



BROCCOLI: THE SOURCE OF VITAL NUTRIENTS

Aditi P. Prabhudesai*, Dr. Dinesh M. Biyani, Dr. Milind J. Umekar

Smt. Kishoritai Bhoyar College of Pharmacy, Behind Railway Station, Kamptee, Dist. Nagpur- 441002, India

*Corresponding author E-mail: aditiprabhudesai69@gmail.com

ARTICLE INFO

Key Words

Broccoli, broccoli sprouts, Sulforaphane, Brassica oleracea



ABSTRACT

Broccoli is an edible green plant that is classified in the Italica cultivar group of the species Brassica oleracea. Broccoli is an herbaceous annual or biannual plant grown for its edible flower heads, which are used as a vegetable. Broccoli plant has a thick green stalk which gives rise to oblong leaves which are gray-blue to green in colour. While broccoli is grown commercially in many states throughout the U.S., about 90% of U.S. production takes place in the state of California. Broccoli is known to be excellent source of indole-3-carbinol. They are also rich in vitamin C, dietary fiber and also contain Glucoraphin, selenium, Sulforaphane, isothiocyanates. These constituents present in broccoli are known to be very popular since they possess several anti-cancer properties and benefits. Broccolis as well as broccoli sprouts both are found to be essential for human health. The therapeutic potential of broccoli has been explain under its role in cancer, diabetes and other diseases. One of the phytoconstituent found in broccoli-Sulforaphane is found to be very essential as it is widely used to treat various diseases and disorders.

INTRODUCTION

Broccoli, Brassica oleracea, variety italica, is an edible green plant in the cabbage family (family Brassicaceae, genus Brassica) which consists of large flowering head and stalk is eaten as a vegetable. The word broccoli comes from the Italian plural of broccolo, which means “the flowering crest of a cabbage”, and is the diminutive form of brocco, meaning “small nail” or “sprout”.^[1, 2] Broccoli resulted from breeding of cultivated Brassica crops in the northern Mediterranean starting in about sixth century BC. Since the time of the Roman Empire, broccoli has been commonly consumed, and is eaten raw or cooked. Broccolis is a particularly rich source of vitamin C and vitamin K. Contents of its characteristic sulphur-containing glucosinolate compounds, isithiocyanates and sulforaphan, are diminished by boiling, but it is better

preserved by steaming, microwaving or stir-frying.^[2, 3] Broccoli is classified in the Italica cultivar group of the species Brassica oleracea. Broccoli are usually dark green in colour, arranged in a tree like structure branching out from a thick stalk which is usually light green and has large flower heads. The mass of flower heads is surrounded by leaves. Broccoli resembles cauliflower, which is a different cultivator group of the same Brassica species.^[4]



Fig. No 1: Broccoli Vegetable

Plant in general, 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 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, phenolic compounds and polypeptides. Broccoli also provides many health-promoting properties which attributes to its anti-carcinogenic and antioxidant compounds.^[5]

VARIETIES OF BROCCOLI: Out of different types of broccoli available, there are some types that are commonly grown. They are Calabrese broccoli, Belstar broccoli, Green Goliath, Romanesco and Purple sprouting broccoli.

Calabrese broccoli



Fig No. 2: Calabrese broccoli

The most familiar is Calabrese broccoli, often referred to simply as “broccoli”, named after Calabria in Italy. It has large (10 to 20cm) green heads and thick stalks. It is a cool-season annual crop. It is an heirloom variety of broccoli from Italy. Sprouting broccoli has a large number of heads with many thin stalks.

Purple sprouting broccoli: It is a type of broccoli grown in Europe and North America. It has a head shaped like cauliflower, but consisting of tiny flower buds. It sometimes, but not always, has a purple cast to the tips of the flower buds.



Fig no. 3 – Purple sprouting broccoli

Belstar broccoli –



Fig No. 4: Belstar broccoli

This is hybrid variety of broccoli that is known to have good tolerance to both cold and heat. It means they are widely adapted. This type of broccoli produces blue-green heads that can measure about 6-inches.

Green Goliath sprouting broccoli –



Fig no.5: Green goliath sprouting broccoli

The green goliath is quite unique when compared to some other varieties. They do not have specific maturity period because the heads do not mature at the same time. Other popular cultivars include, Blue wind, Coronado Crown, Destiny broccoli, Diccico, Romanesco, Sun King, Waltham 29 broccoli – this is a type of broccoli with most prominent flowers.

Beneforte is a variety of broccoli containing 2-3 times more glucoraphanin and produced by crossing broccoli with a wild Brassica variety, Brassica oleracea var villosa. [6]

HISTORY

The cruciferae (Brassicaceae) family of plant is found on virtually all continents and it is particularly diverse and plentiful in the Mediterranean area of Europe, the central and western areas of Asia, and the western half of North America. Some of more recent aspects of this vegetable's history involve its cultivation in Europe and transport to North America. Within a border historical context, broccoli started out as a form of wild cabbage, and it took centuries of selective planting and agricultural practice to allow for its evolution into the familiar varieties. While broccoli is grown commercially in many states throughout the U.S., about 90% of U.S. production takes place in the state of California. Cultivation of broccoli in California makes use of about 115,000 acres of land throughout the state, and about 1.8 billion pounds of broccoli are produced each year. After California, the next largest U.S. producer of broccoli is Arizona. In terms of U.S. imports, the largest amount of broccoli brought into the country is from Mexico. [7]

DESCRIPTION

Broccoli, Brassica oleracea, is an herbaceous annual or biennial grown for its edible flower heads which are used as a vegetable. The broccoli plant has a thick green stalk, or stem, which gives rise to thick, leathery, oblong leaves which are gray-blue to green in colour. The plant produces large branching green flower heads covered with numerous white or yellow flowers. Broccoli can be annual or biannual depending on the variety and can grow to 1m (3.3 ft) in height. Broccoli may also referred to as sprouting broccoli and likely originates from the Mediterranean although the exact location has not been determined. [8]

PRODUCTION: In 2017, global production of broccoli (combined for

production reports with cauliflowers) was 26.0 million tonnes, with China and India together accounting for 73% of the world total. Secondary producers, each having about one million tonnes or less annually, were the United States, Spain, Mexico and Italy. In the United States, broccoli is grown year-round in California- which produces 92% of the crop nationally- with 95% of the total crop produced for fresh sales. [1, 9]

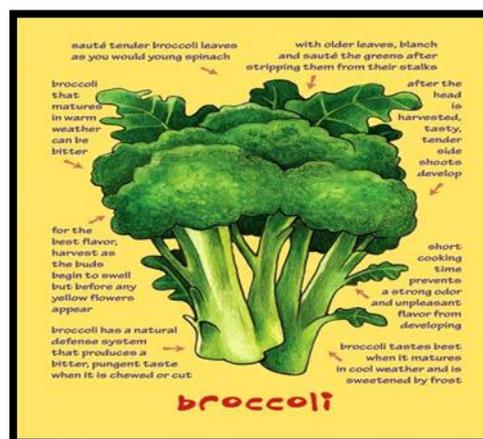


Fig No. 6– Description of broccoli

Table No. 1- Production of Broccoli

Broccoli production-2017 (includes Cauliflower)	
Country	Production millions of tonnes
China	10.4
India	8.6
United States	1.3
Spain	0.7
Mexico	0.7
Italy	0.4
World	26.0
Source: FAOSTAT of the United Nations	

CULTIVATION

The majority of broccoli cultivars are cool-weather crops that do poorly in hot summer weather. Broccoli grows best when exposed to an average daily temperature between 18 and 23°C (64 and 73°F). Broccoli grows best in moist, fertile soil with a slightly acidic pH between 6.0 and 7.0. Broccoli has a high nitrogen requirement and due to the reduced activity of soil microbes in late fall and winter, organic matter should be added

to the soil throughout the year to ensure an adequate supply of nutrients when broccoli is planted. When the cluster of flowers, also referred to as a “head” of broccoli, appears in the center of the plant, the cluster is generally green. Broccoli is ready to harvest when the flower buds are firm and packed tightly in the head. Harvest before the buds open by cutting the stalk of the head at a 45° angle about 13-20 cm (5-8 inch) below the head. Side-shoots will continue to produce after the first harvest. [1, 10, 11]

Chemical constituents of broccoli



Fig. No. 7 – Constituents of broccoli

There are typical phytochemicals found in broccoli: glucosinolates, dithiolthiones, indoles, glucoraphanin, s-methylcysteine sulfoxide, isothiocyanates, and indole-3-carbinol. The phytochemicals in broccoli that are found to be good for immune system include – flavonoid, carotenoids such as beta-carotene and zeaxanthin, glucobrassicin and kaempferol. Broccoli is also good source of lutein - a compound antioxidant, and Sulforaphane – which is very potent antioxidant. [12]



Fig. No. 8– Concentration of sulforaphane in broccoli and broccoli sprouts

Nutritional value of broccoli

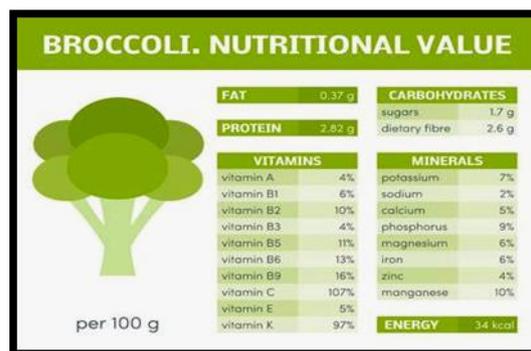
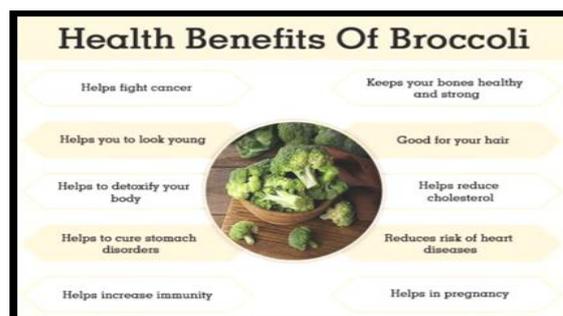


Fig. No. 9– Nutritional value of broccoli

Broccoli is cruciferous vegetable which is very rich in nutrients. It is high in vitamin C, vitamin A, riboflavin, calcium, iron and soluble fiber. It also contains multiple nutrients considered to have potent anti-cancer properties, including diindolylmethane and selenium. The 3,3-diindolylmethane found in broccoli is a potent modulator of the innate immune response system with anti-bacterial, anti-cancer and anti-viral activity. Moreover broccoli also contains vitamin B1, magnesium, omega-3 fatty acids, protein, niacin and zinc. The nutritional benefits of broccoli are reduced if the vegetable is boiled. [13]

Contents	Cooked Broccoli	Raw Broccoli
Fiber	3.3 G	2.6 G
Potassium	293 Mg	316 Mg
Vitamin C	65 Mg	90 Mg
Calcium	40 Mg	47 Mg
Folate	108 Mcg	63 Mcg

Fig No. 10– Health Benefits of broccoli



Pharmacological activities of broccoli^{14,15}

Antioxidant activity: The content of glucosinolates in Brassica plants possesses healthy advantage as they are associated with antioxidant and anti-carcinogenic properties. Glucoraphin is another major compound in broccoli sprouts. Broccoli, being one of the varieties of Brassica sprouts, is grown to evaluate the glucosinolate profile and myrosinase activity during the sprouting. Sulphoraphane is used as an antioxidant dietary supplement. It induces phase I and phase II enzymes to prevent anti-tumor action at post initiation phase and also prevents carcinogenesis.

Antidiabetic activity: The broccoli sprouts are known to improve insulin resistance in type 2 diabetic patients and lessens its complications. Broccoli is rich in flavonoids that have anti-inflammatory and anti-oxidant effects that protect against diabetes. Sulforaphane has the potential to induce some peroxisome proliferators- activated receptors that contributes to glucose homeostasis in oxidative and hyperglycaemic conditions. They also prevent diabetes-induced fibrosis, vascular complications as well as nephropathy. Sulforaphane is known as an excellent choice for supplementary treatment in type 2 diabetes.

Anticancer activity: Cancer is a multistep process that results in uncontrolled cell division. Broccoli sprouts are rich source of several isothiocyanates (ITCs) that are well known class of cancer chemoprotective agents. They inhibit the size, multiplicity and progression of bladder cancer when extracts are delivered selectively to the bladder epithelium through urinary excretion. ITCs are known to prevent the process of prostate carcinogenesis. Isothiocyanates, which are major active constituents of many cruciferous vegetables, are also known to suppress tumor growth by generating reactive oxygen species, or by inducing cycle arrest leading to apoptosis. Selenium-enriched broccoli sprouts, when compared to the normal broccoli sprouts are found to be superior and induce 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. Sulforaphane along with another phytochemicals such as indole-3-carbinol and brassinin from broccoli have been useful for cancer chemoprevention.

Effect in asthma: Broccoli sprout extract (BSE) contains Sulphoraphane that could be used to suppress the nasal inflammatory response. Therefore it is also found to be useful for reducing the impact of particular pollution or allergens on allergic diseases and asthma.

Effects on neural disorders : Sulforaphane prevents neurodegeneration and thereby has its effect on Parkinson's disease and Alzheimer's disease. Other characteristic includes oxidative stress, inflammation and neuronal loss.

Cholesterol reduction : According to Jarzabkowski, broccoli can help lower cholesterol because the soluble fiber in the vegetable binds with the cholesterol in the blood. This binding makes the cholesterol easier to excrete, and consequently lessens cholesterol levels in the body.

Detoxification: Phytochemicals gluconasturtiin, glucoraphanin and glucobrassicin compose a terrific trio in broccoli. Together, they aid all steps of body's detoxification process, from activation to neutralization and elimination of contaminants. Sprouts of broccoli were found to be more potent in this regard.

Heart health : Broccoli can aid in heart health by helping to keep blood vessels strong. The Sulforaphane in broccoli is an anti-inflammatory and may be able to prevent or reverse damage to blood vessel linings caused by chronic blood sugar problems. The vegetables B-complex vitamins can help regulate or reduce excessive homocysteine, an amino acid that builds up after a person eats red meat, increases the risk of coronary artery disease.

Eye health: As carrots are known to be good for eyes, and that's because they contain lutein, it's a compound which is antioxidant that's known to be really good

for eye health, and broccoli is also a great way to get it. Another antioxidant in broccoli called Zeaxanthin is similarly beneficial. Both chemicals may help protect against macular degeneration, an incurable condition that blurs central vision, and also prevents from cataracts, a clouding of eye's lens.

Digestion: Broccoli's digestive benefits are found mostly due to vegetables high fiber content. Broccoli has nearly 1 gram of fiber per 10 calories. Fibers help to regularly maintain healthy bacteria levels in the intestines. Broccoli also aids in digestion by keeping stomach lining healthy. The Sulforaphane in broccoli helps keep the stomach bacteria *Helicobacter pylori* from becoming overgrown or clinging too strongly to the stomach wall.

During pregnancy: Broccoli can be consumed during pregnancy for calcium, carotenoids to foster healthy vision, fiber, folate, and potassium for fluid balance and normal blood pressure. Broccoli also has the raw materials that help body to produce vitamin A.

Side-effects & allergies of broccoli:

Although consuming broccoli has a number of health benefits, there are number of side-effects too. Some people may have an allergic rash when they come in contact with broccoli as it contains a number of powerful compounds. Again, it is not good for people having blood-thinners to suddenly increase or decrease their consumption of Vitamin-k (which is present in broccoli) as it plays a large role in blood-clotting.^[16]

CONCLUSION

The consumption of broccoli and broccoli sprouts are found to be beneficial for human health. It is also found to be economical and simple option for healthy eating. There are several phytochemicals or compounds that are present in broccoli have been proved to reduce the risk of several major diseases including diabetes, cancer, neurodegenerative disorders, etc. broccoli is found to have high nutritional value and is rich in protein and low in fat. Plant in general, 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 large number of diseases caused by micro-organisms.

Acknowledgement: I would like to offer my special gratitude to Dr. Dinesh Biyani sir, Dr. Milind Umekar sir, my colleagues and my family for their valuable guidance and support. I would also like to thank SKB College of pharmacy, Kamptee.

REFERENCES

1. <https://en.m.wikipedia.org/wiki/Broccoli>
2. Merriam-Webster's collegiate dictionary, "Broccoli", 2004; (11):156
3. Nunnecke, IB, "vegetable production". Springer-Verlag New York, LLC, (Nov1989),
4. Nugraedi, Verkerk, ruud, widianarko, budi; Dekker, Matthijs. "A Mechanistic perspective on process-induced changes in Glucosinolate content in Brassica Vegetables: A Review. Critical Reviews in food science and nutrition, 2015; 55 (6): 823-838.
5. "Broccoli (and cauliflower) production in 2017, crops/regions/world list/ production quantity (pick list). UN food and agriculture organization, corporate statistical database (FAOSTAT), 2018.
6. Chandani Ravikumar, "Therapeutic potential of Brassica oleracea (Broccoli) – A review". 04 June, 2015; 7 (2), 009-010.
7. <https://growherbsgarden.com/types-of-broccoli/>
8. <https://www.thespruceeats.com/broccoli-history-1807573>

9. <https://plantvillage.psu.edu/>
10. “Broccoli”. Agricultural marketing resource center, US department of agriculture. 1 June 2018
11. Smith, Powell (June 1999). “HGIC 1301 Broccoli”. Clemson University. Retrieved 25 August 2009.
12. Encyclopedia|title=Broccoli|last=Lip
tay|first=Albert|year=1988|publishe
13. <https://www.livescience.com>
14. <https://nutritiondata.self.com>
15. <https://www.researchgate.net/publication/>
16. <https://academic.oup.com/biohorizons/article>
17. <https://www.lybrate.com/topic/benefits-of-broccoli-and-its-side-effects>