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REVIEW ARTICLE

ANTICANCER EFFICACY OF SOME SELECTED VEGETABLES

Vikas Sharma[1]*, Harminder Kour[2], Komal Sudan[3], Nancy Vohra[4] and Shivangi Sharma[5]

[1,2,3,4] Division of Biochemistry, Faculty of Basic Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha -180 009, Jammu, J&K, India
[5]Department of Chemistry, Govt. Degree College, RS Pura -181102, Jammu, Jammu & Kashmir, India
Email: vikas.skuast@gmail.com

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Abstract: The global cancer epidemic is rising continuously, placing further strains on the individuals, the families and the societies (in which they live). The number of cancer cases and related deaths worldwide, estimated to double over the next 20-40 years. Research over the past several decades suggests that a high intake of vegetables decreases the risk of several cancers both in experimental animals and in humans. Epidemiological studies point to the fact that long-term consumption of diet rich in vegetables reduces the risk of chronic diseases especially cancer (Temple and Gladwin, 2003). Chemoprevention, by the use of natural products, that can reverse / suppress or prevent carcinogenic progression, has become an appealing strategy to combat the dogma associated with increasing cases of cancers worldwide. Such diets can minimize exposure to deleterious substances, activation of procarcinogens and can maximize the intake of certain beneficial nutrients like isothiocyanates, unsaturated fatty acids, polyphenolic terpenoids (PPT), selenium, terpenes, *etc.* Current evidence suggests that garlic, green tea, tomatoes and soy intake as part of the diet may be useful in preventing various cancers. A number of exciting researches suggest that vegetables, fruits, whole grains, herbs, nuts and seeds contain an abundance of polyphenolic compounds, terpenoids, sulphur compounds, pigments and other natural antioxidants, that have been associated with protection from or treatment of conditions such as cancer. Therefore, we can say that natural products have been a prime source of highly effective conventional drugs for the treatment of many forms of cancer and regular consumption of vegetables is associated with reduced risk of cancers and additive/ synergistic effects of phytochemicals in these vegetables are responsible for their potent antioxidant / anticancer activities.

Keywords: Vegetables, Anticancer, Antioxidant, Polyphenols, Terpenoids

INTRODUCTION

There is strong, consistent evidence that high intake of vegetables protect against various cancers. These protective effects of high vegetable consumption are attributed to the active micronutrients (vitamins and minerals) and non-nutritive components (phytochemicals) that exhibit a potential for modulating human metabolism in a manner favorable for the prevention of cancer. In other words, we can say that vegetables consumed in our daily diet could be a solution to this deadly disease by providing chemoprotective and chemotherapeutic remedy. Therefore, efforts are still being made for the search of effective naturally occurring anticarcinogens that would prevent, slow or reverse cancer development. A comprehensive review was conducted to assess the safety and efficacy of some vegetables in an attempt to prevent various diseases including cancer. A seminal description of vegetables that have been selected is given in the following pages. The information within braces is in order as: Family, English name, Hindi name. This system has been followed throughout while describing the particular vegetable.

***Abelmoschus esculentus* [Malvaceae, Okra / Lady's Finger, Bhindi]**

Okra is one of the popular nutritious vegetables of North-East African origin. It is valued for its edible green seed pods. Raw okra is 90% water, 2% protein, 7% carbohydrates and negligible in fat in a 100 gm amount and is rich in dietary fibre, vitamin A, vitamin C, vitamin K with moderate contents of thiamin, folate and magnesium. The genus *Abelmoschus* has been reported to be used for several ethno medicinal practices and have also demonstrated diverse pharmacological activities and possesses several phytochemical and nutritional properties as well as having no adverse effects on living cells. Pods / seeds and leaves of the plant are reported to be used as food in pharmaceutical industries and as traditional remedy all over the world (Liu, 2004). In a study conducted on the action of pectic rhamnogalacturonan (RG-1) obtained by hot buffer extraction of okra pods, results showed that okra RG-1 induces apoptosis in melanoma cells

*Corresponding Author

by interacting with galectin-3, thereby preventing cancer cell proliferation (Sengkhamparn *et al*., 2009). The pectin inhibited the proliferation of highly metastatic mouse melanoma cells (B16 F10) by 75% after 48 hours of treatment and also increased the rate of programmed cell death (apoptosis) by nearly 23-fold (Vayssade *et al*., 2010). A newly discovered component – lectin, obtained from water extraction from bhindi seed was studied for its anti-tumor effects against human breast cancer and skin fibroblast cells. The results showed that it induced significant cell growth inhibition (63%) in MCF-7 cells. The expression of pro-apoptotic caspase-3, caspase-9 and p21 genes was increased in MCF-7 cells treated with okra seed extract, compared to those treated with controls. In this study flow cytometry also indicated that cell death (72%) predominantly occurred through apoptosis. Thus, bhindi in its native form promotes selective antitumor effects in human breast cancer cells and may represent a potential therapeutic to combat human breast cancer (Monte *et al*., 2014). In an elaborate study based on the green synthesis of gold nanoparticles (Au NPs) and silver nanoparticles (Ag NPs) using pulp extract of *A. esculentus,* it has been demonstrated that pulp synthesized Au NPs (*via* green route) showed *in vitro* efficacy against Jurkat cells. Results of the study clearly showed that the IC_{50} dose of Au NPs and Ag NPs is capable of significantly elevating intracellular reactive oxygen species and diminishing mitochondrial membrane potential, indicating the effective involvement of apoptosis in cell death (Mollick *et al*., 2014).

***Brassica rapa* [Brassicaceae, Turnip, Shalgam]**

The turnip is a highly nutritious / starchy, root vegetable. It is one of the world's ancient vegetables having been cultivated for more than 4,000 years. The turnip's root is high in vitamin C (a natural antioxidant) and the turnip leaves sometimes eaten as "turnip greens" are a good source of vitamin A, folate, vitamin C, vitamin K and calcium. Turnip greens are also high in lutein (8.5 mg / 100 g). The vegetable is also a good source of carbohydrates, fibre, calcium, phosphorous, potassium and magnesium. This vegetable is strongly associated with a lower risk of developing numerous cancers due to the presence of phytochemicals which exhibit strong antioxidant activity (Amri, 2014). β-Phenylethylisothiocyanate is abundant in the peel, showed the highest content in turnip and inhibited the growth of human-derived hepatoma cell line ($HepG_2$) in a concentration-dependent manner (IC_{50} value of 24.5 μM), assessed by the MTT method (Hong and Kim, 2008). In another research, cellular viability of shalgam-treated cells compared to untreated controls was observed to vary in a dose-dependent manner, decreasing to 97.7 % at the lowest (50 μg/mL) and to 59.3 % at the highest concentration (6400 μg/mL) of shalgam extract. Viability of Caco-2 cells in the presence of black carrot extract under same conditions and respective concentrations was 96.7 and 62.1%. Shalgam juice revealed higher inhibition on Caco-2 cells compared to untreated control group at the concentrations 3200 and 6400 μg/mL ($p < 0.05$). In a previous study, anthocyanins associated with black carrot juice (2000 μg/mL) were shown to display antiproliferative effect on HT-29 colorectal carcinoma cells (Netzel *et al*., 2007) suggesting that the potential antiproliferative activity of shalgam juice might be associated with its black carrot-associated anthocyanins. Nevertheless, in this study, shalgam juice exhibited statistically higher antiproliferative activities than black carrot juice at 3200 μg/mL ($p = 0.029$) (Ekinci *et al*., 2016). Anticancer activity of turnip was also examined in the human lung (A-549) cancer cell line (ATCC#CCL-185) and it produced a considerable anticancer effect and moderate antioxidant effects (Saeed *et al*., 2012; Farag and Motaal, 2010). The cytotoxic effect of aqueous extract of *B. rapa* roots was also studied in three types of cancer cell lines-Hep-2, AMN-3 and HeLa *in vitro*. The results showed that the cytotoxic effect of the extract dependent on type of cells, amount of dose and exposure time. The concentration 1250 μg/ml gave higher growth inhibition (63 and 42%) against ANM-3 and Hep-2 respectively. The inhibition rate of 10000 μg/ml crude roots extract against HeLa cells was 64% after 24 hours exposure (Barkat *et al*., 2010). An antifungal peptide (9.4-kDa) designated as campesin was isolated from seeds of the plant. It inhibited proliferation of $HepG_2$ and MCF-7 cancer cells with an IC_{50} of 6.4 μM and 1.8 μM respectively (Linn *et al*., 2009).

***Capsicum annuum* [Solanaceae, Capsicum or Sweet/Colored Pepper, Shimla Mirch]**

Capsicum annuum is generally considered in culinary context to be vegetable and has both nutritional and nutraceutical importance (Govindarajan, 1986). Capsicum is rich source of vitamin C, E and bioactive compounds particularly polyphenols, β-carotene and zeaxanthin (Daood *et al.,* 1996; Hervert *et al.,* 2010). Capsicum is the only genus having the potential to produce capsaicinoids, with capsaicin and dihydrocapsaicin accounting for up to 90% of the total pungency of pepper fruits (Backonja *et al.,* 2010). Capsicum is widely used in traditional medicine and capsaicin was shown to be a potent angio inhibitory compound *in vitro* and *in vivo.* Capsaicin was also found to repress the growth of various immortalized or malignant cell lines through the induction of apoptosis and the inhibition of angiogenesis (Jung *et al*., 2001; Kim *et al*., 2004; Min *et al*., 2004). Capsaicin is the major constituent that accounts for the pharmaceutical properties of pepper. It has analgesic effects and is used against arthritis pain and inflammation (Lara *et al.,* 2008). It also showed anticancer activity, protective effects against high cholesterol levels, obesity and activity against neurogenic inflammation (Moore and Moore

2003; Palenius and Ochoa-Alejo, 2005). The studies showed growth inhibition of human breast cell lines *in vitro* using different pepper extracts by slowing down the cell cycle progression through phase G1-S (Molnar *et al*., 2004; Dou *et al*., 2011). Researchers correlated significant growth arrest and apoptosis with the capsaicin content and its accepted mechanism of anticancer activity through the generation of reactive oxygen species (ROS) especially hydroxyl radicals (Yang *et al*., 2009). Capsaicin and dihydrocapsaicin are the most abundant capsaicinoids in pepper fruits (Bernal and RosBarcelo, 1996; Walpole *et al*., 1996). Diverse studies have shown that capsaicin has antiproliferative effect on several human cell lines derived from multiple myeloma (Bhutani *et al*., 2007), gastric cancer (Kim *et al.*, 1997), pancreatic cancer (Zhang *et al*., 2008), breast cancer (Chou *et al*., 2009) and prostate cancer (Mori *et al*., 2006). Capsaicin also produces reactive oxygen species in cells with resultant induction of apoptosis and cell cycle arrest, which is beneficial for cancer chemoprevention with inhibitory effects on cancer development in multiple organs such as stomach, lung and liver (Kundu and Surh, 2009). Furthermore, capsaicin had strong apoptotic activity in B16-F10 cells *via* the down-regulation of Bcl-2 (Jung *et al*., 2007). These results suggest that capsaicin could have an effective role in the management of melanoma cancer patients (Shin *et al.*, 2008).

***Chenopodium album* [Amaranthaceae, Bathua, Bathu]**

Chenopodium album is a herbaceous vegetable plant usually cultivated as pot-herb or grown in gardens. Besides alkaloids (trigonelline and chenopodine), the plant contains essential oils, potassium & vitamin C (Sikarwar *et al*., 2013). *C. album* is an important medicinal plant with diverse pharmacological spectrum and possesses various activities like anticancer, hepatoprotective, antioxidant, antibacterial and anti-inflammatory (Shaneza *et al*., 2016). The cytotoxic and antioxidant properties of lipophilic compounds extracted from different parts of four *Chenopodium species* (*C. album, C. hybridum, C. rubrum* and *C. urbicum*) were evaluated. Large amounts of free polyphenols were observed in herb extracts of *C. album* (3.36 mg/g). The cytotoxic activities of the extracts were assessed against human lung carcinoma (A-549), ovarian carcinoma (TOV-112D) and normal human fibroblast cell lines. This study demonstrated that the extracts from herb and seeds of *C. album* showed the significant antiproliferative effect on the TOV-112D cell line. Toxicity of the extract of *C. album* to skin fibroblasts was also high. The mortality of cells after 72 h amounted to 95% in *C. album* and in seeds (0.2 mg/cm^3) lower cytotoxic activity toward cells of metastatic ovarian carcinoma (55%) was observed. Moreover, 30% activity of this extract to human cells of pulmonary carcinoma was demonstrated, which was likely to exert cytopathic effects (65%) on skin fibroblasts (Nowak *et al*., 2016). In another study aimed to investigate the effect of *C. album* (leaves) on the growth of estrogen dependent (MCF-7) and estrogen independent (MDA-MB-468) human breast cancer cell lines, the different solvent extracts (petroleum ether, ethyl acetate and methanol) were assessed for their cytotoxicity using Trypan Blue exclusion and MTT bioassay. Among the various extracts studied for two cell lines, methanolic extract of *C. album* exhibited maximum anti breast cancer activity having IC_{50} value 27.31 mg/ml against MCF-7 cell line. Significant percent inhibition (94.06%) in the MeOH extract of *C. album* at 48 h of exposure and concentration 100 mg/ml ($p < 0.05$) against MCF-7 indicates the presence of some structural moiety responsible for this observed antiproliferative effect (Khoobchandani *et al*., 2009).

***Cucurbita moschata* [Cucurbitaceae, Pumpkin, Kaddu]**

Pumpkin is a popular and nutritious vegetable consumed worldwide and consists of many beneficial nutrients such as phytoestrogen, selenium, fiber, cucurbitacin E, calcium, zinc, other vitamins, minerals that are not only beneficial for cancer prevention, but also for curing many diseases. The pumpkin plant is considered as a super food for many diseases including cancers, especially gastrointestinal cancer (Wang *et al*., 2012). The cucurbitacins are the most important compounds in cucurbitaceae family. These compounds are anticancer natural triterpenoids and have free radical scavenging effect / antioxidant activity (Jafarian *et al*., 2012). Cucurbitacin E, is a tetra cyclic triterpenoid ($C_{32}H_{99}O_8$) that is extracted from plants of cucurbitaceae family. Cucurbitacin E prevents cancer by inhibiting the action of JAK_2 and $STAT_3$ phosphorylation. Cucurbitacin E has anti-proliferating effect *via* its effect on actin filament in endothelial cells. Actin is an important intermediate in signalling pathways of cell division control, so cucurbitacin E has an inhibitory effect on cell growth (Colagar and Souraki, 2012). Recently, a number of studies have indicated that cucurmosin from pumpkin has cytotoxic properties and induces apoptosis in a number of human tumor cells. Thus, cucurmosin was extracted from pumpkin and *in vitro* studies have shown that it inhibits the proliferation of murine melanoma B16, lung adenocarcinoma A-549, human chronic myelogenous leukemia K562 and human pancreatic PANC-1 cancer cells (Hou *et al*., 2008; Xu *et al*., 2009). Cucurmosin induces apoptosis of human PANC-1, HL60 and K562 cells and induces the differentiation of B16 cells (Xie *et al*., 2006). Based on its cytotoxic activity against multiple human cancer cells through the induction of apoptosis / differentiation, it was hypothesized that cucurmosin is a candidate agent for human hepatoma treatment / chemoprevention. The results of the *in vitro* and *in vivo* studies have demonstrated that it is

a promising agent in inhibiting the growth potential of hepatoma $HepG_2$ cells (Xie *et al*., 2012). In another research treatment with cucurbitacins B and E, showed growth inhibition accompanied by apoptosis and cell cycle arrest in breast cancer cell lines (MDA-MB- 231 and MCF-7) (Sun *et al*., 2005). These compounds also modulated the expression of proteins involved in cell-cycle regulation in both of the estrogen-independent (MDA- MB-231) and estrogen-dependent (MCF-7) in human breast cancer cell lines (Blaskovich *et al*., 2003). Growth inhibition and cytotoxic effect of cucurbitacin B on breast cancer cell lines- SKBR-3 and MCF-7 were attributed to G2/M phase arrest and apoptosis. Cucurbitacin B treatment inhibited Cyclin D_1, C-Myc and β-catenin expression levels, translocation to the nucleus of β-catenin and galectin-3(Dakeng *et al*., 2012).

Lagenaria siceraria **[Cucurbitaceae, Bottle Gourd, Lauki]**

Lagenaria siceraria, an annual herbaceous climbing plant, can be found in the forests of India, Moluccas and Ethiopia. Its aerial parts / fruits are commonly consumed as a vegetable. Traditionally, it is used as medicine in India, China, Brazil, Hawaiian Island and European Countries for its cardio tonic, general tonic and diuretic properties (Tyagi *et al*., 2012). The plant has been suggested to possess antioxidant, anthelmintic, antihypertensive, cardioprotective, hepatoprotective, central nervous system stimulant and free radical scavenging activity. The fruit is reported to contain vitamins (B, C), the triterpenoid cucurbitacins (B, D, G, H), two sterols (fucosterol and campesterol), aerpe nebyonolic acid (an allergic compound), flavone-C glycosides (a ribosome inactivating protein) and lagenin (Minocha, 2015). A study was carried out to evaluate the anti-cancer activity of methanol extract of aerial parts of *L. siceraria* on Ehrlich's Ascites Carcinoma (EAC) model in mice. After inoculation of EAC cells into mice, treatment with aerial parts (200 and 400 mg kg^{-1}) and standard drug 5-Fluorouracil (20 mg kg^{-1}) was continued for 9 days. Evaluation of the effect of drug response was made by the study of tumor growth response including increase in life span, study of hematological parameters, biochemical estimations and antioxidant assay of liver tissue. Experimental results revealed that bottle gourd possesses significant anticancer activity which may be due to its cytotoxicity and antioxidant properties. The anticancer activity of methanolic extract was assumed probably due to its flavonoid content (Saha *et al*., 2011). In another study, the anti-cancerous properties of bottle gourd peel extract and gold nano particles synthesized from bottle gourd peel extract were evaluated *in vitro* against A-431 (skin carcinoma, p53mutant) and A-549 (lung carcinoma, p53 wild type) cells at different concentrations by MTT assay. In A-549 cancer cells, with harbour wild type p53 protein, gold nano particles showed only marginal cytotoxicity up to 75 µg/mL concentration. However, treatment of A-549 cells with gold nano particles at 100 µg/mL caused around 25% survival loss while bottle gourd peel extract did not show any significant anti-cancerous property regarding to A-549 cell line. Although for A-431 cell line, results showed that extract exposure caused some appreciable loss in cell survival. The cells treated with 12.5 µg/ml of gold nano particles decreased the cell viability by 40%. At 75 µg/ml the percentage cell survival was 32.24% compared to 20.12% at 100 µg/mL. The results showed that the cytotoxicity of gold nano particles in cancerous cell is quite effective which suggested that nano-gold possesses great selectivity to cancer cell and can display potential application in cancer chemoprevention (Kumara *et al*., 2015).

Momordica charantia **[Cucurbitaceae, Bitter gourd, Karela]**

*Momordica charantia***,** also known as balsam pear, commonly consumed as vegetable, is widely cultivated in Asia, Africa and South America and extensively used in folk medicines as a remedy for diabetes, specifically in India, China and Central America. The fruit is oblong and resembles a small cucumber; young fruit is emerald green that turns to orange-yellow when ripe (Grover *et al*., 2002). In India, various medicinal properties are claimed for *M. charantia* that include antidiabetic, abortifacient, anthelmintic, contraceptive, antimalarial, laxative and is used for treatment of dysmenorrhea, eczema, emmenagogue, galactagogue, gout, jaundice, kidney (stone), leprosy, leucorrhea, piles, pneumonia, psoriasis, rheumatism, scabies. (Tomar, 2009). *M. charantia* is known to contain glycosides such as momordin, vitamin C, carotenoids, flavonoids and polyphenols (Anila and Vijayalakshmi, 2000; Raj *et al*., 2005). Multiple types of extracts from bitter gourd had *in vivo* (Chiampanichayakul *et al*., 2001; Nagasawa *et al*., 2002; Kohno *et al*., 2004) and *in vitro* (Yasui *et al*., 2005) anticancer activity. Eleostearic acid (α-ESA), which is a conjugated linolenic acid that makes up 60% of bitter gourd seed oil, can block breast cancer proliferation and induce apoptosis through a mechanism that may be oxidation dependent (Grossmann *et al*., 2009). *In vitro* studies using pure α-ESA have reported anticancer activity as α-ESA significantly reduced viability of transformed NIH-3T3 mouse fibroblast (SV-T2) and monocytic leukaemia (U-937) cells (Suzuki *et al*., 2001). In additional reports, DLD-1 colorectal adenocarcinoma cells treated with α-ESA *in vitro* were growth inhibited and underwent DNA laddering indicative of apoptosis (Tsuzuki *et al*., 2004). Both Caco-2 and HT-29 colon cancer cells had decreased viability and increased DNA fragmentation when treated with α-ESA (Yasui *et al*., 2006). Human breast cancer cells (MCF-7 and MDA-MB-231) were used to assess the efficacy of bitter gourd extract as an anticancer agent and it was

found that the extract inhibits breast cancer cell proliferation by modulating cell cycle regulatory genes and promotes apoptosis (Ray *et al*., 2010). MCP_{30}, a protein isolated from bitter gourd seeds selectively induces prostate cancer apoptosis (Xiong *et al*., 2009). *M. charantia* was found effective on highly metastatic PC-3M prostate cancer cell line (Rao *et al*., 2004). Fruit and leaf extracts (50% methanol) from *M. charantia* possess chemopreventive potential on dimethyl benz(a)nthracene (DMBA) induced skin tumorigenesis, melanoma tumor and cytogenicity (Agrawal and Beohar, 2010). Methanolic extract as well as momordin of bitter gourd showed cell toxicity against human cancer cell lines (Lee *et al*., 1998). Chronic treatment with hot water extract of karela inhibited uterine adenomyosis and mammary tumor growth in mice (Nagasawa *et al.*, 2002). It was demonstrated that maximal anticarcinogenic activity is found in the peel of *M. Charantia* (Singh *et al*., 1998). The crude aqueous extract from bitter gourd showed *in vivo* antitumor activity (Jilka *et al*., 1983). Alcoholic extract from the leaves of bitter gourd have an anti-metastatic effect against rat prostate cancer progression both *in vitro* and *in vivo* (Pitchakaran *et al*., 2010). 9, 11, 13-octadecatrienoic acid (α-eleostearic acid), a major linolenic acid in bitter gourd seeds strongly inhibited the growth of some cancer and fibroblast cell lines including those of HL-60 leukemia and HT-29 colon carcinoma (Kobori *et al*., 2008).

***Portulaca oleraceae* [Portulacaceae, Purslane/Littlehogweed, Kulfa]**

Portulaca oleracea is a warm-climate, herbaceous succulent annual plant with a cosmopolitan distribution. It is grown extensively as a potherb and added in soups and salads around the Mediterranean and Tropical Asian countries. Diverse compounds have been isolated from the plant such as flavonoids, alkaloids, polysaccharides, fatty acids, terpenoids, sterols, proteins vitamins and minerals. It contains more omega-3 fatty acids (alpha-linolenic acid in particular) than any other leafy vegetable. It also contains vitamins-A, B, C, E, carotenoids and dietary minerals such as magnesium, calcium, potassium, iron (Simopoulos *et al*., 1992). *P. oleracea* possesses a wide spectrum of pharmacological properties such as neuroprotective, antimicrobial, antidiabetic, antioxidant, anti-inflammatory, antiulcerogenic and anticancer (Zhou *et al*., 2015). An investigation was designed to study the anticancer activity of seed extracts of kulfa on the human hepatocellular carcinoma cells ($HepG_2$). The $HepG_2$ cells were exposed with 5-500 µg/ml of vegetable extracts for 24 h. The results showed that extracts significantly reduced the cell viability of $HepG_2$ in a concentration dependent manner. The cell viability was recorded to be 67%, 31%, 21%, and 17% at 50, 100, 250, and 500 µg/ml of kulfa respectively by MTT assay and 91%, 62%, 27%, and 18% at 50, 100, 250 and 500 µg/ml respectively by NRU assay. Results also showed that plant exposed cells reduced the normal morphology and adhesion capacity of $HepG_2$ cells. $HepG_2$ cells exposed with 50 µg/ml and higher concentrations of kulfa lost their typical morphology, became smaller in size and appeared in rounded bodies (Farshori et al., 2014). In another research, cytotoxic effects of seed oil of *P. oleracea*a gainst human liver cancer ($HepG_2$) and human lung cancer (A-549) cell lines have been investigate. Both cell lines were exposed to various concentrations of *P. oleracea* seed oil for 24 h. The results showed a concentration-dependent significant reduction in the percentage cell viability and an alteration in the cellular morphology of $HepG_2$ and A-549 cells. The percentage cell viability was recorded as 73%, 63%, and 54% by MTT assay and 76%, 61%, and 50% by NRU assay at 250, 500, and 1000 µg/ml, respectively in HepG2 cells. Percentage cell viability was recorded as 82%, 72%, and 64% by MTT assay and 83%, 68%, and 56% by NRU assay at 250, 500, and 1000 µg/ml respectively in A-549 cells. The 100 µg/ml and lower concentrations were found to be non cytotoxic to A-549 cells, whereas decrease of 14% and 12% were recorded by MTT and NRU assay respectively in $HepG_2$ cells. Both $HepG_2$ and A-549 cell lines exposed to 250, 500, and 1000 µg/ml of *P. oleracea* seed oil, lost their normal morphology, cell adhesion capacity, become rounded and appeared smaller in size (Al-Sheddi *et al*., 2015). A subclass of homo isoflavonoids from the plant also showed *in vitro* cytotoxic activities towards four human cancer cell lines (Yan *et al*., 2012).

***Raphanus sativus* [Brassicaceae, Radish, Mooli]**

Raphanus sativus is an essential vegetable crop in India and is thought to have originated in Southern China from where it has spread to Japan and other parts of Asia. Its roots and leaves are edible and it contains glucosinolates which release isothiocyanates by the action of myrosinase. Thus, the major glucosinolate of radish is glucoraphasstin which after enzymatic hydrolysis by myrosinase, produces 4-methylthio-3-butenyl isothiocyanate (raphasatin). This compound which accounts for some of the strong taste of radish, has powerful antioxidant activity and shows selective cytotoxic activity towards some human cancer cell lines (Rakhmawati *et al*., 2009). The plant also possesses antidiabetic (Rakhmawati *et al*., 2011), diuretic (Saganuwan, 2010), antifertility (Mishra *et al*., 2011), hypertensive (Talha *et al*., 2011), antimicrobial (Shukla *et al*., 2011), nephroprotective (Kumar *et al*., 2013), gastroprotective (Alqasoumi *et al*., 2008) and hepatoprotective (Anwar and Ahmad, 2006) efficiency. A study *(in vitro)* showed that *R. sativus* sprout extracts inhibited cell proliferation and induced apoptosis in cancer cells (Papi *et al*., 2008).The study also confirms that ethanol extract of the aerial parts of radish is capable of inducing apoptosis in MDA-MB-231 human breast cancer

cells. These results suggested that radish leaf may be a useful antitumor agent because it directly inhibits the growth of tumor cells and induces apoptosis (Kim *et al*., 2011). In another study, the anticarcinogenic effect of radish in combating chemically induced colon cancer was evaluated. Results showed that radish significantly reduced serum CEA ($p<0.01$) and CA19-9 ($p<0.01$) as evidence of anticarcinogenic effect thus proving that the galactan polysaccharide has pronounced cytotoxic effects on colon cancer cell line and might be a suitable candidate as chemopreventive and adjuvant therapy for colon cancer (Mohamed *et al*., 2013).

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