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Research Article

Sneak Peek into Chemopreventive Potential of *Brassica oleracea*: Milestones Achieved So Far

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ABSTRACT

Brassica oleracea i.e broccoli belonging to family Brassicaceae has a large number of components which can serve in various ailments. This cruciferous vegetable is rich in vitamins, minerals as well as some isothiocyanates which contribute to its therapeutic advantages. The compounds present in broccoli can serve as potential therapeutic agents at a very low dose but the only problem is to protect them from degradation. Various analytical methods to analyze these compouds of broccoli have been developed and published such as UV, HPLC, TLC, LC-MS, and GC-MS etc. Also, the activity of broccoli as a potential treatment for various cancers such as adenocarcinoma, breast cancer, skin cancer etc. have been reported. Some such researches related to this compound such as those mentioned above and others such as biovailability studies, IC50 value determination and antioxidant activity studies etc. have been highlighted in this article so as to give a brief description of the great potential of broccoli and provide valuable source of information about the research milestones achieved so far in the jouney of exploring this vegetable.

Keywords: Broccoli, Sulforaphane, Cruciferous, Anticancer, Analytical methods

INTRODUCTION

Broccoli is a type of cruciferous vegetable belongs to family Brassicaceae. Its scientific name is *Brassica oleracea* L. var. botrytis. Its common name includes: Calabrese, Chou broccoli, Common broccoli, Cruciferous vegetable, Indole-3-carbinol (13c) and di-indolylmethane (DIM). It is derived from a species of wild cabbage with extensive cultivation and selection. Common broccoli has a dense, central flowering head on a thick stem with head surrounded by petiolate leaves. Different varieties of broccoli like green and purple exist. It is a type of cool weather crop. Raw type of green broccoli is a main source of various types of vitamins and minerals like potassium, calcium, magnesium, iron, zinc, selenium and as well as carotene, thiamine, riboflavin, niacin, folate and vitamins C & K. Broccoli has many medical uses. It has a main role in the prevention and treatment of various cancers. Figure1 summarizes the nutrient values of broccoli.

Mechanism of action includes: the induction of phase 1, 2, and 3 enzyme,transporter systems,phase 2 detoxification ,inhibition of histone deacetylation,cell cycle arrest,apoptosis and inhibition of cell growth. Broccoli and its components sulforaphane and various glucosinolates are used in animal studies for various experiments in mice and rats which are induced with prostate, skin, small intestine and mammary cancer[1,2,3,4].

Pilar soengas et al proposed that many types of Brassica vegetables for example Cabbage, turnip, Cauliflower, Broccoli, Brussels sprouts and kale have antioxidants properties. Many people all around the world consumed them. These brassica vegetables when taken in the high amount they help in reducing the age related chronic illness like many of the cardiovascular diseases and also reduce the many types of cancers. These crops have phenolic compounds, vitamins, and carotenoids which have the antioxidant properties. Many types of climatic conditions and as well as agronomic practices also effects the phytochemical content of the plant. Also, brassica vegetables contains many types of the bioactive substances which helps in reducing the oxidative stress, cancers and as well as the physiological stress[5].

People usually bend towards the drugs and nutraceuticals but they never realize that most of the drugs and minerals are derived from plants. *D.A. Moreno et al* reviewed that cruciferous and brassica plants and vegetables are rich in anticancer compounds specially broccoli which is a source of glucosinolates and as well as high amount of vitamins, minerals and flavonoids. Broccoli is also a type of vegetable which is used for skin diseases. The juice of broccoli leaves is used to treat skin warts. There are various types of processing conditions, cooking, transport etc. affects the various types of health benefit properties of broccoli. This study was based mainly on the characterization of chemical and biological properties of the phytochemicals of broccoli and its various effects of the bioactive composition of broccoli.

Main elements which were studied in this experiment are: Importance of Brassicaceae family on human health specially broccoli, Phytochemical health-benefits compounds in broccoli and their analysis, Influence of

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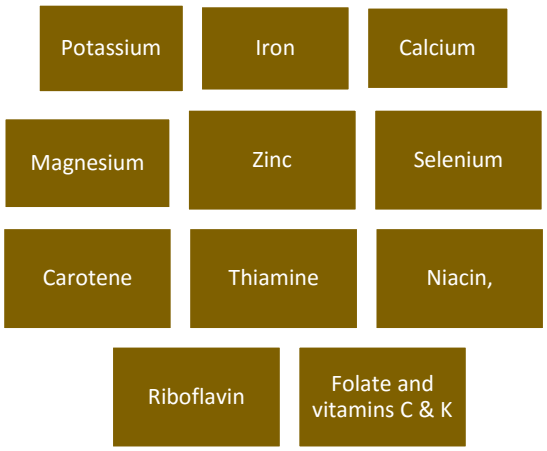

Figure 1: nutritional value of broccoli

processing on the phytochemical composition of broccoli and Bioavailability of broccoli and its phytochemical compounds[6].

An overview of Research Work

Sources for obtaining Sulforaphane

Mohamed A. Farag et al studied the percentage and content of sulforaphane in various types of crucifer vegetables. Sulforaphane content was estimated in: Broccoli, Brussels sprout, green cabbage, red cabbage, Chinese kale, Turnip. Also the anticancer and as well as antioxidant activities have also been estimated in this parallely.

Out of all the cruciferous plant extracts cabbage have shown the profound results. Cabbage have shown the great anticancer effect against the cancer cells of lung and also with the high and pronounced levels of sulforaphane. Crucifer extracts except leaving red cabbage and kale showed the weakest activity[8]. Figure 2 gives various sources of sulforaphane.

Selenium content of Broccoli

Broccoli which belongs to family cruciferae is a selenium accumulator**.** *Finely* et al demonstrated that when broccoli is grown in soil laden with sodium selenate, dry weight of plant tissue was accumulated[11]. Large amount of selenium is present in broccoli as methyl selenocysteine. But selenium from broccoli does not accumulate in man or animals like rats[12,13].

Extraction method

Dandan Han et al demonstrated in their article the process of extraction and purification of sulforaphane from broccoli by the method of Solid Phase Extraction. Various components and conditions were used for this method like silica SPE cartridge, organic solvents like dichloromethane and ethyl acetate as washing and as well as eluting solvents which greatly helps in eliminating the various types of interferences that may originates from the matrix of broccoli. Before injecting the extract in high performance liquid chromatography it should be sufficiently cleaned and purified. The solid phase extraction method provides a higher amount of yield of compound sulforaphane from the crude extracts as compare to any other method[28].

Stela Jokic et al demonstrated in their article about the optimization of microwave assisted extract of broccoli for phenolic compounds and as well as its antioxidant activity. For the optimization response surface method was applied and also high correlation mathematical model was applied for optimization. In this it was analysed total amount of phenolic compounds,flavonoids and as well as antioxidant properties[29].

Qualitative and Quantitative estimation of Sulforaphane

O. N. Campas-Baypoli et al demonstrated the determination of sulforaphane in various products or by products of broccoli. Various types of methods can be used to estimate or test the presence and determination of sulforaphane in broccoli products or by products. In this study conversion of a compound called glucoraphanin into sulforaphane was optimized which is further followed by the purification of various extracts of byproducts of broccoli. In this purification and extraction was done by using solid phase extraction, HPLC and also response surface methodology was done so that optimum conditions for purification could be found. Both fresh florets and as well as the lyophilized florets of broccoli were estimated. Detection for wavelength was done at UV 202 nm. Amount of sulforaphane found in fresh of lyophilized florets, leaves and stalks was different. The amount of sulforaphane in fresh florets was found to be high as compare to stalks and leaves and as well as amount of sulforaphane in lyophilized florets was present in high amount as compare to leaves and as well as stalks.

In this study, amount of sulforaphane was also estimated in freshly harvested broccoli compared to frozen or refrigerated broccoli and as a result there was loss of sulforaphane content in the refrigerated or frozen broccoli[9].

Zhansheng Li *et al* studied the various varieties of cabbage and broccoli for the estimation and verification of the anticancer agent Sulforaphane. Brassica olerecea L.var.capitata was taken as variety of cabbage and *Brassica oleracea* L. var. *italica* Planch was taken as variety of broccoli. A type of simple method was chosen to extract the sulforaphane from cabbage and broccoli. It was found that two different types of inbred lines of broccoli that too with high content of sulforaphane were found in their seeds. Determination was done by reverse phase high performance liquid chromatography. For the extraction of sulforaphane ethyl acetate was used as it is a low toxic solvent. In this study hydrolysis, the ratio of buffer to material and reaction time was analyzed. In this experiment around twelve cultivars of broccoli and eighteen cultivars of cabbage were used and sulforaphane extraction method was analyzed and verified. As a result it was proved that all the material consists of sulforaphane in it and out of all only two cultivars of broccoli were proved to have high percentage of sulforaphane in it[15].

Ana M *et al* demonstrated in their study about the extraction,determination and optimized formation of one of the essential compound of broccoli named sulforaphane by the process of liquid chromatography with the help of diode array detection. The sulforaphane was determined and optimized from various parts of broccoli like florets of broccoli,leaves and as well as stem. Sulforaphane is extracted and optimized by the hydrolysis reaction in

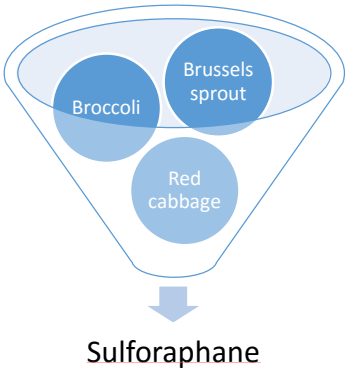

Figure 2: Sources of Sulforaphane.

which glucoraphanin gets breakdown into sulforaphane which is extracted by the solvent extraction method using methyl t-butyl ether. To make separation fast it was done on an analytical column C18 using mobile phase which is formed using acetonitrile and ammonium formate in water in an isocratic elution mode. After the method has been proposed it was applied on two different cultivators of broccoli for the analysis of sulforaphane[19].

Hao Liang et al demonstrated in their activity the method of purification and as well as the separation of sulforaphane from the seeds of broccoli by the process of solid phase extraction and also preparative high performance liquid chromatography. In this article a novel and as well as economical approach is taken to purify and isolate the natural isothiocyanate sulforaphane from the seeds of broccoli is described. In this a procedure was followed which involved the extraction of solvent of sead meal which was autolyzed which was followed by separation which was done by solid phase extraction. The extract was purified by preparative HPLC. The solid phase extraction method was chosen in comparision to other conventional liquid liquid extraction because it provides a much higher amount of yield of sulforaphane. Highest amount of purity and as well as recovery of sulforaphane was obtained by method preparative HPLC by using c18 column and 30% methanol along with water which was used as mobile phase. After the separation and purification of the extract the compound was characterized using Mass Spectroscopy and also H1 and C13 NMR[25].

Hae Won Jnag et al demonstrated in their study the method of analysis and antioxidant activities of broccoli sprouts extracts. For the analysis the samples were prepared from fresh sprouts of broccoli from variety brassica oleracea L. by the process of water distillation or either by freeze drying process for the examination of antioxidant activity by using three assays. A dose dependent antioxidant activity was exhibited by all the samples. When the 500 µg/mL sample was taken the antioxidant activity ranged differently in less volatile sample and dichloromethane extract sample. Both the samples extracted from dichloromethane whether from water distillate of sprouts of broccoli or freeze dried sprouts of broccoli, both showed the potent antioxidant activity.

From this study it was demonstrated that sprouts of broccoli is a very good source of natural oxidants[26].

As Breast Cancer Treatment

Nowadays, breast cancer is a big problem which is caused by the growth of cancerous stem cells. *Yanyan li et al* evaluated that a compound called Sulforaphane which has been derived from broccoli or either broccoli sprouts can be used to kill the harmful breast cancer stem cells and to inhibit its harmful strong mechanism. Various types of assays were used to evaluate the mechanism of sulforaphane in vitro and as well as in vivo. For in vitro mammosphere formation and aldeflour assay were done so that effect of sulforaphane can be evaluated on breast cancer stem cells and as well as for in vivo one or severe combined types of immunodeficient xenograft model was used so that effect of sulforaphane can be checked whether it targets the cancer stem cells or not. Mainly the potential mechanism of the sulforaphane was analyzed by Western blotting and β-catenin assay. Sulforaphane helped in eliminating the breast cancer stem cells and also helped in down regulating the analysis assay used in its estimation i.e. western blotting and beta catenin[7].

Sulfur rich foods are known for having a good percentage of anticancer activity. Sulfur compounds helps in reducing the risk of development of cancer. Broccoli or broccoli sprouts belongs to family, F.cruciferae consists of a sulfur compound known as sulforaphane which has the anticancer properties. It is a cancer chemopreventive type of compound.

As Treatment for Adenocarcinoma

Nowadays in western countries an adenocarcinoma named of Barrett esophageal adenocarcinoma is growing higher day by day at a very high rate. *Aamer qazi et al* studied the various effects of sulforaphane as an anticancer agent. He estimated the therapeutic effect and potential of sulforaphane as an anticancer agent and as an antioxidant in Barrett esophageal adenocarcinoma conditions. For this the sulforaphane was used to treat the Barrett esophageal adenocarcinoma cells along with the chemotherapeutic agent paclitaxel or either telomerase inhibiting agents. In this study at various time points live cell number is determined. Various types of effects were estimated by various methods in this study:effect on drug resistance or chemo sensitivity : rhodamine efflux assay, apoptosis : annexin v labeling & western blot analysis, effects of gene in cell cycle : western blot analyses,In vivo: Barrett esophageal adenocarcinoma cells were injected in mice by s.c route and treated with sulforaphane.

In this various types of studies it was evaluated that sulforaphane helped in inducing the time and as well as dose dependent decline in: cell cycle arrest, apoptosis,cell survival, increases the antitumor or anticancer activity, reduces the efflux of drug, increases the therapeutic and anticancer activity of paclitaxel and suppression of expression of multidrug resistance protein.

Hence this study concluded that sulforaphane which is derived from broccoli has a great effect and potential to kill the Barrett esophageal adenocarcinoma cells[10].

Role in Gold nanoparticle Synthesis

Prakash Piruthiviraj et al demonstrated the effect of broccoli i.e. Brassica oleracea as an antimicrobial agent

against various human pathogenic bacteria and fungi. Gold nanoparticles were synthesized using green technology for this study so that antimicrobial agents can be produced. For this study extract of flower bud is used. It is used as a reducing agent for an acid named chloroauric acid. Synthesis of the gold nanoparticles was observed after the incubation of 30 mins by change in the color of extract from pale yellow to purple. Gold nanoparticles were characterized by: UV–visible spectral analysis, FTIR spectroscopy analysis, SEM and EDX analysis and XRD.
Also antimicrobial activities were shown and analyzed by: Subjecting the particles to human pathogenic bacteria: Gram-positive;Staphylococcus aureus ;Gram-negative Klebsiella and Pneumonia;Fungi : Aspergillus flavus;Aspergillus niger; Candida albicans)
This is done by using disc diffusion method. Gold nanoparticles of broccoli showed the great and efficient results for antibacterial and antifungal activity. Also in some cases when the concentrations of gold nanoparticles was increased the zone of sensitivity also increased.
It was concluded that the broccoli gold nanoparticles have great potential and are really capable against the antimicrobial activity in humans. Also they help in minimizing the duration of treatment and as well as reducing the side effects and adverse reactions of drugs[14].
Menka Khoobchandani et al reviewed in their article about the formulation of broccoli phytochemicals encapsulated gold nanoparticles and also their applications in the field of nanomedicine. When phytochemical cocktail of broccoli interacts with salt of gold it results in the surface capping and as well as dual reduction so as to produce the stable, well defined and as well as biocompatible broccoli gold nanoparticles. In this study the broccoli phytochemical encapsulated gold nanoparticles were fully characterized. In this study the nanoparticles were characterized using in vitro stability testing which was done in various biological fluids for testing affinity and as well as selectivity of tumor cells. And as a result it was found that gold nanoparticles of broccoli phytochemicals shown effective results against various types of cancer cells like MDA-MB-231, SkBr3, PC-3 etc. when broccoli phytochemicals cocktail was surface encapsulated on gold nanoparticles it leads to the facilitation of cellular internalization which leads to validation of various in vitro therapeutic effects of these type of the nanoparticles. Presence of various types of biologically active phytochemicals like allyl isothiocyanates, 2-phenylethyl isothiocyanates,sulforaphane,vitamin C,folic acid,glucoraphanin,phenethyl glucosinolates and quercetin was confirmed by the detailed analyses done using gas chromatography–mass spectrometryalong with the combination with liquid chromatography–tandem mass spectrometry[27].

Antioxidant Potential of Broccoli

Yvette Porter et al determine the amount of antioxidant properties of various vegetables under different cooking conditions. Amount of antioxidant differs in various conditions of cooking. Various types of food and diet which consists of fruits and vegetables in it associated with the less and reduced risk of various types of chronic diseases. This study mainly explored the antioxidant in food in various cooking conditions. In this experiment green broccoli and purple sprouting broccoli were taken and effect of microwaving and boiling were done on it. Broccoli extracts were taken and antioxidant properties of extracts were tested. Activity of antioxidants of broccoli extracts were analyzed by using: Antioxidant activity,Vitamin C estimation,Total phenols determination (Folin–Ciocalteu Reagent), Flavonoid determination (colorometric method), Anthocyanins determination(pH differential method). It was concluded that antioxidant properties of cooked and uncooked broccoli are different from each other. After microwaving the broccoli the content was retained or enhanced as compare to after boiling as boiling cause leaching of antioxidants which increases with time. Also amount of antioxidants found to be higher in purple sprouting broccoli as compare to green

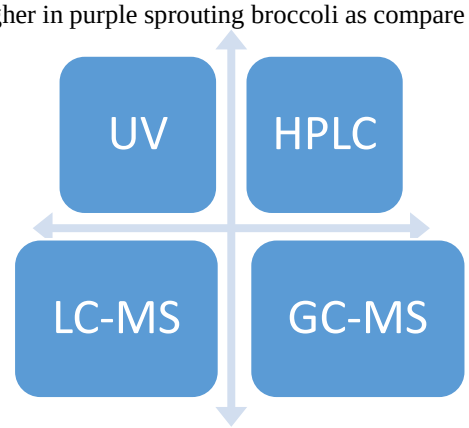

Figure 3: Methods of Qualitative and Quantitative Estimation of Sulforaphane

broccoli. The main aim of this study was to show that cooking cause a high amount of alterations in the food like damage, changing antioxidant properties and
transformation of components of food. Therefore it is important for considering all the dietary indications and precautions while having any type of diet[16]. In today's world people are recommended to have proper diet, diet full of healthy vegetables and fruits for the prevention of diseases like cancer.

Synergistic Anticancer Activity of Broccoli with Tomato

Kirstie canine- Adams et al reviewed the enhancement of antitumor activity in dunning R3327-H prostate cancer by using the combination of tomato and broccoli. Different combinations of tomato and broccoli were taken and is tested subcutaneously in male Copenhagen rats. The effect of diet to finasteride and as well as surgical castration were compared. In both the cases effects on prostate and as well as on tumor weights was different. In case of finasteride there is decrease in prostate weight but had no change in tumor weight or its area and in case of castration there is reduction in prostate weights, tumor areas and tumor weight.
It was studied that broccoli and tomato alone was not that more effective alone as compare to the combination of both. And as compare to broccoli and tomato, broccoli decrease more tumor weight and tomato less as compare to broccoli. For this study various analysis were done:

Dunning R3327-H prostate tumor implantations,Androgen ablation and serum androgen analysis, Tissue histology and immunohistochemistry,Lycopene quantification. Lycopene extractions were done using, Glucosinolate analysis and Pcna staining[17].

As the age increases it leads to high oxidative stress and also leads to increase in high inflammatory response to infection. Broccoli consists of sulforaphane which is converted by glucoraphanin by plant myrosinase. Antioxidant enzymes like NADPH quinone oxidoreductase and heme oxygenase I increased by sulforaphane and it helps is inhibiting inflammatory cytokines.

As an Agent for Reducing Age Related Oxidative Stress

Brigitte E. Townsend et al demonstrated the use of broccoli to evaluate its effect on neuroinflamation and lipopolysaccharide induced sickness behavior in aged mice. For this study young, adult and aged mice were given broccoli diet for around 28 days that to before giving them an intraperitoneal LPS injection.Various methods were done in this study like: immune challenge, behavioral testing,tissue collection and analysis and statistical analysis . From this study it was concluded that: Lipopolysaccharide increased glial markers, whereas broccoli diet reduced GFAP and increased CX3CR1 mRNA in aged mice, Broccoli diet did not attenuate LPS-induced reduction in social interactions, Age and LPS increased proinflammatory IL-1β mRNA in liver and brain,Cytochrome b-245 β was elevated in liver of aged mice. As a result it was found that the 10% broccoli helps in modest reduction of age related oxidative stress and glial reactivity, but it was not effective in inhibiting LPS-induced inflammation[18].

Bioavailability of sulforaphane

As we all know dose selection and schedule of the dose is one of the major challenges which are faced during the clinical chemoprevention trial design. So for the above study a cross over type of clinical trial was done so as to compare two major factors named bioavailability and second is tolerability of compound sulforaphane in two different types of beverages of broccoli sprouts.

Patricia A. Egner *et al* demonstrated in their review about the bioavailability of the compound named sulforaphane in two different beverages of broccoli sprout. One beverage was rich in Glucoraphanin and the other one was rich in Sulforaphane. For this clinical trial around fifty healthy people are taken and were requested to take crucifer diet. For the measurement of level of glucoraphanin, sulforaphane thiol and sulforaphane in the urine samples, isotope mass spectrometry was used. When bioavailability of sulforaphane and as well as its metabolites was measured in the urine excretion it was found that bioavailability of sulforaphane rich beverage is high that glucoraphanin rich beverage but on the other hand the interindividual variable excretion of sulforaphane rich beverage is lower than glucoraphanin rich beverage[20]. Sulforaphane is one of the most useful and effective isothiocyanate present in broccoli. It has chemopreventive properties in it.

Natalaya *et al* demonstrated in their study about the determination of bioavailability and also the dose dependent type of pharmacokinetic behavior of the compound sulforaphane. these factors were analysed using rat plasma. LC-MS or MS was used to determine the sulforaphane in a very small volume of plasma of rat. It was properly validated so as to determine the absolute bioavailability and as well as the pharmacokinetic characters of sulforaphane. Sulforaphane was given to rats either intraveneously or by orally. The plasma concentration of sulforaphane was determined and analysed in the bleed of rat taken from rat tail at the regular intervals. Sulforaphane plasma profile in this study was determined by two compartment modeling. Sulforaphane showed a rapid absorption and a good absolute bioavailability but it was decreased when the doses are increased which showed that sulforaphane shows dose dependent type of pharmacokinetic behaviour. Also at the high doses the factors like biological half-life, volume of distribution and rate of absorption also decreases significantly. From the above study it was concluded that when sulforaphane was administered orally to rats it was rapidly absorbed which leads to high amount of absolute bioavailabilty and also it was shown that the bioavailability decreases with increase dose[21].

As treatment for various cancer and determination of IC50 value

As we all know that broccoli and broccoli sprouts contains various types of chemopreventive isothiocyanates which helps in inducing carcinogen detoxifying enzymes and as well as helps in inhibiting the development and growth of skin amd mammary tumors in the rodents. The main isothiocyanate which is the principal component of broccoli and its extracts not only helps in inducing carcinogen detoxifying enzymes but also helps in the activation of apoptosis and as well as blocking the progression of cell cycle. Li Tang *et al* demonstrated in their article about the effectiveness of broccoli aqueous extract that potentially helps in inhibiting the development and growth of carcinoma cells of human bladder in culture and the inhibition is due to the isothiocyanates components. In broccoli sprouts isothiocyanates are present as glucosinolates precursors. It helps in blocking and abolishing the antiproliferative activity of broccoli extract. It was found that the activity of synthetic sulforaphane and as well as isothiocyanates in the extract was almost same and identical which was tested by the IC50 value. It was also shown that broccoli sprout extract of isothiocyanate helps in activating the apoptosis pathwayand as well as halted cells present in S and M phases which was mediated by mitochondria. The arrest of cell cycle was due to Cdc25C downregulation and also the disruption of mitotic spindles. This study showed that broccoli sprouts is a highly promising and effective substance for prevention of cancer as well as treatment[22].

Sulforaphane which is chemically an isothiocyanate, [1-isothiocyanato-4-(methyl-sulfinyl) butane)] present in cruciferous plants and vegetables which has tremendous amount of chemopreventive activity. *Yanyan Li et al* analysed in their study about the effects of sulforaphane as

how it helps in the proliferation of cancer cells of pancreas. It helps in the inhibition of growth and development of cancer cells of pancreas in vitro along with IC50 which was around 10-15 μM and helps in inducing apoptosis. Sulforaphane administration in xenograft mouse model of pancreatic cancer showed the tremendous and as well as remarkable effect in inhibiting the growth of tumor. It was found that sulforaphane greatly helps in inducing the degradation of Hsp90 i.e heat shock protein 90 and also helps in blocking the Hsp90 interaction with its cochaperone p50Cdc37 in cancer cells of pancreas. With the help of nuclear magnetic resonance spectroscopy (NMR) along with the isoleucine-specific labeling strategy the protein size limit of the conventional NMR was found and also interaction of sulforaphane along with full length hsp90 was studied. This study mainly helps in suggesting the sulforaphane mechanism that helps in disrupting protein protein interaction in complex Hsp90 so as to study its chemopreventive activity[23].

Other chemical constituents

Donglin Zhang et al demonstrated in their study about the activity of different important components present in broccoli and also their changes during normal conventional cooking and as well as the microwave cooking. In this, effects of antioxidant components like ascorbic acid, phenolics and carotenoids present in florets and stem of broccoli and also the antioxidant activity and also their changes during microwave cooking and as well as the normal conventional cooking is studied and investigated. In this study the florets and stems of broccoli were cooked by both methods conventionally and as well as by microwave upto 300s. After the study it was found that the level of phenolic components, ascorbic acid and carotenoids were retained more in microwaved broccoli florets and stems as compared to cooked broccoli florets and stems. Antioxidant activity and as well as components were lost more during cooking[24].

CONCLUSION

Thus we can conclude that broccoli offers a wide arena of benefits. Broccoli is a reserve of vitamins and minerals such as calcium, magnesium, iron, zinc, selenium, carotene, thiamine, riboflavin, niacin, folate, vitamin C and K etc. Sulforaphane has been found to inhibit cell growth in cancer. It can be obtained from various sources but yield varies according to source and conditions of extraction. The qualitative and quantitative estimation is an important aspect as the compounds from broccoli are enormous and need to be characterized for making formulations. The use of sulforaphane as treatment for skin cancer, adenocarcinoma etc. is remarkable. It is also used in the synthesis of gold nanoparticles and shows great antioxidant properties. Broccoli has also been found to be synergistic in anticancer activity with tomato. Bioavailability studies depict that bioavailability significantly decreases after cooking broccoli. IC50 value of sulforapahne was found to be reported as 10-15 μM by the studies. Thus, overall anticancer activity has been proven to be beneficial yet some effective formulations need to be developed to be able to make this gift of nature more accessible and acceptable.

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