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Anti-cancer properties of cruciferous vegetables

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Abstract. Broccoli (*Brassica oleracea* var. *Italica* plenck) is an annual vegetable plant belonging to the cabbage family. Like many other medicinal plants, broccoli is a good source of various phytochemicals. This variety of cabbage is considered a natural anti-cancer anti-carcinogenic vegetable and it is known in folk and traditional medicine due to the presence of high concentrations of indole-3-carbinol (I3C), which is used to treat breast cancer and a number of other diseases.

Introduction. Since ancient times, various plants around the world have been used as medicines and vegetables. In accordance with the Decree of the President of the Republic of Uzbekistan dated May 20, 2022 No. PP-251 “On measures to organize the widespread cultivation and processing of medicinal plants and their widespread use in treatment”, we want to get acquainted with the cultivated Broccoli vegetable.

Broccoli (*Brassica oleracea* var. *Italica* Plenck) is an annual vegetable plant of the Cabbage family, a subspecies of cauliflower. The name of this vegetable comes from the Italian word "brocco", which means "shoot" or "branch". Vegetables of the Brassicaceae family such as cabbage, broccoli, cauliflower, turnip, horseradish, mustard are popular and are among the most consumed vegetables in the world. Many epidemiological studies have shown that a diet rich in these vegetables reduces the risk of some forms of cancer. In addition, broccoli, which belongs to the cabbage family, has strong antioxidant properties [1;2;3].

Like most other vegetables, kale, including broccoli, are good sources of a variety of nutrients and phytochemicals that may work synergistically to help prevent cancer [4]. These herbal products are also associated with beneficial health effects due to the presence of biologically active compounds with antioxidant capacity, such as vitamins C and E, carotenoids, phenols, flavonoids [5].

For many years, cruciferous vegetables have been of particular interest for cancer treatment due to their high content of glucosinolates, the main breakdown products of which (isothiocyanates and indoles) have anticarcinogenic properties in vitro and in vivo [6].

It has been suggested that they inhibit the growth of cancer cells by interfering with the production of proteins involved in abnormal cell reproduction and by

stimulating the production of tumor suppressor proteins. In addition, they have been reported to interfere with cell proliferation, signal transduction, and induce apoptosis in cancer cells by interfering with the production of compounds normally produced to resist apoptosis. [7].

The anti-cancer properties of cruciferous vegetables are primarily documented by the Roman statesman Cato and the Elder (234-149 BC), who in his study of medicines wrote: "If a cancerous ulcer appears on the chest, apply a crushed cabbage leaf to it, and he will recover." It is now well known that cruciferous vegetables contain a precursor of the phytochemical open glucosinolate, which is hydrolyzed by the plant enzyme myrosinase to form a biologically active compound known as I3C [8].

Indole-3-carbinol (I3C) is a naturally occurring anti-carcinogenic compound found in high concentrations in Brassicaceae family vegetables such as broccoli and cabbage and has been shown to inhibit proliferation and induce apoptosis in various cancer cells, including breast cells, prostate, colon and leukemia. However, only high doses of I3C have been shown to inhibit cell proliferation (IC(50) = 200–300 $\mu\text{mol/L}$) [9;10].

I3C suppresses the expression of insulin-like growth factor receptor-1 (IGF1R) and insulin receptor substrate (IRS1) in MCF-7 human breast cancer cells [11].

The most important property of indole-3-carbinol, which has attracted the attention of researchers for more than 30 years, is the suppression of the formation and growth of hormone-dependent tumors. The significance of this component of broccoli, which can suppress the growth of hormone-dependent tumors, is very high, since about 2/3 of fatal cancers in women and some tumors in men are formed in estrogen-producing tissues, and the growth of many of them is estrogen-dependent.

Another study suggests that: overweight women with a high risk of breast cancer received 300-400 mg of indole-3-carbinol per day for two months, which led to a normalization of the ratio of 2-hydroxyestrogens to estradiol [12].

By acting on the cytochrome P450 system, I-3-K is able to shift estrone hydroxylation towards the formation of 2-OH-estrone instead of 16 α -OH-estrone, thus exerting a protective effect against estrogen-dependent tumors [13].

I3C can shift estrogen metabolism towards less estrogenic metabolites. Systemic lupus erythematosus is associated with estrogen. In a study using mice bred to develop lupus, the group fed the I3C diet lived longer and had fewer signs of the disease [14]. Recent studies have shown that I3C has a beneficial effect on lipid metabolism, which may be of great importance in preventing cardiotoxicity. [15].

In addition, other studies have reported that I3C can prevent cardiac remodeling through activation of the AMP kinase enzyme, resulting in improved

myocardial function and modulation of the expression of genes responsible for the production of markers of hypertrophy and fibrosis with regeneration of damaged myocardium. tissue, which significantly reduces the activity of cardiac enzymes such as lactate dehydrogenase and creatine phosphokinase [16].

When added to breast cancer cells in culture, I3C has been found to inhibit the transcription of estrogen-sensitive genes stimulated by 17β -estradiol [17].

I3C may represent a promising therapeutic agent for the treatment of a wide range of diseases, including cancer, diabetes mellitus, endocrine disorders, and cardiotoxicity. This can be explained by its antioxidant, anti-inflammatory and anti-apoptotic properties, as well as the ability to restore the normal functions of the endocrine system of the human body [18].

I3C is chemically unstable in the aqueous and acidic environment of the stomach and is rapidly converted to numerous condensation products. The main condensation product of I3C in vivo is 3,3'-diindolylmethane. DIM has a distinct pleiotropic effect on cancer cells [19].

3,3'-diindolylmethane (DIM) is an acid-catalyzed dimer of idol-3-carbinol (I3C) found in the plasma of women taking I3C, confirming that DIM is the predominant bioactive compound found in cruciferous vegetables, including broccoli, Brussels sprouts and white cabbage [20;21].

DIM also inhibits angiogenesis and xenograft development of human mammary tumor cells in rodent models.

The growth of vascular endothelial cells is of key importance in angiogenesis. Our results show that DIM strongly slowed down endothelial cell proliferation at a concentration as low as $5\ \mu\text{M}$ [22].

One of the challenges in studying the relationship between consumption of cruciferous vegetables and cancer risk in humans is separating the benefits of diets. [23].

A diet rich in cruciferous vegetables such as cauliflower, broccoli and cabbage has long been considered healthy. Even in ancient times, it was believed that extracts from these vegetables have medicinal and healing properties. In the 20th century, epidemiological studies began to accumulate, pointing to the protective properties of cruciferous vegetables in an anti-cancer diet [24].

The pooled results of all studies showed that a high intake of cruciferous vegetables was significantly associated with a reduced risk of breast cancer [25].

A small clinical study showed that consumption of 250 g of broccoli and 250 g of Brussels sprouts per day significantly increased the urinary excretion of a potential carcinogen found in well-done meat, namely 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine (FIP)[26].

When using broccoli powder, significant changes in impaired parameters of cellular immunity in the dynamics of carcinogenesis were revealed [27].

This article discusses the mechanisms by which glucosinolate breakdown products are thought to inhibit carcinogenesis. It describes how isothiocyanates, thiocyanates, nitriles, cyanoepithioalkanes, and indoles are formed from glucosinolates by the action of myrosinase, an epithio-specific protein, and an epithio-specific modifier protein released from cruciferous vegetables during plant injury [28].

Most isothiocyanates are metabolized in vivo via the mercapturic acid pathway. Indole compounds can react with ascorbic acid to form ascorbigen, and in the case of low gastric Ph, a number of condensed products that can act as additional biologically active compounds [29].

The aim of our study of plant materials is the pharmacognostic analysis of localized species of broccoli (*Brassica oleracea* var. *Italica* plenck) and their use in traditional medicine. On the basis of I3K, the drug "Indinol Forto" is produced for the treatment of estrogen-dependent tumors and a number of dietary supplements: Indole, Indole Forte, Nodinorm, Indinol and others [30;32]. Based on these literature data, we decided to continue further research in this area.

Conclusion. Based on the study, we can conclude that broccoli - *Brassica oleracea* L. var. *italica* Plenck is not only a food crop, but also a medicinal plant - a source of the most valuable biologically active additives such as Indole-3-carbinol.

Broccoli is considered a natural anti-cancer, anti-carcinogenic, and antioxidant vegetable and is known in folk and traditional medicine for its high concentrations of indole-3-carbinol (I3C) as well as other biologically active compounds.

The object under study is of interest for further in-depth study of its chemical composition in order to create regulatory documentation for vegetable raw materials and dietary supplements based on broccoli grown on the territory of the Republic of Uzbekistan.

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