins are organic compounds that play a regulatory role in the body's metabolic processes, with some also functioning as antioxidants (e.g., vitamins C and E). Vitamins can be classified based on their solubility: some are water-soluble, while others are fat-soluble (Slavin and Lloyd, 2012). Among the water-soluble vitamins, the B-group vitamins and vitamin C are the most significant, and their key properties are summarized in Table 1 (Bryant et al., 2017).

Table 1: Water-soluble vitamins

Vitamins	Benefits and deficiency symptoms	References
Vitamin B1 (Thiamine)	• Supports energy production, muscle function, and nerve function, among numerous other beneficial effects reported in the literature. • Deficiency can lead to neurological impairments, among other symptoms.	Bryant et al., 2017 Fattal-Valevski, 2011
Vitamin B2 (Riboflavin)	• Plays a role in metabolism, the functioning of the skin, eyes, and nervous system, possesses antioxidant properties, and protects the body against oxidative stress. • Deficiency may result in symptoms such as weakness and anemia.	Bryant et al., 2017 Ashoori and Saedisomeolia, 2014
Vitamin B3 (Niacin)	• Supports the nervous system, brain function, and cardiovascular health, and contributes to skin health and metabolic balance.	Bryant et al., 2017 Sallabi et al., 2021
Vitamin B5 (Pantothenic Acid)	• It plays a crucial role in metabolism, the synthesis of neurotransmitters, hormones, and hemoglobin, as well as in the stimulation of the immune system. • Deficiency results in disruptions in these physiological functions.	Bryant et al., 2017 Bourgin et al., 2022
Vitamin B6 (Pyridoxine)	• Involved in nerve function, metabolism, and the production of antibodies and hemoglobin. • Deficiency adversely affects mental health.	Bryant et al., 2017 Stach et al., 2021
Vitamin B7 (Biotin)	• Plays a role in maintaining the health of bones and hair, as well as in lipid metabolism. • Deficiency may cause muscle pain or dermatitis.	Bryant et al., 2017 Zempleni et al., 2009
Vitamin B9 (Folate or Folic Acid)	• Numerous beneficial effects of vitamin B9 have been reported in the literature. • It is essential for healthy fetal development. • Deficiency increases the risk of neural tube defects in newborns.	Bryant et al., 2017 Zsigrai et al., 2019
Vitamin B12 (Cobalamin)	• Involved in metabolism and the production of red blood cells. • Deficiency results in pernicious anemia, characterized primarily by fatigue and neurological disturbances.	Bryant et al., 2017 O' Leary and Samman, 2010
Vitamin C (Ascorbic Acid)	• Vitamin C acts as an antioxidant and supports the growth and maintenance of body tissues. • Deficiency leads to weakened immune function and delayed wound healing.	Bryant et al., 2017 Chambial et al., 2013

The benefits and deficiency symptoms of the fat-soluble vitamins A and E are summarized in Table 2.

Table 2: Summary of the Properties and Deficiency Symptoms of Fat-Soluble Vitamins A and E

Vitamins	Benefits and deficiency symptoms	References
Vitamin A (retinol and its derivatives such as retinal and retinoic acid)	• Vitamin A is essential for normal visual function and growth. • A deficiency in vitamin A can result in visual impairment, including night blindness and, in severe cases, xerophthalmia.	Bryant et al., 2017 Booth et al., 1992
Vitamin E (primarily in the form of α-tocopherol)	• In addition to its antioxidant properties, vitamin E protects cell membranes, contributes to the maintenance of healthy skin and eyes, and supports immune function.	Bryant et al., 2017 Rizvi et al., 2014

In addition to vitamins, the human body also requires minerals. Some minerals are needed in relatively large amounts (macroelements), while others are required only in trace amounts (microelements). Macroelements -such as magnesium, potassium, calcium, phosphorus, sulfur, and sodium- play a significant role in maintaining overall health. Their key properties are summarized in Table 3 (Bryant et al., 2017; Głodowska and Krawczyk, 2019; Chaudhari et al., 2024).

Table 3. Contribution of Macroelements to the Maintenance of Human Health

Macroelements (macrominerals)	Benefits and deficiency symptoms	References
Magnesium	• It plays a vital role in the functioning of the immune system, muscles, and nerves. • Its deficiency disrupts the balance of the nervous system and cardiovascular health.	Bryant et al., 2017 Schwalfenberg and Genuis, 2017
Potassium	• It contributes to the regulation of muscle and nerve function. • Its deficiency may result in muscle cramps and cardiac arrhythmias.	Bryant et al., 2017 Weaver, 2013
Calcium	• It contributes to the health of bones and teeth and plays a role in the functioning of the nervous system and muscles. • It supports growth in children and the attainment of peak bone mass.	Bryant et al., 2017 Cormick and Belizán, 2019
Phosphorus	• It is essential for healthy bones and also participates in the conversion of nutrients into energy. • Deficiency may result in muscle weakness.	Bryant et al., 2017 Calvo and Lamberg-Allardt, 2015
Sulfur	• It is an essential component of many proteins. • It plays an important role in the synthesis of new body tissues.	Bryant et al., 2017 Komarnisky et al., 2003
Sodium	• It regulates the body's fluid balance. • Low levels may cause headaches and, in severe cases, disrupt homeostasis.	Bryant et al., 2017 Strazzullo and Leclercq, 2014

Among the microelements, the key properties, beneficial effects, and deficiency symptoms of copper, fluoride, iodine, zinc, iron, and selenium are also summarized in Table 4 (Bryant et al., 2017, Buturi et al., 2021). In addition to dietary fiber, vitamins, and micro- and macronutrients, phytochemicals are also significant components of fruits and vegetables (Kohima et al., 2023). Flavonoids, due to their potent antioxidant activity, are capable of maintaining the balance of reactive oxygen species within cells, thereby providing protection against abiotic stress factors (Zheng et al., 2025). The discovery of naturally occurring phytonutrients marked a new chapter in the assessment of the health effects of plant-based foods. Phytochemicals are bioactive, plant-derived chemical compounds (e.g., terpenes, sulfides, saponins, carotenoids, polyphenols) that contribute to plant growth and survival, while also supporting human health (Liu, 2013). Among their health-promoting effects, their antioxidant, anticarcinogenic, antimicrobial, and anti-inflammatory properties are particularly noteworthy. In addition, they support the functioning of the gastrointestinal, cardiovascular, and nervous systems. Phytochemicals have also been shown to alleviate menopausal symptoms and contribute to the prevention of certain cancers (Tsegay and Mulaw, 2025).

Table 4. Contribution of Microelements to the Maintenance of Human Health

Microelements (trace elements)	Benefits and deficiency symptoms	References
Copper	• It plays a role in the function of numerous enzymes and in iron metabolism. • Its deficiency is associated with anemia.	Bryant et al., 2017 Collins and Klevay, 2011
Fluor (Fluoride or Fluorine)	• As an ionic compound, it strengthens bones and teeth. • Its deficiency leads to dental caries.	Bryant et al., 2017 Kanduti et al., 2016
Iodine	• It plays an important role in thyroid function. • Deficiency can result in developmental disorders, physical impairments, and intellectual disabilities.	Bryant et al., 2017 Fuge and Johnson, 2015
Zinc	• It plays a crucial role in maintaining immune system homeostasis and in the function of enzymes essential to physiological processes.	Bryant et al., 2017 Saper and Rash, 2009
Iron	• It enables oxygen transport by red blood cells and contributes to energy production. • Its deficiency causes iron-deficiency anemia.	Bryant et al., 2017 Abbaspour et al., 2014
Selenium	• Its antioxidant properties contribute to cellular protection.Deficiency is most commonly observed in individuals consuming products grown in selenium-deficient soils.	Bryant et al., 2017 Kieliszek, 2019

4.4 Environmental Requirements of Domestic Vegetables and Their Importance in Healthy Nutrition

In the following sections of our article, we summarize the environmental requirements, key characteristics, and nutritional composition of several commonly grown domestic vegetables (Table 5, Table 6 and Table 7). In addition, we examine the role of these vegetables in healthy nutrition, disease prevention, and their significance in Hungarian gastronomy.

Table 5: Vegetables for Human Consumption: Environmental Requirements, Nutritional Composition, and Their Role in Healthy Nutrition

Domestic vegetables intended for eating	Their most important characteristics, cultivation, and environmental conditions and nutritional composition	References
Celery (Apium graveolens)	• Celery belongs to the Apiaceae family. In Hungary, it is primarily cultivated outdoors, with three main types recognized: celeriac (root celery), blanching celery, and leaf celery (celery stalks). • Celery contains notable amounts of dietary fiber, potassium, and folate, and its essential oils contribute to its characteristic aroma and flavor. • Bioactive compounds such as phthalides have been associated with blood pressure regulation and anti-inflammatory effects. • The plant prefers moist, nutrient-rich soils and a cool, temperate climate.	Szabó, 2001 Cserni et al., 2015
Garlic (Allium sativum)	• Garlic is characterized by its high protein and inulin content. The ratio of inulin to fructose significantly influences its flavor and pungency. • Its characteristic odor is attributed to allyl sulfide compounds. Among minerals, garlic is particularly rich in phosphorus and potassium, while its vitamin C content is also notable. • Due to its antibacterial, vasodilatory, and digestive stimulant properties, garlic has been used in traditional and modern medicine. • As a spice, it holds a prominent place in Hungarian gastronomy.	Hodossi et al., 2004 Koczka, 2017
Head lettuce (Lactuca sativa)	• The appearance of lettuce heads intended for consumption can vary greatly depending on the cultivar, including differences in shape, color, size, and leaf thickness. • Consumer preferences for head lettuce typically include light green leaf color, thin leaves, large head size, good overlap of wrapper leaves, and a broad, well-closed base.	Hodossi et al., 2004 Boros, 2021
Horseradish (Armoracia rusticana)	• Horseradish (Armoracia rusticana) belongs to the Brassicaceae family and is a characteristic ingredient of Hungarian cuisine, commonly used for flavoring and seasoning. • It is also effective in alleviating symptoms of the common cold.	Szabó, 2001 Ördögh, 2017
Tomato (Solanum lycopersicum)	• The tomato is a soft stemmed, annual, self-fertile plant, which is one of the most important vegetable crops in the world. • In terms of its environmental needs, tomatoes are a moderately heat-loving plant and have a medium water requirement. • The most favourable soils are medium-compact, sandy loam, loam or clay-loam soils with a pH value of 5.6-8.2 and a humus content of at least 1.2-1.4%.	Hodossi et al., 2004 Horváth et al., 2020 Lugasi et al., 2003 Ráth et al. 2019

Table 6: Vegetables for Human Consumption: Environmental Requirements, Nutritional Composition, and Their Role in Healthy Nutrition

Domestic vegetables intended for eating	Their most important characteristics, cultivation, and environmental conditions and nutritional composition	References
Pepper (Capsicum annuum var. grossum)	• In our country, pepper is grown as an annual plant, at its place of origin we can also find perennial, woody semi-shrubs. • Its vitamin C content varies between 50-300 mg/100 g, but it also has a significant content of vitamins B1, B2, B6, beta-carotene, cryptoxanthin. In terms of its environmental needs, pepper is an extremely heat-demanding plant and its water requirement is also significant. • It prefers neutral, but rather slightly acidic soils.	Hodossi et al., 2004 Jadon et al., 2016
Long pepper (Capsicum annuum var. longum)	• The tradition of growing long pepper dates back a long time, mainly due to its taste, aroma, colouring and excellent seasoning effect. • Its use is most widespread as a ground product, spice powder, soup powder, among others. • The centre of long pepper production in Hungary is Kalocsa and Szeged. In terms of its environmental needs, it is an extremely light and heat-demanding plant. • A steady water supply is essential for its continuous development. • It can be grown most successfully on brown sandy or medium-compacted loam soil that warms easily and has good air and water management.	AlOudat et al., 2021 Hodossi et al., 2004
Potato (Solanum tuberosum)	• In Hungary, Balástya and its surroundings, the southern region of Bács-Kiskun County, the surroundings of Paks and Dunaföldvár, the sandier areas of Mohács Island and Alsónémedi can be considered the center of early potato cultivation. • In terms of its environmental requirements, potatoes are a plant that prefers moderate heat and its water requirements are highest during tuber formation, while they are more modest at the beginning and end of the vegetation. • Brown sandy soil with humus that warms up easily is the most suitable for its cultivation.	Coelho et al., 2022 Hodossi et al., 2004
Cauliflower (Brassica oleracea convar. botrytis var. botrytis)	• Cauliflower (Brassica oleracea convar. botrytis var. botrytis) belongs to the Brassicaceae family. • It is nutritionally significant, containing 50–80 mg of vitamin C per 100 g, and is also rich in vitamins B1 and B2.	Hodossi et al., 2004
Cucumber (Cucumis sativus)	• In our country, cucumber cultivation is primarily associated with Győr-Moson-Sopron, Szabolcs-Szatmár-Bereg and Bács-Kiskun counties. • Its high potassium content has a beneficial effect on kidney function. • It is an extremely heat-requiring plant with medium light requirements. • Soils that warm up quickly, have good structure, are rich in organic matter and have a nearly neutral pH are the most favourable for it.	Hodossi et al., 2004 Orbán et al., 2014
Zucchini (Cucurbita pepo var. giromontia)	• Zucchini is considered a plant that expands the range of products and its cultivation is booming. • It is grown both for the fresh market and for processing purposes. • It is an outstanding vegetable from a nutritional point of view, which is proven by numerous manuscripts. • In terms of its environmental needs, zucchini has a high light requirement and grows well in full sunlight. • Its heat and water requirements are also significant. • It grows best on easily warming, humus-rich, medium-compacted and well-aerated soil.	Hodossi et al., 2004 Martínez-Valdivieso et al., 2017

Table 7: Vegetables for Human Consumption: Environmental Requirements, Nutritional Composition, and Their Role in Healthy Nutrition

Domestic vegetables intended for eating	Their most important characteristics, cultivation, and environmental conditions and nutritional composition	References
Watermelon (Citrullus lanatus)	• Watermelon belongs to the Cucurbitaceae family and the Citrullus genus. • It is a fruit substitute vegetable containing 6-12 % sugar. • It is also rich in potassium, sodium, calcium, iron, sulfur and phosphorus. • It has a diuretic effect and improves digestion thanks to its high fiber content. • Relatively wind-protected, windless places are the most suitable for its cultivation. • Its soil requirements are the same as those of melon, i.e. it prefers humus-rich, quickly warming, deep soils with a nearly neutral pH.	Hodossi et al., 2004 Lendvay, 2021
White cabbage (Brassica oleracea convar. capitata var. alba)	• White cabbage (Brassica oleracea convar. capitata var. alba) belongs to the genus Brassica and is one of the oldest cultivated vegetable crops. • It has significant nutritional value, primarily due to its high content of dietary fiber, vitamin C, and vitamins B1 and B2. • It can be stored effectively using simple preservation methods.	Hodossi et al., 2004
Green pea (Pisum sativum)	• Green Peas are easily digestible, rich in protein, vitamin C and minerals so they can be easily incorporated into a healthy diet. • In terms of their environmental needs, they are a plant that prefers low temperatures. • Their light requirements are medium. • They can be grown on all soil types (except extremes), so from loose sandy loam soils to medium clay soils are perfect for them. • Experiments related to green peas were found in several manuscripts.	Hodossi et al., 2004 Pap and Pap, 2007 Várallyay et al., 2016 Várallyay et al., 2017
Green bean (Phaseolus vulgaris)	• Green Beans are high in protein and fiber, and their vitamin B1, B2, B3, C, carotene and mineral content also contribute to health maintenance and disease prevention. • In terms of their environmental needs, green beans are a heat-loving plant with medium light requirements. • Looser-textured brown sand, sandy loam, humus-rich potting soil and lime-rich soils are also suitable for their cultivation.	Hodossi et al., 2004 Györgyi, 2008
Sweet corn (Zea mays var. saccharata or Zea mays var. rugosa)	• Both sweet corn and forage corn are annual, monoecious, and dioecious monocotyledonous plants belonging to the Poaceae family. • In addition to their caloric, carbohydrate, and protein content, they are rich sources of vegetable oils, minerals (calcium, phosphorus, potassium, magnesium, iron), and vitamins (B1, B2, B3, and C).	Hodossi et al., 2004 Gere et al., 2013
Onion (Allium cepa)	• Onion consumption is still significant today, which is due to its vitamin (vitamin A, B, C) and potassium content. • Bactericidal substances are also found in it and its pungency is caused by allyl sulfide. • Domestic onion production accounts for 1% of world production. • In terms of its environmental needs, onion is a cold-tolerant plant, moderately water-intensive. • It prefers humus-rich, medium-compacted soils.	Geisseler et al., 2022 Hodossi et al., 2004

Table 7 (Continued)

Domestic vegetables intended for eating	Their most important characteristics, cultivation, and environmental conditions and nutritional composition	References
Radish (Raphanus sativus)	• The radish (Raphanus sativus) is an annual plant belonging to the Brassicaceae (mustard) family, with three main varieties: spring (or salad) radish, summer radish, and autumn-winter radish • In Hungary, it is not among the most economically significant vegetable crops, but it is commonly cultivated in home gardens as well as in small- and large-scale agricultural operations.	Szabó, 2001 Terbe, 2017

4.5 Edible Fruit Species in Hungary: Ecological Requirements and Nutritional Importance

Tables 8 and 9 provides an overview of the main characteristics, environmental conditions required for cultivation, and the contribution to health maintenance of several fruit species commonly grown in Hungary.

Table 8: Environmental Demands, Compositional Properties, and the Dietary and Culinary Importance of Fruits Intended for Human Consumption

Domestic fruits intended for eating	Their most important characteristics, cultivation practices, and environmental requirements are presented, along with their physiological roles and health benefits in the human body.	References
Apple (Malus domestica)	• Apples are one of the best-known and most consumed fruits, • Its most important health-protective effect lies in its pectin content. • In addition to its fiber content, it is also rich in minerals (calcium, nickel, manganese) and vitamins (E, B2, B6). • In terms of its environmental needs, it can be grown best on moderately compact, sandy loam and loamy soils where the humus layer is thick and where the groundwater is located at a depth of 2-3 m. • A cool and rainy growing location has a negative effect on the quality of the apple.	Sipos, 2002 Szabó, 2012
Apricot (Prunus armeniaca)	• The domestic apricot is a recognized fruit and a popular raw material for the production of pálinka (Hungarian fruit brandy). • Its environmental requirements are outstanding compared to other domestic fruit species. • The fruit is extremely sensitive to spring frosts, cannot tolerate cold temperatures above -20 °C and requires a lot of sunlight. • It can be grown most successfully on the southwestern and northwestern slopes of hilly regions. • Experiments and research on the yield and fruit size of the Hungarian apricot can also be found in scientific databases.	Drén et al., 2006 Sipos, 2002
Cherry (Prunus subg. Cerasus)	• In Hungary, cherry (Prunus subg. Cerasus) represents one of the most important sources of preserved fruit for winter consumption • It is notable for its substantial carbohydrate content, as well as its richness in vitamins (B1, B2) and minerals, including potassium, calcium, copper, zinc, and cobalt.	Sipos, 2002 Szabó, 2012
Pear (Pyrus communis)	• Pear is rich in both carbohydrates and fiber and among the minerals it contains calcium and potassium, while among the vitamins it contains significant amounts of vitamins B1 and B2. • Winter and autumn pear varieties prefer cooler, more humid growing areas where the soil is medium-firm, deep and has good water permeability. • Dryer, sandy areas are most ideal for summer varieties. • Strong winds reduce the quality of the fruit for all pear varieties.	Nótári and Ferencz, 2014 Sipos, 2002 Szabó, 2012

Table 9: Environmental Demands, Compositional Properties, and the Dietary and Culinary Importance of Fruits Intended for Human Consumption

Domestic fruits intended for eating	Their most important characteristics, cultivation practices, and environmental requirements are presented, along with their physiological roles and health benefits in the human body.	References
Peach (Prunus persica)	• Peaches also play a significant role in domestic fruit production. • As a raw material for soft drink production, it is one of the most popular fruits. • In addition to its fiber content, it contains significant amounts of vitamins such as biotin and folic acid, and minerals such as potassium and manganese. • In terms of its environmental requirements, slightly alkaline, medium-compacted loam and clay loam soil is the best growing area for peaches. • It has a significant need for warmth and sunlight, but is sensitive to late frosts, which damage the quality of the fruit.	Lin et al., 2022 Sipos, 2002 Szabó, 2012
Plum (Prunus domestica)	• It exhibits a high degree of versatility in its applications, being suitable for the production of brandy, preserves, and fruit juice, among others. • It also holds a significant place in traditional Hungarian cuisine, where it is frequently used in the preparation of heritage dishes. • The author reports on domestic yield trials conducted with selected plum cultivars in the present manuscript.	Sipos, 2002 Czinege, 2014
Sour Cherry (Prunus cerasus)	• Sour cherry (Prunus cerasus) is a popular fruit for home preservation during the winter months. • It is characterized by a high content of carbohydrates and organic acids. • Among its minerals, it is particularly rich in potassium, calcium, phosphorus, and cobalt, while in terms of vitamins, it contains notable amounts of vitamin B1 and vitamin C.	Sipos, 2002 Szabó, 2012
Walnut (Juglans regia)	• The exceptional nutritional value of the walnut (Juglans regia) is primarily attributed to its high content of beneficial monounsaturated and polyunsaturated (essential) fatty acids. • Among its vitamins, it is particularly rich in vitamin B1, vitamin E, and pantothenic acid, while its mineral profile is notable for its potassium, calcium, zinc, and copper content.	Sipos, 2002 Szabó, 2012

5. Conclusions

The environmental requirements of the examined plant species highlight that successful cultivation is strongly linked to the optimization of light, water, nutrient supply, and soil conditions. Notably, the increasing frequency of extreme weather events caused by climate change demands enhanced adaptability and technological flexibility from producers. Furthermore, the results reinforce the importance of regular consumption of dietary fiber, vitamins, minerals, and phytonutrients in reducing the risk of cardiovascular diseases, diabetes, obesity, and certain types of cancer. The beneficial effects of phytochemicals - including their antioxidant, anti-inflammatory, antimicrobial, and anticancer properties - underscore the need for further research and promotion of fruits and vegetables in nutrition. One of the key contributions of this study is the comprehensive synthesis of the ecological conditions of vegetable and fruit production in Hungary, along with a detailed overview of the nutritional and gastronomic values of the most commonly cultivated species. The study promotes an interdisciplinary perspective that frames horticultural production within the interconnected objectives of food security, sustainability, and public health.

6. Recommendations

- Further research is needed to investigate the stress tolerance, nutrient composition, and phytochemical profiles of domestic vegetable and fruit varieties in the context of global climate change.

- The organization of educational and advisory programs is recommended to promote environmentally conscious cultivation practices, particularly among small- and medium-sized farms.

- Public health campaigns and educational materials should be developed and disseminated to increase awareness of the health benefits of fruit and vegetable consumption.

- To preserve and enhance gastronomic heritage, traditional plant-based dishes should be rediscovered and integrated into contemporary culinary practices.

- Sustainability principles should be more widely applied in horticultural production, with special attention to circular economy models, the utilization of by-products, and the reduction of food waste.

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