



A REVIEW ON BIOLOGICAL ACTIVITIES OF BRASSICA OLERACEA

Miss. Rutuja Prashant Nangare ¹, Miss . Pallavi Jadhav ², Mr. Vikas Wamane

¹ B.Pharmacy Student, Pratibhatai Pawar College Of Pharmacy, Wadala, Shirirampur , Pin Code -413709

² Department of pharmaceutical chemistry, Pratibhatai Pawar College of Pharmacy, Shirirampur

For correspondence Email: rutujanangare2001@gmail.com.

ABSTRACT

Broccoli is an edible green plant that is classified in the Italica cultivar group of the species *Brassica oleracea*. Broccoli is considered as a nutritional powerhouse. The present review comprises the phytochemical and biological activities or therapeutic potential of broccoli. Broccoli is a good source of health promoting compounds such as glucosinolates, flavonoids, hydroxycinnamic acids and vitamins. Moreover, broccoli is the kind of nutrient that has so many wonderful applications including gastroprotective, antimicrobial, antioxidant, anticancer, hepatoprotective, cardioprotective, anti-obesity, anti-diabetic, anti-inflammatory, and immunomodulatory activities. They are rich in vitamin C, dietary fiber and also contain glucoraphin, sulforaphane, selenium and isothiocyanates. Broccoli is widely used in the treatment of several forms of cancer and also treats other neural disorders. 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: *Brassica oleracea*, biological activities, phytochemistry.

1. INTRODUCTION

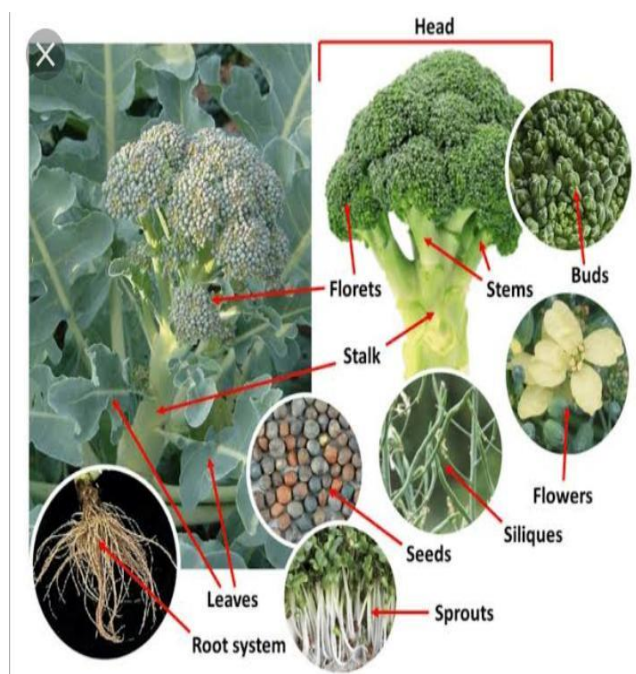
Broccoli is thick green Plant with green or purple flower head which can be cooked and eaten. Broccoli is botanical name is *Brassica oleracea* var *Italica*, Broccoli, *oleracea* belongs to family Brassicaceae. Broccoli is fast growing annual plant that grows 60 - 90 cm tall. Many anti-microbial agents that derived from traditional medicinal plants are available for treating large no. of diseases caused by microorganisms [1]. Broccoli also provides many health promoting properties which attribute to its antioxidant & anti- carcinogens compounds. Also, it possesses antidiabetic potency. Broccoli sprout extract contains sulforaphane that could be used to suppress nasal inflammatory responses. Broccoli has been marketed as health - promoting food because it naturally has high content of bioactive phytochemicals such as glucosinolates, phenol compounds, vitamin c & mineral nutrients [2].



The group of anti- microbial phytochemicals is several categories that include alkaloids, flavonoids, tannins, polyphenols, essential oils, phenolics and polypeptides [3]. The word "Brassica" means to cut off the head. Broccoli is an Italian word from the Latin brachium, meaning an arm or branch. The term sprouting as used in sprouting broccoli refers to the branching habit of this type, the young edible inflorescences often being referred to as sprouts. The sprouting broccolis are thought to have originated from the eastern Mediterranean then introduced into Italy. A remarkable diversity of broccoli-

like vegetables has been developed in Italy. According to (FAO statistics, 2012), China is the top world producer of broccoli (9,596,000 tons) [4]. The flowers of broccoli are borne on a faceted floral shoot so that the inflorescence terminates the axis of the plant. The inflorescence, which has been described as a corymb, a corymbose panicle or a modified racemose panicle, consists of functional floral buds, perfect flowers, stem, and bracts. At the time of harvesting, the inflorescence is a growing, faceted axis bearing a large number of immatures, stalked flowers, floral buds, and varied bracts which are smaller and simpler in form than the vegetative leaves. The bracts are absent from the terminal portion of the inflorescence [4, 5]. The aim of the present study was to develop a database for the amazing green world of broccoli that can be used to encourage daily dietary intake through investigating diet–disease relationships. We highlight the phytochemical content, discuss its relation with the pharmacological activities, evaluate toxicity, summarize nutritional value and appreciate the influence of cooking method on phytochemical content to complete the whole picture providing significant information could be used as a dietary guideline that encourage broccoli consumption for the management of various diseases. In addition to provide notes on studies on broccoli tissue cultures and its by-products,

This review provides a few recommendations that will help to define a sounder, proof - of - concept for the complete benefit of broccoli. Broccoli sprouts contain negligible quantities of indole glucosinolates, that predominate in the mature 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 [6]. 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 [7]. 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. [] Broccoli (*Brassica oleracea* L. *italica*) has been marketed as a health-promoting food because it naturally has high content of bioactive phytochemicals such as glucosinolates, phenolic compounds, vitamin C, and mineral nutrients. Thus, a diet rich in broccoli plays a role in the prevention of chronic diseases, such as cardiovascular and carcinogenic pathologies, and breast and prostate cancers [8]. Broccoli has also been found to exhibit antioxidant activity that prevents oxidative stress related to many diseases [9]. Broccoli parts being used for food are mostly florets, which make up 30% of the whole broccoli. Currently, the use of broccoli by-products such as leaves and stems is restricted to flour and fiber [10], but the potential use of these by-products as important sources of phytochemicals is now gaining more attention in the scientific community [11]. More than 72% of all broccolis produced in Korea is grown in Jeju. Broccoli is not only produced in large amounts, but it is also discarded in high amounts as by-products such as leaves and stems.

This has a negative impact on agricultural environments and recycling those by-products for physiologically active substances could help reduce environmental problems and increase farmers' profits [12]. Many studies on broccoli have been performed on the antioxidant and anticancer activities of broccoli components, but most of the studies analysed florets of different varieties [12] ... Domínguez-Perles et al. [12] determined the antioxidant activity of broccoli leaves and stalks of three different cultivars, but not at different harvest times. Furthermore, the determination of the anticancer activity has not been previously and simultaneously detailed for different broccoli parts at different harvest times. The biological activities may be significantly different various growth stages of broccoli leaves and stems from different cultivars. Thus, it might be valuable for the food industry to

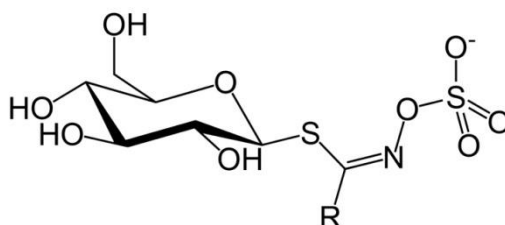
investigate the functionality of broccoli by-products such as stems and leaves as useful industrial materials, rather than only using the florets. The purpose of this study was to evaluate total phenolic and sulforaphane contents, and antioxidant and anticancer activities of broccoli by-products from different cultivars and harvest dates of broccoli grown in Jeju, Korea. Broccoli known as the “vegetable crown” is an annual plant in Brassica genus of the Brassicaceae family (Wu et al., 2020). Epidemiological studies have shown that regular intake of cruciferous vegetables can effectively reduce the incidence of chronic diseases (e.g., heart and vasculature diseases).

The consumption of broccoli can reduce the incidence of chronic health disorders, which has progressively resonated with health-conscious consumers. Broccoli exerts good antioxidant capacity because two types of phytochemicals in broccoli contribute to defense lines against oxidative stress: [16] Direct antioxidants, which are directly involved in redox reactions and scavenge oxidation products. The main direct antioxidants in broccoli include vitamin C, phenolic compounds, carotenoids, and vitamin E (Jane et al., 2007; Paulina et al., 2014). [17]. Indirect antioxidants, which comprise a wide range of chemical structures and can induce the cytoprotective (Phase 2) response. The main indirect antioxidants in broccoli are isothiocyanates (ITCs), which are obtained by hydrolysis of glucosinolates by endogenous myrosinase (Dinkova-Kostova & Kostov, 2012). Glucoraphanin is the most abundant glucosinolate in broccoli, and is also rich in cruciferous vegetables of the Brassica L. such as cabbage, cauliflower, etc. (Atle & John, 2006; Juge, Mithen & Traka, 2007). The hydrolysate of glucoraphanin is sulforaphane (SF). Glucoraphanin exists and is abundant in the vacuoles of broccoli.

2. PHYTOCHEMISTRY

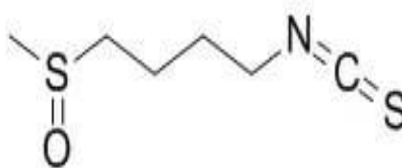
1. Glucosinolates

Broccoli inflorescence contains glucosinolates, flavonoids, hydroxycinnamic acids, and other minor chemicals, making it a good source of healthpromoting substances [18]. Brassica produces almost all of the glucosinolates. They are thought to play a function in microorganism and plant health. Insect repellent When plant cells are disrupted (for example, during a drought), glucosinolates are formed when food is sliced, chewed, cooked, frozen thioglucosidase enzyme (myrosinase) hydrolysis to isothiocyanates, epithiocyanates, epithionitriles, and nitriles oxazolindines). Glucosinolates of various types were discovered in Liquid chromatography mass spectrometry of broccoli sprouts. Tandem mass spectrometry and liquid chromatography such as glucoiberin, glucocheirolin, glucoraphanin, progoitrin, sinigrin, glucoalysingluconapin, glucoiberin, glucoalysin, gluconapin, glucoiberin, 4-hydroxyglucobrassicin, glucoerucin, glucobrassicin, hydroxyglucobrassicin, gluconapoleiferin, methoxyglucobrassicin, and neoglucobrassicin (Fig. 1) [19], as well as by GC/MS analysis of such compounds as 1, 2, 4-disulphide dimethyl, trisulphide dimethyl, disulphide dimethyl, 3,5-dimethyl trithiolane, ethenyl isothiocyanate, allyl isothiocyanate, isothiocyanate, 4-methyl thiobutyl isothiocyanate, and 2-methyl isothiocyanate [20] phenylethyl isothiocyanate. Aside from that, isolation of N-(4-hydroxy)uridine, uridine 9-acetate, obtocarbamate [21, 22], phenyl acetamide, and p-hydroxy benzoic acid, a Cinnamoyl derivative [6'-O-trans-(4-glucosinolate)] is a novel glucosinolate. 4-(methylsulphonyl) butyl hydroxycinnamoyl) Glucosinolate [23].



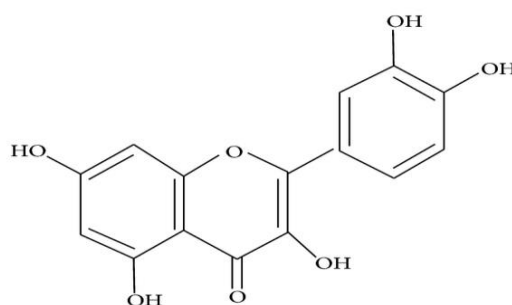
2. Sulforaphane

The chloroform extract (475.7 mg/kg of sulforaphane) had the highest quantity of 5-methylsulfinylpentyl nitrile (including sulforaphane). sulforaphane (222.6 mg/kg, fresh sprouts), sulforaphane (222.6 mg/kg, fresh sprouts), and sulforaphane (222.6 mg/Kg) (63.0 mg/kg) 4-methylsulfinylbutyl nitrile [24]. Broccoli is a vegetable rich in vitamins and minerals. One of the primary flavonol sources has been identified in diet. The flavonols quercetin-3-glucoside and rutin-glucoside were the most abundant in the inflorescences. quercetin-3-O-glucoside; O-sophorotrioside-7-O-glucoside quercetin-3-O-sophorotrioside, sophoroside-7-O-glucoside-7-O-sophoroside.



3. Flavonoids

All of the flavonoids that had previously been discovered have been discovered. hydroxycinnamic acids (p-coumaric, caffeic, etc.) are used to acylate the compounds. Sinapic and ferulic acids). As a result, broccoli has a lot of nutrients. hydroxycinnamic acid mixtures with other compound flavonoids that have been heavily glycosylated [25]. The sterols are a type of lipid that can be found in a variety of foods. sitosterol was the most abundant sterol in both the florets and stems. Brassicasterol [26] is a kind of brassicasterol that is found in brassicas. Indeed, broccoli is considered a storehouse of various phytochemicals.



3. BIOLOGICAL ACTIVITIES:

Dietary use of broccoli has encouraged scientists to test for a wide range of biological activities including anti-microbials, antioxidant, anti-cancer, anti-inflammatory, anti-diabetic, anti-obesity, gastrointestinal, hepatoprotective, cardioprotective and immunomodulatory activities.

1. Antimicrobials Activity

Despite recent advances, infectious diseases produced by bacteria, fungi, viruses, and parasites continue to pose a serious threat to public health. Human medicine has come a long way. Their impact is significant. Because of the relative poverty in emerging countries, the gap is very great. medical shortages and the rise of [27] There is extensive drug resistance. Benkolseppon and colleagues, (2010) looked on the occurrence of antimicrobial peptides in food. [28] in broccoli leaves Chloroform and ethyl acetate are two types of ethyl acetate. Broccoli floret extracts were discovered to be efficient. *B. subtilis* and *B. cereus*, respectively. Ethyl acetate is a kind of ethyl acetate. against *E. coli*, and ethanol extracts were highly effective. Furthermore, ethyl acetate and chloroform extracts revealed High anti-*Candida albicans* action [21]. Biologically. Ag nanoparticles were synthesised from aqueous extract of Broccoli florets were discovered to be useful in reducing inflammation. *Klebsiella pneumoniae*, *Klebsiella sonnei*, *Klebsiella sonnei*, *Klebsiella sonnei*, *Klebsiella Staph. E. coli* and *Saprophyticus* [29]. 320 g mL⁻¹ were found to be the minimum inhibitory concentration (MIC). *B. tested* against the majority of six foodborne bacteria; *C. tested* against the majority of six foodborne bacteria; *D. tested* against the *Staph. aureus*, *E. coli*, *Staph. typhi*, and *cereus*, *B. subtilis*, *Staph. aureus*, *B. subtilis*, *Staph. aureus*, *E. coli*, *Staph. typhishigella flexneri* as a possible pathogen with acetone and methanol. *B. subtilis* (15.4 mm) and *B. cereus* extracts (16.3 mm) They were discovered to be the most vulnerable creatures among the pathogens that have been tested [30]. Broccoli stem extract was found to have antimicrobial activity against *Listeria monocytogenes*, antimicrobial activity against *Listeria monocytogenes*, antimicrobial activity against *Listeria* 102.4 mg/mL was the MIC. CGMS (Comparative Genomics Mass Spectrometry) analysis allows for the identification of organic acids such as ascorbic and lactic acid. phenolic substances such as sinapinic, ferulic, and malic acids, as well as caffeic acids [31].

2. Antioxidant Activity

The content of glycosylates 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 [32]. Sulforaphane is used as an antioxidant dietary supplement. It induces phase I and phase II enzymes to prevent carcinogenesis and presents anti-tumour action at post-initiation phase suggesting supplementary roles in cancer prevention [33]. Oral broccoli consumption has been linked to a higher antioxidant level overall [34]. Chickens fed a low-antioxidant diet containing 10% apple/broccoli mixture were used in *in vivo* studies. Erythrocyte stability was shown to be significantly improved. Carbonyls in insoluble muscle diminish when exposed to H₂O₂.

In heat-treated liver, proteins slow lipid oxidation [35]. Examples Hydrophilic oils have a high antioxidant capability. broccoli extracts analysed by oxygen radical absorbance the ORAC assay resulted in a range of 65.8 to 121.6 mol /L the capacity of trolox equivalents (TE)/g of tissue Lipophilic extracts had TE/g values ranging from 3.9 to 17.5 mol [36]. Twenty-seven young healthy people consumed broccoli thereafter. After ten days of smoking (250 g/day), the level of oxidised carbon was measured. Resistance to H₂O₂-induced DNA damages decreased by 41%. The number of strand breaks caused by induced DNA breaks rose by 23%, and the number of strand breaks persisted at a greater level. The

glutathione S-transferase (GST) M1-null genotype was found to provide protection in subjects [34]. Models in vitro broccoli is a natural source, as evidenced by the fact that In vitro models show that broccoli is a natural source of antioxidants, suggesting that it could be used as a nutraceutical. Possible applications in decreasing oxidative stress. The health benefits of reducing stress. Superoxide inhibition. The use of aqueous and ethanolic extracts to scavenge demonstrated a positive result. 0.93 and mg/mL, respectively, are the IC₅₀ values. Chelation of metal ions. Both extracts had an IC₅₀ of 0.35 mg/mL and were capable of positive control, Tetra-acetic ethylenediamine acid. The antioxidant activity of the ethanolic extract was greater. DPPH radical and superoxide anion scavenging activity compared to aqueous extract [35]. In addition, three-day-old. The anti-oxidative activity of broccoli seedlings was the highest. When tested for anti-oxidative activities, the young plant outperformed the mature planted radical technique is used. Taking in little amounts of broccoli sprouts have the same anti-inflammatory properties as broccoli ingesting a huge number of mature plants [36]. Chanting et al., (2013) determined that physiologically reduced substances have a reducing property. Ag nanoparticles were synthesised from an aqueous extract of attributed the reducing property of biologically synthesised Ag nanoparticles from broccoli floret aqueous extract to the presence of antioxidant viz. polyphenols, ascorbic acid, ascorbic acid, ascorbic acid, ascorbic acid, ascorbic acid, ascor. Free radical scavenging action and quantitative assay. DPPH scavenging activity [29] has been demonstrated.

3. Anti – cancer activity

The glucosinolates in broccoli are broken down into biologically active molecules such as indoles, nitriles, thiocyanates, and other substances during preparation, chewing, and digestion. Isothiocyanates. Isothiocyanates and indoles have been discovered. In multiple studies, it was discovered to limit the growth of cancer. Bladder [37], breast [38], and organs in rats and mice [39], liver [40], lung [41], prostate [42, 43], renal [44], crown-gall [45], oral mucosa [46], colon [47], and skin [48] are some of the organs that have been studied. Animal research at the National Cancer Institute (NCI) and Experiments using laboratory-grown cells have yielded positive results. There is concentrated form of sulforaphane found in broccoli has been shown reduce the number of lymphoblastics leukemia cells in the lab and have both preventative and therapeutic properties in solid tumors. studies have shown that people who eat a diet rich in broccoli have lower risk of some cancer. Broccoli is unmatched in its anti-cancer effect.

4. Anti- Inflammatory Activity

The impact of a 10-day broccoli (250 g/day) diet on inflammatory markers in young male smokers was investigated. C-reactive protein levels in the blood (CRP), Interleukin 6 (IL-6) and tumour necrosis factor alpha (TNF-) (IL-6), Adiponectin and the interleukin 6 receptor (IL-6sR) were studied. Broccoli consumption had no effect on TNF, IL-6, IL-6sR, or adiponectin, however it did lower plasma CRP by a factor of 48. An inverse relationship exists between lycopene and TNF- and IL-6sR were found at the start [49]. Another study found that Broccoli florets ethyl acetate fraction reduced nitric oxide production. RAW cells activated with LPS release oxide 264.7 cells and inhibited IB-II in a dose-dependent manner nuclear factor- κ B activation and degradation in RAW 264.7 cells activated with lipopolysaccharide [50]. Furthermore, sulforaphane has the potential to be a new medicinal agent for the treatment of rheumatoid arthritis unstimulated cells are inhibited by sulforaphane. Regarding the proliferation of cells produced by interleukin-1 (IL-1) RASFs (rheumatoid arthritis synovial fibroblasts); matrix metalloproteinase expression (MMP-1, MMP-3), and the COX-2 cyclooxygenase mRNA and protein; and E2 prostaglandin (PGE2) IL-1 stimulates production. Sulforaphane also prevents IL1 from activating NkB and phosphorylating ERK-1/2, p-38, and JNK [51].

5. Anti- diabetic Activity

Consumption of antioxidants included in broccoli leaves helps to reduce cell damage and speeds up the healing of pancreatic cells and, as a result, pancreatic function. It raises insulin levels and lowers blood sugar levels. That was it. Treatment of streptozotocin-induced diabetics has been demonstrated. Broccoli doses of 100 mg/kg and 200 mg/kg body weight rats aqueous extract ameliorate IR in type 2 diabetes patients [52,53]. It was established with the help of eighty-one witnesses. In a patient clinical investigation, fresh broccoli eating was found to be beneficial. For four weeks, sprouts [10 g/day] result in a considerable reduction. homeostasis model and serum insulin concentration IR index evaluation [54] of sprouts, which results in a considerable reduction at 14th and 21st days in blood glucose a hepatic glycogen.

6. Anti- obesity activity

Obesity is increasing at an alarming rate over the world, and it is quickly becoming a significant public health concern with enormous social and economic repercussions. Dietary phytochemicals appear to be able to target many stages of development. The lifecycle of adipocyte (fat cell) [55]. The weight of the body mesenteric adipose tissue and the weight of the gain were both increased. In rats, a high fat diet was used initially, but this was gradually reduced to the normal diet. After the usual diet group reached the same level administration of ethanol with broccoli aqueous extract brussels sprouts [56,57]. Chloroform extract was used in another investigation. a mixture of ethyl acetate and ethanol, as well as a crude extract of Broccoli florets resulted in a considerable reduction in body weight. 5% and 1% of female rats, respectively. When the results have been obtained, green tea water extract (117 g total) was compared. chloroform extract was found to be more effective in reducing body weight loss (180 g) [58]. Total body weight decrease

7. Gastro-protective activity:

Helicobacter pylori infection of the stomach is a worldwide problem, but it is especially prevalent in developing countries where there is also a high prevalence of H. pylori. cancer of the stomach Sulforaphane has two functions: it's a powerful antioxidant and it's a powerful anti-inflammatory. Bacteriostatic agent against three reference bacteria and 45 additional strains H. pylori clinical isolates and blocking the formation. Thus, benzo[a]pyrene-induced foregut cancers in mice provide hope that these approaches will work in a synergistic manner to give dietary

protection against Human gastric cancer [59]. Galan and colleagues reported a preliminary study in 2004 on the temporally linked eradication of *H. pylori* infection in three of nine individuals who were given broccoli sprouts orally [60] advised that more research be further studies. Yanaka was born in the year 2009 and his colleagues demonstrated that consuming sulforaphane-rich foods daily *H. pylorus* is reduced by eating broccoli sprouts for two months. Colonisation in mice and improves infection outcomes in infected mice and *Helicobacter pylori*-infected mice and *Helicobacter pylori*-infected mice and *Helicobacter pylori*-infected mice patients who have been infected [61]. According to Moon et al., (2010). The highest inhibition zones (>5 cm) against *H. pylori* were by broccoli sprouts chloroform extract, followed by the 5.03 cm hexane extract, 4.90 cm ethyl acetate extract butanol extract (cm) (3.10 cm), The residual water fraction did not reveal any inhibitory zone, unlike the crude methanol extract (2.80 cm) and the crude methanol extract (2.80 cm). Broccoli sprouts can be a tasty side dish. A great supply of therapeutic compounds in the form of food [62].

8. Hepato-protective Activity:

Broccoli extract, given at doses of 150 and 300 mg/kg, provided considerable hepatoprotection by lowering serum enzyme activity and bilirubin levels, while also improving liver function raised NP-SH levels and decreased MDA levels in the liver tissue. The liver's histopathological findings are very interesting. Broccoli has a preventive effect against CCl₄-induced cancer. In rats, hepatic damage has been observed. The results obtained indicate that Broccoli has hepatoprotective properties and may be beneficial to the liver. Possible therapeutic utility in the treatment of certain liver diseases, most likely because of its anti-oxidative effects on Due to flavonoids and sulfurated chemicals, hepatocytes [63 and 64].

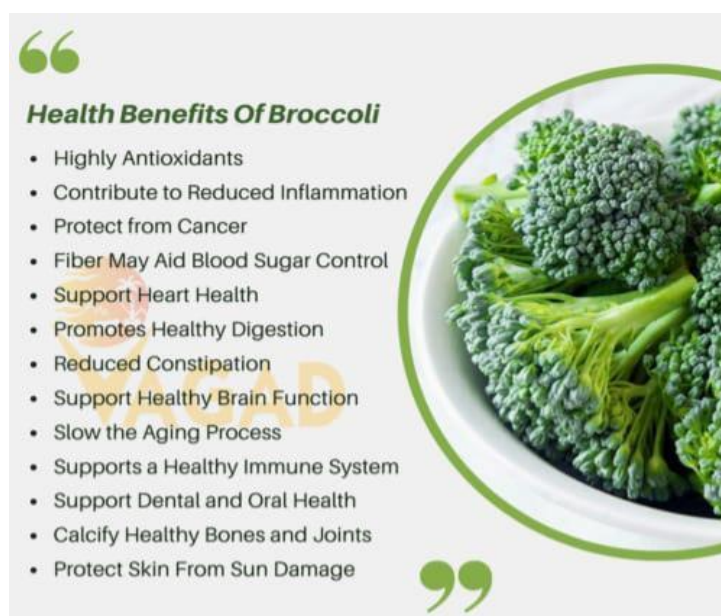
9. Cardio-protective Activity

According to current epidemiological forecasts, the globe is on the verge of a vascular typhoon of cardiovascular disease burden. Cardiovascular disorders are predicted to be the leading cause of death by 2020 is expected to be the leading cause of disability and death in Consumption of broccoli sprouts in underdeveloped nations [65]. Sulforaphane-rich foods were proven to reduce oxidative stress. SHR (suddenly hypertensive stroke-prone rats) and SHR (suddenly hypertensive stroke-prone rats) As a result, it both raises and lowers blood pressure inflammation. Consumption of fresh broccoli sprouts [100 gm/day] for a week reduces LDL, total cholesterol, and triglycerides, according to a 12-patient clinical research. Cholesterol levels, as well as an increase in HDL cholesterol. Another 34,492 postmenopausal women participated in a related prospective study. In Iowa, broccoli was found to be closely linked to [65]. There is a lower risk of coronary heart disease a new study broccoli eating has been shown to help prevent cancer. Ischemic injury causes a decrease in mRNA and protein levels. Cardiomyocyte death is caused by reperfusion damage. Furthermore, another study found that broccoli had anti-inflammatory properties. Treatment can help to enhance heart function and decrease myocardial infarction. Acute myocardial infarction and cardiomyocyte apoptosis [65] Reperfusion injury. Broccoli protects the heart through a variety of ways, including: (a) inhibition of phase I enzymes and DNA adducts; (b) activation of antioxidant enzymes. antioxidant detoxifying enzyme, phase II; antioxidant detoxifying enzyme, phase III; antioxidant detoxifying enzyme, phase IV; antioxidant detoxifying enzyme, function; (d) cell cycle arrest induction; (e) inhibition of angiogenesis; and, as a result, anti-inflammatory characteristics [65] Considered as a possible functional food.

10. Immunomodulatory Activity

In BALB/c mice, intraperitoneal treatment of Sulforaphane (500 mg/dose/animal/day) increased the total WBC count (12,950 cells/mm³) on the 9th day, dramatically increased phagocytic activity of peritoneal macrophages LPS decreased the high level of TNF-production. Increased cellularity of bone marrow due to activated macrophages J. Pharm. Sci. & Res., Vol. 7(9), 2015, 696-703 699, A. I. Owis (23106 cells/femur) and -esterase positive cells (1346.66 out of 4000 cells) sulforaphane is a sulforaphane-based treatment. Sheep red blood cells, in addition to the antigen (SRBC), resulted in an increase in the number of circulating antibodies in the spleen, and the quantity of plaque producing cells (PFC) On the sixth day, (315.83 PFC/106 spleen cells) These are the outcomes. Sulforaphane's immunomodulatory effect is indicated. Dietary factors influence intestinal immune functions [66]. Ligands for the aryl hydrocarbon receptor (AhR). Indole-3-carbinol Broccoli sprouts have an AhR ligand. Following the oral presentation, In the presence of indole-3-carbinol, indole-3-carbinol is transformed of stomach acid to ligands with a high affinity for indoles[3,2-b] carbazole or 6-formylindolo [3,2-b] carbazole [67].

4. HEALTH BENEFIT OF BROCCOLI



EFFECT OF COOKING METHODS

The quantity of glucosinolates, sulforaphane, polyphenols, and antioxidant activity in broccoli is affected by processes such as blanching, cooking, and chopping. Broccoli that has been steamed Antioxidant properties (through phenols and flavonoids) should be improved anti-carcinogenic flavonoids (through glucosinolates) properties. After cutting or chopping the broccoli, cook it. blanching at temperatures below 100 degrees C is a good choice. because of its anti-carcinogenic effects These problems appear to be Processing broccoli as a functional food appears to be promising. enhanced health-promoting qualities in diet [68]. Broccoli that had been steam treated had a higher antioxidant content. because of the greatly improved extractability improved the bioavailability of phenols and flavonoids. In vivo, these chemicals improve health-promoting qualities [69,70]. In comparison to raw broccoli, traditional and microwave cooked broccoli had a considerable reduction in polyphenols [73]. blanching and blanching cooking at a temperature of 50°F to 60°F 90oC and C influence the glucosinolate concentration of broccoli [71 ,72]. Their disappearance from vegetative tissue is mostly related to contaminating the boiling water and relying on the circumstances for cooking Furthermore, glucosinolates can be Myrosinase, which is found in the plant, hydrolyzes it tissue [73], in addition to cutting and crushing, which helps Myrosinase is released, which stimulates the synthesis of myrosinase. Anti-carcinogenic isothiocyanates, for example, are active isothiocyanates. sulforaphane, hence increasing the potential of broccoli has been identified as a functional food [68 ,74 ,75].

1. Effect of cooking on glucosinolates:

The total and individual glucosinolate contents of broccoli cooked using various techniques were quantified. Glucoraphanin and glucoiberin were the most common aliphatic glucosinolates in broccoli, whereas glucobrassicin and neoglucobrassicin were the most common indole glucosinolates (Table 1). Jia et al., 2009; Schreiner et al., 2006) found that the glucosinolate profile of broccoli in our investigation was like previous publications (Jia et al., 2009; Schreiner et al., 2006). Figure 4 shows the content of total aliphatic and indole glu-cosinolates in broccoli following various cooking methods. In stir-fried, stir-fried/boiled, microwaved, and boiled broccoli, total aliphatic glucosinolates were reduced by 55 percent, 54 percent, 60 percent, and 41 percent, respectively (P0.05). Steamed broccoli, on the other hand, had essentially little change in total aliphatic glucosinolate content. Each value represents the mean of three replicate samples plus a standard deviation. At P0.05, values that do not have a common letter are significantly different.

DW stands for dry weight. Methods of preparation: Raw, boiled, steamed, microwaved, stir-fried, stir-fried/boiled all cooking procedures considerably reduced the quantity of total indole glucosinolates in broccoli (P0.05); also, the loss rate of total indole glucosinolates was significantly reduced by all cooking treatments (P0.05). The amount of indole glucosinolates in broccoli was substantially higher.

5. DISCUSSION

Five distinct cooking methods and their effects (steaming, microwaving, boiling, stir-frying, and other methods) on the contents of chlorophyll (stir-frying/boiling), total carotenoids, total soluble sugars, total lipids, Glucosinolates and soluble proteins were studied. In the current research the amount of greenness that exists because of the amount of chlorophyll in a plant is crucial in determining its health. Green vegetable quality at the end (Nisha et al., 2004). It has also been shown that chlorophyll and its derivatives have anticarcinogenic and antimutagenic properties (Turkmen et al., 2004). Green veggies have a low colour quality, according to 2006. as well as a lower chlorophyll content when compared to After being thermally processed, the raw material (Adebooye) Turkmen et al., 2006; et al., 2008). Now is the time boiling, stir-frying/boiling, and stir-frying Microwaving of broccoli resulted in a significant loss of chlorophyll. coli. Steaming, on the other hand, had no discernible effect. Significant chlorophyll depletion. By all accounts, total aliphatic glucosinolates have a higher level of glucosinolates than total aliphatic glucosinolates Microwaving was the only cooking procedure that did not yield a significant result (P0.05). Steaming had the least amount of total indole glucosinolates lost (36.8%), whereas stir-frying

and stir-frying/boiling had the most (67 percent and 64 percent, respectively). Individual glucosinolates responded similarly to total aliphatic and indole glucosinolate cooking treatments. However, as compared to other glucosinolates, goflucobrassicin loss was much larger, ranging from 42 percent to 71 percent (P<0.05). Microwaving resulted in the greatest loss of glucoraphanin (62%), while steaming had no effect.

1. Effect of cooking on isothiocyanates

Isothiocyanates according to the existence of their parents GLS, glucoraphanin, and glucoiberin, the concentration of sulforaphane (SFN) in broccolini samples and the content of iberin (IB) in kale samples were investigated in terms of ITC content. Furthermore, both ITC were chosen because they have been linked to anti-inflammatory and anticancer effects in human cell lines [76,77]. Our findings revealed a considerable fall in ITC content following cooking, with the most significant losses occurring after boiling (Figure 1). The level of SFN in raw broccolini samples was 2.4 mg 100 g F.W., however this decreased after steaming (20%), stir-frying (36%), and boiling (88%). (Figure 1a). Martinez-Hernandez et al. (2013) showed huge losses of SFN (>99 percent) in broccolini (kai lan-hybrid broccoli) after cooking, possibly due to different processing treatments and analytical methods [78]. These results are interesting because they have not been described by other authors before Jones et al. (2010) also reported SFN amounts in broccoli florets after cooking, finding that losses of this ITC ranged from 20 to 50% following steaming, microwaving, and boiling, with these contents being lower than those found in the current study after steaming and stir-frying [79]. Other researchers looked at the effect of boiling on other Brassica spp., such as Brussels sprouts [80] and broccoli heads [81] and found no SFN. This feature drew attention to broccoli as a variety that needs to be studied further in terms of the impact of processing on its composition and potential health implications [82,83] effect of cooking on sulforaphane.

The concentration of sulforaphane in freeze-dried leaves, leaf stems, stems, and florets were determined using Bertelli et al. [84] technique with minor modifications. Each 0.4 g of the freeze-dried sample in a conical tube 4 mL distilled water was added to 2 mL distilled water and extracted with 4 mL 30 minutes at ambient temperature with mL methylene chloride. Each tube was centrifuged for 10 minutes at 3,000 g. The procedure was used to collect the methylene chloride layer. Three times, the dure was repeated. The total methylene vacuum-evaporated chloride extract was filled up to 4 mL methylene chloride solution Purification of the extract Supelclean™ LC-Si SPE (Supelco Inc., Bellefonte, PA) was used.

The solid-phase extraction was carried out as follows: 3 mL methylene chloride before loading Using 3 mL of the extract as a starting point. After that, the mixture was rinsed. 3 mL ethylacetate was thrown, and the rest was used. The sulforaphane was extracted. The sulforaphane was then eluted with 3 mL of methanol after being washed with 3 mL of ethylacetate, which was discarded. The methanol layer was evaporated, and the container was filled to 3 mL with the use of methanol. The amount of sulforaphane in the extract was measured. High-pressure liquid chromatography was used to evaluate the samples. raphy (Agilent Technologies, Santa Clara, 1200 series) California, United States of America). The separation was carried out using an Xterra R. (4.6250 mm, 5 m film thickness; RP18 column) Waters of Maidstone, Kent, United Kingdom) with a solvent system of acetonitrile (A) and water (B): 015 minutes, 20% A (v/v); 15–20 minutes, 50%–20% A. The flow rate was 0.8 gallons per minute. The injection volume was 10 L, and the flow rate was 0.8 mL/min. The temperature of the column was 30o C, and the wavelength for determination. The sulforaphane was detected at 240 nm. Sulforaphane is a sulforaphane derivative. The tent was measured in g per g of freeze-dried material.

Nutritional value:

Broccoli is one of the top 20 raw vegetables consumed in the United States [88]. Broccoli is a good source of carbs, potassium, and fibre, according to USDA, 2014 (Table 1). potassium, vitamin K, vitamin C, vitamin A, vitamin E, and vitamin K folate. It's high in dietary fibre, protein, and iron. Calcium, phosphorus, magnesium, and sodium are the four elements that make up the human body. Dietary Vitamins A, C, and E are essential in a healthy diet. Because of their antioxidant and free radical scavenging properties. They are essential in human nutrition [85]. In furthermore, the avoidance of carcinogenic nitrosamine another protective process is development in the stomach. To obtain vitamin C. Broccoli is also high in phytonutrients, notably one type of phytonutrient called glucosinolates, which broccoli excels at. Isothiocyanates (ITCs) are a kind of isothiocyanate found in broccoli. The secret to broccoli's cancer-preventive properties is glucosinolates advantages [86]. Broccoli is a good choice if you have a cold. Xerophthalmia [87], xerophthalmia due to vitamin A deficiency scurvy in children caused by a vitamin C deficiency [88] and anaemia caused by a lack of folate [89]. The ion exchange was used to identify the following amino acids. glutamine, proline, and glycine chromatography in raw broccoli florets asparagine, valine, arginine, isoleucine, threonine, and leucine are some of the amino acids found in the human body. Smethylcysteine, histidine, ornithine, glutamic acid, aminobutyric acid, glycine, and serine [90]. Phenylalanine, aspartic acid, lysine, alanine, tyrosine, Smethylcysteine, histidine, ornithine, glutamic acid, aminobutyric acid, glycine, and serine [91]. This appeared to be the most important component. Except when antibiotics are administered, the bacterial microflora of the human colon likewise shows myrosinase activity. During the some intact glucosinolates in the absence of myrosinase activity are believed to be absorbed from the human gastrointestinal tract, However, the biological implications of this are unknown. Further To determine the primary absorption site, more research is required. It's not totally obvious what's going on in the upper gastrointestinal system. Glucosinolate breakdown products' bioavailability in greater depth, so that the benefit-to-consumer ratio is better balanced. The term "preference" can be defined in a variety of ways.[92]

6. CONCLUSION

Plants are a gift from nature to humanity. They are regarded as the most valuable sources of human nutrition and medicine. Nutritional understanding is rapidly expanding. Plants and therapy have revolutionised their lives. Nutritional therapy is a novel word that has gained popularity. In the last few years, it has aggressively spread. Strong endorsements for the intake of natural plant foods and the use of Nutritional therapy are becoming increasingly popular for a variety of reasons. Health improvement, prevention, and treatment of a variety of diseases ailments, Broccoli is a popular vegetable in many nations. It is clear from this review that several studies have used various procedures were used, and the results were positive.

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