

Therapeutic Potential of *Brassica oleracea* (Broccoli) - A Review

Chandini Ravikumar

Saveetha Dental College and Hospital, Chennai, India

*Corresponding author: Chandini Ravikumar, Saveetha Dental College and Hospital Chennai-77, Tamilnadu, India, Tel: 91 9840104130; E-mail: chandiniravikumar@yahoo.com

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Abstract

Broccoli is an edible green plant that is classified in the Italica cultivar group of the species *Brassica oleracea*. They are rich in vitamin C, dietary fiber and also contain glucoraphin, sulforaphane, selenium and isothiocyanates. Broccoli is also an excellent source of indole-3-carbinol. These constituents present in broccoli are known to be very popular since they possess several anti-cancer properties and benefits. These anti-carcinogenic compounds have a wide variety of uses and benefits for the treatment of various diseases and disorders. Broccoli is widely used in the treatment of several forms of cancer and also treats other neural disorders. The therapeutic potential of broccoli has been explained under its role in cancer, diabetes and other diseases. In the treatment of cancer, most of the constituents or the phytochemicals of broccoli such as brassinin, isothiocyanates, indole-3-carbinol etc. have been proved to be effectively beneficial. Even selenium plays a very important role in cancer prevention. The antioxidant activity of broccoli is induced by other phytochemicals such as glucosinolates, glucoraphin and sulforaphane. Sulforaphane in broccoli sprouts also has the potential to cure neural disorders such as Alzheimer's disease and Parkinson's disease. It is also used to bring about cure in asthma and diabetic patients. Flavonoids have the effect of reducing the risk of diabetes. Therefore sulforaphane is widely used to treat various diseases and disorders.

Keywords: Broccoli; Cancer; Diabetes; Sulforaphane; Isothiocyanates

Introduction

Broccoli, *Brassica oleracea*, variety Italica, belongs to the family Brassicaceae. Broccoli is a fast growing annual plant that grows 60-90 cm tall. They are native to the eastern Mediterranean and Asia Minor, and were later introduced to England and America in the 1700s [1] Figure 1. Plants in general, are known to be extremely rich in a variety of secondary metabolites that are found to possess anti-microbial properties. Many anti-microbial agents that are derived from traditional medicinal plants are available for treating a large number of diseases caused by micro-organisms. The groups of anti-microbial phytochemicals are of several categories that include alkaloids, flavonoids, tannins, polyphenols, essential oils, phenolics and polypeptides [2]. Broccoli also provides many health-promoting properties which attributes to its antioxidant and anti-carcinogenic compounds. It is primarily composed of polyphenols, glucosinolates, sulforaphane and selenium [3]. Broccoli sprouts contain negligible quantities of indole glucosinolates, that predominate in the mature



Figure 1: Inflorescence of *Brassica oleracea*.

vegetable and gives rise to degradation products like indole-3-carbinol that has the capability to enhance tumorigenesis. Hence, small quantities of crucifer sprouts may protect against the risk of cancer as effectively as much larger quantities of mature vegetables of the same variety [4]. They are also known to contain a high content of flavonoids, vitamins and mineral nutrients. Vitamin C, insoluble complexes, is a good adjuvant in iron therapy but can interfere with the metabolism of some drugs and antineoplastic agents. The presence of these contents has shown that broccoli provides immense benefits in protecting humans against cancer, and also assures to reduce the risk of specific cancers. One of the phytotherapeutic roles of broccoli is for skin diseases in which the juice of the leaves is used to treat warts [5]. Broccoli is different among the common cruciferous vegetables that possesses high levels of these constituents. The pharmacokinetics of broccoli explains that when hydrolysis takes place, glucoraphanin produces many products that include the bioactive isothiocyanate sulforaphane. The percentage of isothiocyanate sulforaphane present in these vegetables varies depending upon the conditions of hydrolysis, food handling, and preparation procedures. The food in broccoli family results in under dosing of metabolic drugs. The drug-food interactions of broccoli are further described under pharmacological activities [6].

Pharmacological Activities

Broccoli plays a major and a beneficial role in treating cancer of several forms that occurs in different parts of the body and also effective in the treatment of other diseases. Therefore the pharmacological activities of broccoli are explained based on the diseased states.

Broccoli in cancer prevention

Cancer is a multistep process that results in uncontrolled cell division. Isothiocyanates, which are the major active constituents of many cruciferous vegetables, suppress tumor growth by generating reactive oxygen species, or by inducing cycle arrest leading to apoptosis [7]. Broccoli sprouts are a rich source of several isothiocyanates (ITCs) that are well known class of cancer chemopreventive agents. They inhibit the size, multiplicity and progression of bladder cancer when the extracts are delivered selectively to the bladder epithelium through urinary excretion [8]. ITCs are also known to prevent the process of prostate carcinogenesis. Erucin (ER) which is a dietary ITC, is

considered to be a major cancer chemopreventive phytochemical. But ER showed a lower potency in inhibiting the proliferation of prostate adenocarcinoma cells (PC3) [9]. Selenium-enriched broccoli sprouts, when compared to the normal broccoli sprouts are found to be superior and induces apoptosis of prostate cancer cells, inhibits cell proliferation and decreases prostate-specific antigen secretion. The Se-enriched broccoli sprouts are used as an alternative selenium source for prostate cancer prevention and therapy [10]. The sprouts of high Se-broccoli are protective against chemically induced mammary or colon cancer. The cancer-preventive effect of Se in high Se-broccoli extends to mammary cancer and the protective forms of broccoli against colon cancer include high Se-broccoli sprouts [11]. Sulforaphane along with another phytochemicals such as indole-3-carbinol and brassinin from broccoli have been useful for cancer chemoprevention. Considering their level of safety, expenditure and oral bioavailability, phytochemicals have great potential in cancer prevention [12].

Broccoli in the treatment of diabetes

Broccoli is one among the few vegetables that claims to possess antidiabetic potency and are commonly consumed in India. *Brassica oleracea* has shown the beneficial hypoglycaemic influence in both experimental animals and humans [13]. The broccoli sprouts are known to improve insulin resistance in type 2 diabetic patients and lessens its complications. This is one of the new approaches by the use of its antioxidant components [14]. Broccoli is rich in flavonoids that have anti-inflammatory and antioxidant effects that protect against diabetes. Flavonoids can result in reduced risk of incident diabetes [15]. Sulforaphane has the potential to induce some peroxisome proliferators-activated receptors that contributes to glucose homeostasis in hyperglycaemic and oxidative conditions. They also prevent nephropathy, diabetes-induced fibrosis and vascular complications. Sulforaphane is an excellent choice for supplementary treatment in type 2 diabetes [16].

Effect in neural disorders

Sulforaphane prevents neurodegeneration and thereby has its effect on Alzheimer's disease and Parkinson's disease. Other characteristics include inflammation, neuronal loss and oxidative stress [17].

Effect in asthma

Broccoli sprout extract (BSE) contains sulforaphane that could be used to suppress the nasal inflammatory response. Therefore it also holds good for reducing the impact of particulate pollution on allergic disease and asthma [18].

Antioxidant activity

The content of glucosinolates in *Brassica* plants is known to represent a healthy advantage as they are associated to antioxidant and anti-carcinogenic properties. Broccoli, being one of the varieties of *Brassica* sprouts, is grown to evaluate the glucosinolate profile and myrosinase activity during the sprouting. Glucoraphin is another major compound in broccoli sprouts [19]. Sulforaphane is used as an antioxidant dietary supplement. It induces phase I and phase II enzymes to prevent carcinogenesis and also presents anti-tumor action at post-initiation phase suggesting supplementary roles in cancer prevention [20].

Conclusion

Therefore, the several phytochemicals or compounds that are present in broccoli have been proved to reduce the risk of several major

diseases including cancers, neurodegenerative disorders, diabetes etc.

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