BRASSICA OLERACEA VAR. *CAPITATA* F. *ALBA*: CULTIVATION, PHYTOCHEMICAL CONTENT AND HEALTH EFFECTS. A MINI REVIEW.

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Abstract

White cabbage (Brassica oleracea var*. capitata* f. *alba, family Brassicaceae) is a cruciferous vegetable cultivated worldwide for its nutritional, medicinal and economic importance. The review aims to investigate the effect of some technological measures on production, use, biochemical composition and antioxidant capacity of white cabbage, through the analysis of some published scientific articles, accessible in the worldwide literature. To achieve the objective, citations of studies from open access online sources such as Google Scholar, Google Academic, Research Gate and Science Direct were carried out. These scientific studies confirm that white cabbage is a rich source of phytochemicals, including glucosinolates and phenolic compounds, as well as important nutrients such as vitamins, minerals and fiber with beneficial health properties. The content of phytochemicals and antioxidant compounds varies significantly depending on genotypes, agronomic practices, environmental factors or cultivation methods. To further increase the yield and quality of white cabbage, it is necessary to improve the cultivation technology and apply the most optimal standards of fertilization that maximize the biological productivity of varieties.*

***Key words**: **Brassicaceae; cultivation; phytochemistry; traditional uses**.*

INTRODUCTION

White cabbage, Brassica oleracea L. var. capitata, is an important species of the genus Brassica, family Brassicaceae with a global production of 73828504.77 tonnes in 2023 (FAOSTAT, 2025). The major producing countries of cabbage are China, the main producer (998,448 ha), followed by India (433,000 ha) and the Russian Federation (70,278 ha).

In the European Union, the main white cabbage producing countries are Poland, Germany, Romania and Netherlands. Thus, the area and volume of white cabbage production in the EU, in the period 2019-2023, were decreasing from 95.6 thousand ha in 2019, to 74.77 thousand ha in 2023, respectively from 3272.8 thousand tons in 2019, to 2697.7 thousand tons in 2023 (Eurostat, 2025).

In Romania, the areas cultivated and production with white cabbage, in the last 10 years, have decreased from 55,051 ha in 2013 to 19,140 ha in 2023, respectively from 1.158,747 t in 2013 to 357,610 t in 2023 (FAOSTAT, 2025). Production is a particularly complex characteristic and depends on the development of productivity elements, which are characteristics fixed in the hereditary base of cultivars, and influenced by environmental conditions (Dinu et al., 2024).

Climate change has become a serious threat and affects many aspects of the life of organisms in all regions of the world (Iancu et al., 2024), including white cabbage production. White cabbage is produced throughout the year, as an early and summer type, and used for fresh consumption or fermentation. This species prefers cool and humid growing regions and responds favorably at all stages of growth to optimal temperatures (Rashid et

al., 2020), and unsuitable growing conditions cause stress and affect plant productivity. For vegetative growth, it requires loamy soils, with a high organic matter content and an alkaline pH, between 6.0 and 6.8, for optimal growth.

The optimum temperature is 15-20°C, and longer exposure of young plants to low temperatures, 5 to 7°C of the sensitive cabbage varieties and hybrids, leads to vernalization and flowering (Cervenski et al., 2025). Mature plants in the head phase withstand temperatures down to -5…-7°C. (Soare, 2022). The combination of appropriate growing conditions, intensive cultivation practices, irrigation and mechanization can stimulate the genetic potential of cabbage varieties or hybrids. The processes that influence soil quality and productivity are a field of great complexity and importance in land resource management (Bălan 2023, Bălan 2024). Local climatic conditions affect to a large extent cabbage production, mainly plant growth, the occurrence and development of diseases, insect pests and weeds (Cervenski et al., 2022).

White cabbage forms heads characterized by the closed growth pattern of the leaves around the central bud. These edible organs can vary in shape, color and texture of the leaves, resulting in a large number of cabbage cultivars (Björkman et al., 2011). This species is today an economically important crop, cultivated in over 90 countries around the world. The economic importance of the crop results from the fact that average yields can be very high (approximately 100 t/ha), the harvest is carried out over a long period of the year, ensuring income, practically, from spring to autumn. For high cabbage production, it is important to select genotypes appropriate to local growing conditions together with appropriate technology. Root and extra-root applied fertilizers lead to significant increases in cabbage production and quality (Soare et al., 2018).

Currently, this vegetable is consumed in large quantities both in Europe and around the world, being preferred by consumers due to its availability and low price (Leahu et al., 2018; Šamec et al., 2017).

Regarding the alimentation importance, raw white cabbage can be used in numerous forms as salad, juice, and cooked or canned (pickled, dehydrated, frozen or fermented). It is frequently used for cabbage soup or sauerkraut dishes. It is also a very important raw material in the food canning industry and especially in vitaminized juice, usually mixed with carrot juice (Buta and Apahidean, 2009).

White cabbage attracts consumers due to its superior nutritional profile, offering significant benefits for human health (Bute et al., 2024; Nkosi and Msimango, 2022). Within this species, there are numerous white cabbage cultivars, which differ in morphological traits, phytochemical composition and tolerance to abiotic and biotic stresses (Šamec et al., 2017).

Due to its high content in vitamins, fibers, polyphenols and flavonoids, white cabbage represents a valuable source of nutrients (Nawaz et al., 2018). Other authors state that cabbage is rich in calcium, proteins, and vitamins C and E, contains various bioactive compounds with pharmacological properties, such as luteolin, myricetin, quercetin, and polyphenols (Rajapriya et al., 2017).

By analyzing current studies, this paper provides information about the cultivation method, nutritional and antioxidant potential of white cabbage with benefits for human health.

MATERIALS AND METHODS

This review provides comprehensive scientific information on agronomic requirements, use, macronutrient and phytochemical content, and biological activity obtained from open access online sources such as Google Scholar, Google Academic, Research Gate and Science Direct.

RESULTS AND DISCUSSIONS

1. Cultivation

To achieve high yields of cabbage, farmers are interested in improving crop technology to increase the productivity of this species, including optimizing nutrient management and improving varieties or hybrids. Among the various factors influencing cabbage production, soil moisture and nutrient availability are crucial for increasing production. It is known that by applying growth regulators, such as gibberellic acid (GA_3), plant height growth and biomass accumulation are improved. Also, mulching can suppress weed growth, conserve moisture and provide additional temperature to early crops, thereby reducing production costs. In a study conducted by applying an improved technology, with polyethylene mulch and straw mulch and Four levels GA3 application viz. G0 = Control (0 ppm GA3), G1 = 80 ppm GA3, G2 = 100 ppm GA3 and G3 = 120 ppm GA3, the results showed that the polyethylene mulch treatment registered a production of (3.03 t ha-, while the GA3 treatment, G2 (100 ppm GA3) offered the best performance (Nila, 2020). Similarly, Adamović et al. (2023) found that the use of black polyethylene mulch significantly increased the marketable yield of cabbage. The use of organic or mineral fertilizers on the production and quality of white cabbage has attracted considerable attention in scientific research. Integrated nutrient supply system has become an accepted strategy for improving soil fertility and protecting the environment. It involves the use of organic manure fertilizers, foliar nutrients and microbial inoculants that improve plant photosynthesis and implicitly productivity (Brahmbhatt et al., 2023). The of organic foliar fertilizers contribute to the optimal plant growth and development and to the correction of nutritional deficiencies (Dinu et al., 2015).

In a study conducted by Kavaliauskaitė et al. (2023) on white cabbage, the highest marketable production of white cabbage was 80.5 t/ha obtained by applying granular fertilizer based on poultry manure in autumn and mineral fertilizer in spring. Similar results were also reported by Maghfoer et al. (2018) who claim that the application of organic fertilizers increased the yield of cabbage.

Kartika et al. (2017) demonstrated that fertilization with inorganic fertilizers generally improved cabbage growth and yield compared to the control/no fertilizer group.

To improve cultivation technologies for early white cabbage, the use of non-woven textiles, such as AGRYL, or double protection with plastic, which creates a favorable microclimate for plant growth, contributing to improving quantitative and qualitative production, also plays an important role. Thus, there are reports that, by protecting early white cabbage crops with Agryl P17 in an assortment of cultivars, a maximum production of 32.57 t/ha was obtained (Stoleru et al., 2012), and by double protection of the cabbage crop with a plastic tunnel and with Agryl, an 11.4% increase in production was achieved, compared to simple protection with a plastic tunnel (Apahidean et al., 2004).

2. Content phytochemical

Cabbage is an important source of bioactive compounds with beneficial effects on health. Due to its antioxidant, anti-inflammatory and antibacterial properties, this species has a wide use in traditional medicine, for the relief of symptoms associated with gastrointestinal disorders (gastritis, peptic and duodenal ulcers, irritable bowel syndrome), as well as in the treatment of minor wounds. White cabbage is also an important source of fiber, protein, vitamins, minerals and secondary metabolites.

White cabbage is an essential source of phytonutrients in the human diet due to its abundance of phytochemicals such as glucosinolates, polyphenols, carotenoids and vitamins, which have demonstrated antioxidant actions (Šamec et al., 2017).

Most studies on phytochemicals in Brassica have focused on glucosinolates. Glucosinolates are secondary metabolites widely found in Brassicaceae plants, and are valued for their antioxidant properties, cardiovascular disease prevention and antidiabetic effects (Hsieh et al., 2024). The total glucosinolate content can vary depending on the species or cultivar. Thus, some authors have reported values from 3.99 to 23.75 µmol g d.w.. depending on the species, white or red cabbage, and regarding the individual glucosinolates they differed significantly between varieties (Bhandari et al. 2020). Selection of varieties with high content of glucoabrassicin, glucoraphanin and sinigrin is important for anticancer properties (Agerbirk et al., 2009). In the study of Yue et al. (2024) were reported values of total glucosinolate content from 9.98 to 13.2 umol/g, depending on the cabbage varieties, purple spherical and green cow heart cabbage varieties. Through the lactic acid fermentation process of cabbage using a bioreactor, with particular emphasis on glucosinolate retention, a notable improvement in antioxidant capacity was demonstrated, with a 16.32% increase in the DPPH radical scavenging rate compared to unfermented cabbage (Hsieh et al., 2024).

Phenolic compounds are a diverse class of secondary metabolites, known for their antioxidant, antimicrobial and anti-inflammatory properties. The main representatives of phenolic compounds in cabbage are flavonoids, mainly flavonols and anthocyanins, as well as hydroxycinnamic acids (Cartea et al., 2010.). Cabbage leaves are recognized for their nutritional value, containing antioxidant phytochemicals (Singh et al., 2007, Sharma et al., 2018). Studies have shown that white cabbage (Brassica oleracea var. capitate f. alba) is rich in phenolic acids and flavonols (Yue et al., 2024; Šamec et al., 2017; Hounsome et al., 2009; Heimler et al., 2006). There are numerous studies that have reported a great variability in the accumulation of phytochemicals in white cabbage, strongly influenced by genotype, variety, climate, location or agronomic practices. Thus, following polyphenolic analyses of an assortment of white cabbage genotypes, were reported values up to 11.94 ± 0.62 mg GAE/g dw and in TF and TFL of 5.69 ± 0.32 mg CE/g dw and 69.36 ± 2.09 µg CE/g dw, respectively (Šamec et al., 2013). Regarding the variety, total polyphenol and flavonoid content has been reported to be higher in purple spherical cabbage and round-flattened cabbage and lower in green cow heart cabbage (Yue et al., 2024). Soare et al., (2016), have reported a total flavonoid content of from 17.14 (Sarmalin F1) to 26.23 mg Q/100g FW (Bucharest F1) in a white cabbage hybrid variety and Kusznierewicz et al., (2008) reported the total flavonoid content in white cabbage cultivars between 1.18 and 1.82 mg CE/g dry weight. Also, by fermenting cabbage by lactic acid bacteria, Hsieh et al. (2024) reported a higher content of free phenolic compounds and flavonoids by 41.13% and 24.44%, respectively, compared to unfermented cabbage.

3. Vitamine and minerals

Vitamin C or ascorbic acid is important for nutrition because it cannot be synthesized by the human body due to the lack of the enzyme that catalyzes the last step of its synthesis, L-gulonolactone oxidase (Statilko et al., 2024). Vitamin C is a water-soluble compound with antioxidant properties that act against oxidative stress (). It is also essential for collagen synthesis, and for the prevention of scurvy (Drouin et al., 2011).

Several studies have reported a variable vitamin C content in white cabbage. It may vary depending on environmental factors such as light intensity, temperature, humidity conditions, or agronomic practices, etc. The application of organic fertilizers to vegetables decreased the nitrate content, but increased the sugar and vitamin C content (Nurhidayati and Murvwani, 2016).

The ascorbic acid content in white cabbage varied depending on the fertilization treatment applied between 33.73 mg/100 g fw and 35.78 mg 100 g fw (Soare et al., 2018). Other authors have reported different values of ascorbic acid content depending on genotype and region. Thus, Singh et al. (2007), studying the content of phytochemical antioxidants in 18 cabbage varieties, reported an ascorbic acid content ranging from 5.66-23.5 mg/100 g, with an average of 9.65 mg/100 g, and Bahorun et al. (2004) reported 18.8 mg of ascorbic acid/100 g. In the study of Kapusta-Duch and Leszczynska, (2013), in diversified ecological conditions the ascorbic acid content ranged from 34.0 mg/100 g fw to 41.2 mg /100g fw, and Singh et al. (2007) reported an average of 9.65 mg/100 g of vitamin C content in white cabbages.

Penas et al. (2011) investigated the vitamin C content of five white cabbage varieties grown in two different geographical regions of Spain and reported a high content in eastern Spain, with values ranging between 4.2 and 6.0 mg/g d.w.

Lower growing temperatures, especially in the final stages before harvest, increase the accumulation of vitamin C in white cabbage, values of 15.10 mg g−1 for the “Bagočiai” variety and up to 13.50 mg g−1 for the “Kamienna Glowa” variety, were observed in 2021, when the air temperature in the last months of cabbage vegetation (August–September) was 5.6 °C lower than in 2020 (Juškevičienė et al., 2025).

The essential mineral content of cabbage is represented by calcium (Ca), potassium (K), magnesium (Mg) and phosphorus (P), and essential or potentially essential trace elements: cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), selenium (Se) and zinc (Zn) with an important role in human, animal and plant cellular metabolism (Leahu et al., 2018). Regarding mineral composition, it was shown that there was a higher content of K, Mg, Cu, Mn and Zn in purple cabbage, reaching 9,511.6 mg/kg, 7,656.6 mg/kg, 6.64 mg/kg, 2.31 mg/kg and 3.15 mg/kg, respectively. Furthermore, the Fe content of the green oblate form (66.29 mg/g) and the Ca content of the elongated and green form (5,777.2 mg/kg) had high values, with no significant difference in Fe content between the other three forms (Yue et al., 2024).

To meet the different demands of consumers, breeders need to cultivate several cabbage genotypes that differ in leaf shape, size, color, or texture. Numerous researches recommends introducing the investigated varieties in diet due to the rich content of compounds with antioxidant properties (Soare et al., 2015; Soare et al., 2017; Babeanu et al. 2022).

4. Health effects

White cabbage, in addition to being a frequently consumed food, is also appreciated for its therapeutic value. This species is recommended in diets because it is low in fat and rich in fiber, helping to keep calories and fat levels to a minimum. Consumption of dietary fiber has an important role in the prevention of diseases such as constipation, irritable colon, obesity and diabetes. Pickled cabbage has a high content of vitamin C and B vitamins, which play a role in stimulating the body's immunity. The recently discovered that isothiocyanates stop the development of cancer, and these are also maintained during lactic fermentation (Stanciu, 2023). Some authors confirm that lactic acid fermentation of white cabbage increases the total flavonoid content, thus increasing the antioxidant capacity and functional components of the product (Hsieh et al., 2024.

Increasing evidence indicates that cabbage has various pharmacological properties against a wide range of diseases, such as cardiovascular diseases, liver diseases and cancer (de Carvalho et al., 2019). Cabbage extract protects against oxidative stress and suggests that it can be used as an

alternative therapeutic strategy to prevent oxidative stress in the heart (Dong Kwon Yang, 2018). A high intake of cabbage also ensures sufficient levels of iodine in the human body, which can help the proper functioning of the brain, thyroid gland and nervous system (Pandey et al., 2018). White cabbage can also be used for the treatment of bruises, rheumatic pain and cuts (Passalacqua et al., 2007).
The literature has reported that extracts from the Brassicaceae family and their purified constituents have anti-inflammatory properties, as well as immunomodulatory regulatory roles, maintaining intestinal barrier integrity and intestinal flora balance (Cecio et al., 2022) Furthermore, a group of sulfur and nitrogen-containing compounds called “glucosinolates”, present in all cruciferous vegetables, contribute to the general defense mechanism of the plant.

CONCLUSIONS

To obtain high cabbage productions it is necessary to improve crop technology by optimizing nutrient management, obtaining hybrids with good adaptability, and effective agronomic practices. White cabbage is an essential source of phytonutrients in the human diet due to its abundance of phytochemicals, dietary protein and fiber, which are valuable for human health. Studies show that the accumulation of these constituents is influenced by various factors, such as meteorological conditions, varieties, genotype and crop season. Therefore, it is necessary to find innovative ways to increase the nutritional quality of this species.

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