Broccoli

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Broccoli is one of the jewels of the horticultural crops worldwide, belonging to the cruciferous family and very rich in key nutrients (vitamins, minerals, fibre, etc.) as well as a great group of bioactive compounds including carotenoids, phenolic compounds and glucosinolates. Among these phytochemicals, the most-studied in crucifers associated with disease prevention and wellbeing are glucosinolates [See also https://encyclopedia.pub/808]. The content of carotenoids, phenolic compounds and glucosinolates naturally present in broccoli, can be increased through the management and control of the agronomic and environmental conditions used for broccoli cultivation. In this sense, the study of the effects of pre-harvest factors in the concentration of health-promoting compounds in broccoli, as a new strategy to be implemented in the field, can be considered of great interest. This would help to determine the best agronomic practices and cultivation conditions to improve the content of the compounds of interest in broccoli, without compromising its overall quality.

carotenoids phenolic compounds glucosinolates bioactive compounds pre-harvest factors quality composition methyl jasmonate seasonal variations

1. Introduction

The *Brassica* family is a group of vegetables widely consumed around the world, including cabbages, cauliflower, Brussels sprouts, radishes and broccoli (*Brassica oleracea* L. var. *italica*) among others[1]. In the last few years, the consumption of cruciferous foods in Spain has increased. Specifically, the consumption of broccoli has undergone a significant rise, with a positive effect on the agricultural economy, particularly in the Murcia region (southeastern Spain), which is the region with the greatest production of broccoli in Europe[2][3]. This rise in consumption is related to increased adherence to healthier diets by European consumers, since this family of vegetables, and particularly broccoli, has high contents of fiber, minerals and vitamins, and is an important source of bioactive compounds with high antioxidant activity (carotenoids, phenolic compounds and glucosinolates)[4].

2. Bioactive compounds contents and influencing factors

Although a single serving of broccoli provides a wide range of phytochemicals with beneficial effects for human health[1], the contents of these compounds vary depending on physiological, genetic and agronomic factors (including the cultivar, soil composition, agronomic treatments, climatic conditions and pre- and post-harvest treatments[5][6]). Carotenoids, one of the characteristic groups of compounds in broccoli, are natural pigments derived from the isoprenoid pathway, and are formed of a C40 backbone that differs according to the specific carotenoid being considered[7]. Carotenoid content can vary in broccoli plants as a result of environmental conditions—mainly temperature and sunlight[8][9]—while genetic factors and treatment applications can also affect the content[10]. Moreover, the content varies among the distinct parts of the plant, being higher in florets than in stalks[11]. The major carotenoids found in broccoli are β-carotene and lutein[12]. Phenolic compounds comprise one or more aromatic rings attached to hydroxyl groups[13]. Quercetin and kaempferol are the main flavonol glycosides, whereas chlorogenic and sinapic derivatives are the main hydroxycinnamic acid derivatives found in broccoli[14][15]. Glucosinolates (GLSs) are constituted by a thioglucose group, a sulphonated oxime group and a side chain derived from methionine, phenylalanine, tryptophan or a branched-chain amino acid[16]. Glucoraphanin (GRA), glucoiberin (GIB) and glucobrassicin (GBS) are the major GLSs in broccoli[17][18], and their breakdown products the isothiocyanates (ITC) and indoles are important due to their health-promoting activities, being strong inducers of phase II detoxification enzymes by regulation of the Nrf2–Keap1–ARE cellular system, with a wide role in the development and progression of chronic diseases (e.g., cancers, respiratory problems and type 2 diabetes mellitus, and their anti-inflammatory properties[19].

Long-term clinical studies, as well as in vivo and in vitro studies, have associated the consumption of broccoli and its phytochemicals, mainly GRA and its related ITC sulforaphane, with a reduction in the risk of suffering non-communicable-diseases (NCDs), such as metabolic syndrome (obesity, diabetes and dyslipidaemia) and some types of cancer (lung, stomach, colon and rectal)[19][20][21]. However, the amount of glucosinolatos ingested, the inter-individual variability among subjects, the bioaccessibility and bioavailability of these compounds, as well as the factors that affect phytochemical composition in the natural matrix(namely the production practices, handling, cooking procedures, among others), must be taken into account to provide scientific evidences of the health effects of bioactive compounds from broccoli[19].

For this reason, there is increased industrial interest in the improvement of the synthesis and accumulation of their bioactive compounds in plants, which naturally varies due to physiological, genetic and agronomic factors[6][22][23]. Additionally, cooking practices also affect the content of GLSs and degree of conversion to their bioactive ITC[19]. With regard to improving the quality of the vegetables or the content of bioactive compounds, an increase in plant stress[6][24] can lead to a higher synthesis of these secondary metabolites.

The management of agronomic and environmental conditions is very important to the content of phytochemicals. Broccoli shows little tolerance to cold and windy climates, preferring mild and bright environments with neutral soil pH[5]. Low temperatures can change the color of the florets from green to purple (anthocyanins), affecting the overall market acceptability. Elicitation is the main tool used to increase the content of secondary metabolites in vegetables, as it induces stress responses in plants. There are several types and classifications of elicitors; depending on their origin, we can differentiate among biotic, abiotic (chemical or physical) and phytohormones[23]. Another important classification is the time when the elicitor is applied; there are pre-harvest and post-harvest treatments, which can sometimes be combined. Several studies have involved the application of elicitors to broccoli plants in order to improve their nutritional properties (although this application is more common for seeds and sprouts). For instance, methionine, glucose, sucrose and mannitol applied as biotic elicitors during germination can increase the total contents of GLSs, anthocyanins and phenolics[25][26]. Ethanol and UV-C radiation have been used as abiotic, chemical and physical elicitors, respectively, and post-harvest treatments have led to an increase in GLSs and phenolic compounds[27][28]. Finally, for broccoli, phytohormones are probably the most-studied elicitor, while jasmonic acid (JA), methyl-jasmonate (MeJA) and salicylic acid are the most widely used, and have yielded increases in bioactive compounds in broccoli sprouts and adult plants[26]. Most of these studies have been performed under controlled conditions based on laboratory experiments or greenhouse control. However, in the scientific literature very few studies can be found under field conditions.

In this sense, a recent study has reported the results of a field-based experiment where three crop trials were carried out to evaluate the effects of seasonal and dosage application of methyl-jasmonate on ‘Parthenon’ broccoli, cultivated under real producing conditions in South-Eastern Spain[29]. Different quality parameters and the content of individual bioactive compounds (carotenoids, glucosinolates and phenolic compounds) were measured as authors hypothesed that the application of methyl-jasmonate treatments as elicitor in aerial parts of the plants would improve its content and accordingly its beneficial properties on health. The results showed that the use of methyl-jasmonate as preharvest treatment could be a new field strategy to improve the health-promoting compounds of ‘Parthenon’ broccoli, without compromising its overall quality. The results can be considered to be of great interest to grower and processor industries that sell broccoli and look for the best agronomic practices and conditions to offer healthier products to consumers.

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