

## Antioxidant and Anticancer Efficacy of Fruits

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### Abstract

Fruits are good sources of natural antioxidants such as carotenoids, vitamins, phenols, flavonoids, dietary glutathionine, and endogenous metabolites. These antioxidants are capable of performing a number of functions including acting as free radical scavengers, peroxide decomposers, singlet and triplet oxygen quenchers, enzyme inhibitors and synergists. Active oxygen species are generated as by-products of normal metabolism. Increased levels of these active oxygen species or free radicals create oxidative stress which leads to a variety of biochemical and physiological injuries often resulting in impairment of metabolism and eventually, cell death. The consumption of fruits has been associated with low incidences and mortality rates of cancer (Ames *et al.*, 1993; Dragsted *et al.*, 1993; Willett, 1994) and heart disease (Verlangieri *et al.*, 1985). Fruits also contain a wide range of flavonoids and phenolic acids. The main flavonoid sub groups in fruits are anthocyanins, proanthocyanins, flavonols, and catechins. Phenolic acids present in fruits are glycosides of hydroxylated derivatives of benzoic acid and cinnamic acid (Macheix *et al.*, 1990). Good sources of natural antioxidants are found in many fruits, most notably prunes, raisins, blackberries, black currants, blueberries, raspberries, strawberries, grapes and pomegranates (Prior *et al.*, 1998; Wang and Lin, 2000; Gil *et al.*, 2000). The different antioxidant components found in fruits provide protection against harmful free radicals and have been associated with lower incidence and mortality rates of cancer and heart disease, in addition to a number of other health benefits. A number of researchers have identified the anticancer and antioxidant properties of different fruits using different methods. A comprehensive review of the work done and reported anticancer and antioxidant properties of different fruits has been done in this paper. This paper summarizes the traditional uses of some important fruit crops as well as their antioxidant and anticancer properties.

**Keywords:** Antioxidants; Jamun; Bael; Mulberry.

### Introduction

The trend of agricultural production has deviated from mere focusing on maximizing production to optimizing the nutritional composition of fruits in

order to promote health. In this regard, much reform in the agricultural practices has been put in place to enhance the nutritional content of the fruits. Fruits not only provide vitamins and minerals but also health promoting antioxidants. Antioxidants are the natural compounds that help in scavenging free

radicals that are produced as by-products of normal metabolism. Interest in the role of antioxidants in human health has prompted research in the fields of horticulture and food science to assess fruit antioxidants, such as ascorbate, carotenoids, tocopherols, and phenolics. Fruits are good sources of both phenolics and ascorbate, and since fruits are often consumed fresh, antioxidant capacity is not lost due to any adverse effects of heat and oxidation during processing.

Cancer research has become a major area of scientific research supporting the foundations of modern biology to a great extent. In spite of recent advances in cancer research and significant development in the field of synthetic drug chemistry, the global trend currently calls for discovery of new molecules of natural origin which are less toxic, endowed with fewer side effects and more potent in their mechanism of action. Regular consumption of fruits is associated with reduced risk of cancers and additive/ synergistic effects of phytochemicals in fruits are responsible for their potent antioxidant and anticancer activities. Natural products from some fruits offer new sources of drugs, but there are still a number of fruits in which all the active constituents have not yet been investigated although their medicinal effect is established by traditional use.

Carcinogens are becoming a big load on families and economies. Despite a good understanding of the molecular basis of the disease and advances in treatment, globally cancer is still a major cause of death. Estimates are that it will surpass cardiovascular disease as the leading cause of death, with higher incidence developing in countries that have minimal resources. Fruits consumed in our daily diet could be a solution to this burden by providing a chemoprotective and/or chemotherapeutic remedy. An estimated 12.6 million people are diagnosed with cancer every year and 7.6 million people die of the disease annually. Numerous lines of evidence suggest that lifestyle and nutrition play an important role in cancer development. As for nutrition, diets that are rich in fruits and vegetables have been shown to lower the risk of cancer incidence. In addition, several phytochemicals that are present in fruits and vegetables have been scientifically established to have properties that can prevent and treat this malevolent disease.

#### **Antioxidant and Anticancer Efficacy of Fruits**

It is increasingly being realized now that majority of the diseases are mainly due to the imbalance between pro-oxidant and anti-oxidant homeostatic phenomenon in the body. Pro-oxidant condition

dominates either due to the increased generation of free radicals and/or their poor quenching/scavenging in to the body. Free radicals are the fundamentals to any biochemical process, and represent an essential part of the aerobic life and our metabolism. They are continuously produced by the body, such as respiration and some cell mediated immune functions. There is a dynamic balance between the amount of free radicals generated in the body and anti-oxidants to quench and/or scavenge them and protect the body against the deleterious effects. Thus, the oxidant status in human reflects the dynamic balance between the anti-oxidant defense and pro-oxidant conditions and has been suggested as a useful tool in estimating the risk of oxidative damage (Khan, 2009). The anticancer and antioxidant properties reported in fruits has been summarized as under:

#### **Olive (*Olea europaea*; Oleaceae; Olive; Zaitoon)**

Olive (*Olea europaea* L.) is an evergreen tree belonging to family Oleaceae. The tree has a native wild form *Olea cuspidate* L. which bears small fruits of pea size. Majority of the cultivated olive belongs to *Olea europaea* L. Olive oil is traditionally used in foods as it is considered good for health. It contains less saturated fatty acids as compared to other oils. Folklore use olive oil for massaging to cure any kind of inflammation, allergy etc. Olive fruits also possess anti-oxidant properties. Presence of peroxisomes in olive (*Olea europaea* L.) fruits and different anti-oxidant enzymes in the plant tissue has been reported (Huertas and Rio, 2014).

Olive leaves are used for their antimicrobial (Bisignano *et al.*, 1999; Pereira *et al.*, 2007; Markin *et al.*, 2003), gastroprotective (Dekanski *et al.*, 2009), anti-oxidant (Benavente *et al.*, 2000; Briante *et al.*, 2003; Skrget *et al.*, 2005; Somova *et al.*, 2003), hypotensive (Khayyal *et al.*, 2002), hypoglycaemic (Gonzalez *et al.*, 1992; Al-Azzawie and Al-hamdani, 2006), antiarrhythmic (Somova *et al.*, 2004), anti-atherosclerotic (Wang *et al.*, 2008), anti-viral (Lee-Huang *et al.*, 2003; Micol *et al.*, 2005), anti-tumor (Hamdi and Castellon, 2005; Abaza *et al.*, 2007) and anti-inflammatory properties (Pieroni *et al.*, 1996). Historically olive leaves have been used as a remedy for fever and other diseases such as malaria (Ciardini and Zullo, 2002; Fernansez *et al.*, 1999; Gucci *et al.*, 1997). Essential oil of *olea europaea* L. leaves contain anti-inflammatory and alabgesic compounds like  $\alpha$ -pinene, 2,6-dimethyloctane and 2-methoxy-3-isopropylpyrazine which show radical scavenging activity at different concentrations. *Olea europaea* L. essential oil at doses of 100, 200 and 300

mg/kg significantly reduced acetic acid induced abdominal constrictions and paw edema in male adult wistar rats and swiss albino mice (Haloni *et al.*, 2010).

Olive oil intake has been reported to prevent colon cancer. In particular, positive associations between elevated intakes of dietary fat and cancer of the colon (Armstrong and Doll, 1975), breast (La Vecchia *et al.*, 1998), prostate (Chan *et al.*, 1998) and ovary (Risch *et al.*, 1994). Mediterranean diet has lower incidences of major illness such as cancer and cardiovascular disease, despite high intake of fat. The implication is that the health conferring benefits of the Mediterranean diet are mainly due to a higher consumption of fibre, fish, fruits and vegetables, but more recent research has focused on other important factors such as olives and olive oil (Owen *et al.*, 2004). Phenols extracted from virgin olive oils on a series of *in vitro* systems that model important stages of colon carcinogenesis. Phenols extracted from virgin olive oil are capable of inhibiting several stages in colon carcinogenesis *in vitro* (Gill *et al.*, 2005).

#### **Bael (*Aegle Marmelos*; Rutaceae; Stone Apple; Bil)**

Bael (*Aegle marmelos* L.) is another Indian medicinal plant which has enormous traditional value against various diseases and many bioactive compounds have been isolated from this plant (Badam *et al.*, 2002; Gupta and Tondon, 2004). According to hindu mythology, the tree is another form of lord Kailashnath (Purohit and Vyas, 2004). Various phytoconstituents have been isolated from the various parts of *Aegle marmelos* L., which may be categorized as

##### Leaf

Skimmianine, Aegeline, Lupeol, Cineol, Citral, Citronella, Cuminaldehyde, Eugenol, Marmesinine

##### Bark

Skimmianine, Fagarine, Marmin

##### Fruit

Marmelosin, Luvangetin, Aurapten, Psoralen, Marmelide, Tannin

(Source: Maity *et al.*, 2009)

Different parts of Bael are used for various therapeutic purposes such as for treatment of asthma, anaemia, Fractures, healing of wounds, swollen joints, high blood pressure, jaundice, diarrhea, healthy mind and brain typhoid troubles during

pregnancy (Saswati, 2004). *Aegle marmelos* has been used as a herbal medicine for the management of diabetes mellitus in Ayurvedic, unani and siddha systems of medicine in India (Kar, 2003), Bangladesh (Lampronti, 2003), and Srilanka (Karinanayake, 1984). The unripe dries fruit is astringent, digestive, stomach ache and used to cure diarrhea and dysentery. Sweet drink prepared from the pulp of fruits produce soothing effect on the patients who have just recovered from bacillary dysentery. Anticancer potential of folk medicine used in Bangladesh as evaluated using extracts of *Aegle marmelos* for cytotoxic action using brine shrimp lethality assay, sea urchin eggs assay and MTT assay using tumor cell lines. The extracts showed toxicity on all used assays (Latica and Costa, 2005). Presence of skimmianine in the *Aegle marmelos* leaves contributes to the apoptosis activity (Gagetia *et al.*, 2005).

#### **Amla (*Embllica Officinalis*; Euphorbaceae; Gooseberry; Amla/Aonla)**

Amla (*Embllica officinalis* L.) also called as amakali in Sanskrit has a special place in Ayurveda, which is the oldest health system in the world. Ayurveda appreciates and uses amla to treat a host of diseases and promote positive health. It is extensively used as a rejuvenator in ayurveda. It is also used widely in combination with other two [chebulic and belleric] myrobalans [fruit bearing plant species] as triphala. Amla is the key ingredient in the popular ayurvedic recipe, chyavanaprasha. More than anything, it can be called as "King of Rasayana" [rejuvenation], owing to its multiple health benefits. The fruit is rich in quercetin, phyllaemblic compounds, gallic acid, tannins, flavanoids, pectin and vitamin C and also contain various polyphenolic compounds. A wide range of phytochemical components including terpenoids, alkaloids, flavonoids and tannins have been shown to possess useful biological activities (Kim *et al.*, 2005; Arora *et al.*, 2003). Many pharmacological studies have demonstrated the ability of the fruits to show anti-oxidant, anti-carcinogenic, anti-tumor, anti-genotoxic, anti-inflammatory activities, supporting its traditional use. Amla fruit contains more than 80% of water and nearly 20 times as much vitamin C as orange juice (Jain *et al.*, 2000; Bharthakur *et al.*, 1993).

The seeds yield a fixed oil (16%) which is brownish-yellow in colour. It contains fatty acids such as linoleic acid, linolenic acid, oleic acid, stearic acid, palmitic acid and myristic acid (Thakur *et al.*, 1989). The phytochemicals of this plant include hydrolysable tannins (Emblcanin A, Emblcanin B,

punigluconin, pedunculagin) (Ghosal *et al.*, 1996), flavonoids (Kaempferol 3 O alpha L (6" methyl) rhamnopyranoside, Kaempferol 3 O alpha L (6" ethyl) amnopyranoside) (Rahman, 2007), alkaloids (Phyllantidine and phyllantine) (Khanna *et al.*, 1975). Phyllaemblic acid, a novel highly oxygenated norbisabolane is present in the roots of *P. emblica* (Zany *et al.*, 2003). Ellagic acid and lupeol are present in the roots of *P. emblica* (Kapoor, 1990; Rastogi *et al.*, 1993).

Because of the cooling nature, amla is a common ingredient in treatments for a burning sensation anywhere in the body and for many types of inflammations (Dang *et al.*, 2011; Muthuraman *et al.*, 2010; Nicolis *et al.*, 2008) and fever; those are manifestations of pitta (fire) agitation (Williamson, 2000). Amla berry and other rasayanās are effective broad spectrum anti-oxidants and free radical scavengers, helping to reduce disease and slow the aging process. The use of amla as an anti-oxidant has been examined and authenticated (Kumaran *et al.*, 2006; Rao *et al.*, 2005; Naik *et al.*, 2005; Bajpai *et al.*, 2005; Bhattacharya *et al.*, 2002; Anita *et al.*, 2002; Scartezzini, 2000; Bandopathyay *et al.*, 2000; Chaudhuri, 2003). Studies conducted in Japan have showed that amla is a potent scavenger of free radicals and amla preparations contained high levels of free-radical scavengers, super oxide dismutase (SOD) (Goshal, 1996). Aqueous fruit extracts of *P. emblica* significantly inhibited the growth of several human cancer cell lines at doses of 50-100 µg/ml (Ngamkitidechakul *et al.*, 2010). *Emblica officinalis* polyphenols (EOP) are very effective in inducing apoptosis in human carcinoma cell lines (Rajeshkumar *et al.*, 2003). *Emblica officinalis* has the potential to be useful in ameliorating the carcinogen-induced response in rat (Sarwat *et al.*, 2008).

Valid research indicative of chemopreventive potential of *P. emblica* against skin carcinogenesis has also been reported (Garima *et al.*, 2005). Amla fruit contains 18 compounds that inhibit the growth of tumor cells such as gastric and uterine cancer cells (Zhang *et al.*, 2004). Chemoprevention with food phyto-chemicals is presently considered as one of the most important strategies to control cancer. Chemo-preventive potential of amla extract on 7,12-dimethylbenz (a)anthracene (DMBA) induced skin tumorigenesis in Swiss albino mice have been found (Sancheti *et al.*, 2005). Amla extract is potent in inhibiting *in vitro* cell proliferation towards human tumor cell lines, including human erythromyeloid K562, T-lymphoid Jurkat, B-lymphoid Raji, erythroleukemic HEL cell lines (Khan *et al.*, 2002).

### **Jamun (*Syzygium Cumini* L.; Family; Black Plum; Jamun)**

Jamun (*Syzygium cumini* L.) commonly known as black plum, Indian black berry, rose apple or 'jamun' is an important medicinal plant in various traditional systems of medicine. It is blackish-violet coloured juicy berry fruit that grows throughout the country particularly in rainy season. It is effective in the treatment of diabetes mellitus, inflammation, ulcers and diarrhea and preclinical studies have also shown it to possess chemo-preventive, radio-protective and antineoplastic properties. The plant is rich in compounds containing anthocyanins, glucosides, ellagic acid, isoquercetin, kermferol and myrecetin. The seeds are claimed to contain alkaloid, jambosine, and glycoside jambolin or antimellin, which halts the diastatic conversion of starch in to sugar (Swami *et al.* 2012). Jamun fruits are good source of iron, calcium, phosphorus, minerals, vitamin-C, sodium, potassium and carotene and are reported quite useful for the heart and liver dysfunction. The seeds of jamun are an effective home remedy commonly used by ayurvedic practitioners from times immemorial to control diabetes. It has been named as diabetic fighter as recommended by studies conducted by Indian Journal of Pharmacology, Division of Bhabha Atomic Research Center and Central Drug Research Institute - for its hypoglycaemic properties (lowering sugar level) (Baliga, 2011). Jamun seed has also gastro-protective properties. Jamun is effective in peptic ulcers, it helps to promote the mucosal defensive factors and antioxidant status and decrease lipid peroxidation. It has hypoglycaemia, anti-inflammatory, anti-bacterial and anti-HIV effects.

### **Mulberry (*Morus Alba*; Family; Mulberry; Shahtoot, Toot)**

Many scientific and medical studies have examined mulberry fruit for its antioxidation and anti-inflammation effects both *in vitro* and *in vivo*. Studies have reported on the chemical composition and nutritional potentials of some mulberry species worldwide (Ercisli and Orhan, 2007; Arabshahi-Delouee and Urooj, 2007; Darias-Martin *et al.*, 2003; Elmacy and Altuo, 2002; Gao *et al.*, 2000; Gerasopoulos and Stavroulakis, 1997). The deep coloured mulberry fruits are rich in phenolic compounds, including flavonoids, anthocyanins and carotenoids (Lin and Tang, 2007; Sass-Kiss, 2005; Zadernowski *et al.*, 2005). Such natural substances extracted from plants have been shown to have greater antioxidant and anti-inflammatory effects and have been used for health maintenance and

disease management since the beginning of recorded history (Krishnaswamy and Raghuramulu, 1998). Mulberry is traditionally used in Chinese medicines as a pharmaceutical for antifever diuretics, liver protection, eyesight improvement, blood pressure reduction and cardiovascular disease prevention. Dietary mulberry has been reported to have not only antioxidative, anti-inflammatory, antitumor and antidiabetic effects, but also cardio-vascular, hepato- and neuro-protective properties (Andallu *et al.*, 2001; Huang *et al.*, 2008; El-Beshbishy *et al.*, 2006; Kimura *et al.*, 2007; Isabelle *et al.*, 2008; Wang *et al.*, 2000). A study reported the proximate composition of mulberry fruits (Imran *et al.*, 2010). Mulberry fruits contain 78.03-82.4 percent moisture (fresh weight). The ash content ranged between 0.46 and 0.87 g/100g dry weight (DW). The total lipid contents were in the range of 0.48-0.71 g/100g DW. The total protein contents of the fruits vary between 0.96 to 1.73 g/100g DW. The overall proximate composition of mulberry fruits indicates that it is a potential source of lipids, proteins, fibres, carbohydrates and hence, energy.

Among the phyto-chemicals in mulberry fruits, phenolic acids and flavonoids are regarded as major functional food components and are thought to contribute to the health effects of fruit derived products due to prevention of various diseases associated with oxidative stress (Lodovici *et al.*, 2001). Many studies suggest flavonoids, a family of compounds with a C6-C3-C6 skeleton structure, display several biological activities, including antiallergic, antiviral, antitumor, and anti-inflammatory action and antioxidant activity (Harborne and Williams, 2000). HPLC analysis showed that the main flavanols rich in mulberry fruit were rutin, morin, quercetin, and myricetin. These flavanols are reported to be effective antioxidants (Lu *et al.*, 2006). Morin significantly reduced the tissue level of cyclosporine, a potent immunosuppressive agent with narrow therapeutic range, and dramatically decreased the nitric oxide production by the activated macrophages (Fang *et al.*, 2005). In addition, C3G isolated from mulberry fruits inhibited the cerebral ischemic damage caused by oxygen glucose deprivation in PC12 cells (Kang *et al.*, 2006). Black mulberry fruit juice inhibited the human cytochrome CYP3A activity in the pooled human liver microsome system (Kim *et al.*, 2006).

Mulberry anthocyanins, cyaniding 3-rutinoside, and cyanidin 3-glucoside, exhibited an inhibitory effect on the migration and invasion of a human lung cancer cell line by regulating the activation of c-Jun and NF- $\kappa$ B (Chen *et al.*, 2006). Mulberry fruit extracts

result in human glioma cell death *in vitro* through the reactive oxygen species (ROS)-dependent mitochondrial pathway and glioma tumor growth *in vivo* via reduction of tumor cell proliferation and the induction of apoptosis (Jeong *et al.*, 2010). Mulberry fruit colour does not affect the antioxidant capacity. Researches made on pink, white and black fruit exhibited no significant effect on the antioxidant potential of the mulberry fruit. However, location has a role to play in the antioxidant capacity of mulberry fruit (Bajpai *et al.*, 2014). The source from genotypes from different sampling locations is more important as compared to fruit colour in determining antioxidant capacity, total polyphenol content (TPC), total flavonoid content (TFC) and total anthocyanin content (TAC) in *M. alba* fruit.

#### **Ber (*Ziziphus Mauritiana* L.; Rhamnaceae; Chinese Apple; Ber)**

Ber (*Ziziphus mauritiana* L.) also known as Chinese apple, Jujube, Indian plum and Masau is a tropical fruit tree species belonging to the family Rhamaceae. Ber, though an underutilized fruit, has medicinal properties as well. The fruits are applied on cuts and ulcers, are employed in pulmonary ailments and fevers; and mixed with salt and chilli peppers, are given in indigestion and biliousness. The dried ripe fruit is a mild laxative. The seeds are sedative and are taken, sometimes with butter milk, to halt nausea, vomiting and abdominal pains in pregnancy. They check diarrhoea and are poultice on wounds. Mixed with oil, they are rubbed on rheumatic areas. The leaves are applied as poultices and are helpful in liver troubles, asthma and fever and, together with catechu, are administered when an astringent is needed, as on wounds. The bitter astringent bark decoction is taken to halt diarrhea and dysentery and relieve gingivitis. An infusion of flowers serves as an eye lotion.

#### **Karonda (*Carissa Carandas*; Apocynaceae; Karanda; Karonda)**

Karonda (*Carissa carandas*) another underutilized tropical fruit of Indian subcontinent. The karonda fruit is an astringent, antiscorbutic and used as a remedy for biliousness and for cure of anaemia. In traditional medicine, the fruit is used to improve female libido and to remove worms from the intestinal tract. The fruit has anti-microbial and anti-fungal properties and its juice used to clean old wounds which have become infected. The fruit have an analgesic action as well as an anti-inflammatory one.

The juice can be applied to the skin to relieve any skin problems. Traditionally karonda has been used to treat anorexia and insanity. A leaf decoction of karonda is used against fever, diarrhea and earache. The roots serve as a stomachic, vermifuge, remedy for itches and insect repellent. Traditional healers of Chhattisgarh having expertise in treatment of different types of cancer from karonda. They use its different plant parts to dress the cancerous wounds and to kill the maggots.

#### **Phalsa (*Grewia Subinequalis* L.; Tilliaceae; The Elusive Berry; Phalsa)**

Phalsa (*Grewia subinequalis* L.) is indigenous throughout the Himalayan region. Fruits are globose drupe, 1.8-2.2 cm in diameter, indistinctly lobed, red or purple, finely warty and with stellate hairs and ripe fruits are eaten as a dessert. Their taste and flavor are very much liked and they fetch high prices. According to Ayurveda, the ancient Indian treatise on medicine, the fruits are cooling, tonic and aphrodisiac, they allay thirst and burning sensation, remove biliousness, cure inflammation, heart and blood disorders and fevers. The bark is used as a demulcent. It cures urinary troubles and relieves burning in the vagina. Fruit extracts of phalsa exhibit antitumor and *in-vitro* cytotoxic activity against ehrlich's ascites carcinoma cell lines (Kakotiet *et al.*, 2011).

#### **Pomegranate (*Punica Granatum* L.; Punicaceae; Pomegranate; Anar)**

Pomegranate (*Punica granatum* L.) fruit is also a potential source of antioxidants and exhibits anticancer activity. The peels (pericarp, rind or hull) amounts to approximately 60% of the pomegranate fruit weight (Lansky and Newman, 2007). Pomegranate fruit extracts are rich in ellagitannins (ETs) that act as antioxidant and anticancer agents especially against breast and colon cancer (Lansky and Newman, 2007; Adams *et al.*, 2010; Kasimsetty *et al.*, 2010; Sharma *et al.*, 2010). Pomegranate peel extracts have exhibited marked antioxidant capacity in several studies using solvents such as methanol and a mixture of methanol, acetone, ethyl acetate and water (Ghasemian *et al.*, 2006; Negi *et al.*, 2002; Panichayupakarananta *et al.*, 2010). Powdered peels of pomegranate also exhibit antioxidant capacity (Hasnaouiet *et al.*, 2014). Ellagitannins (ETs) are the predominant phenolics in pomegranate peel, mesocarp and arils extracts (Fischer *et al.*, 2011). Upon consumption, these ETs are hydrolysed releasing EA, which is then converted to urolithin derivatives by

gut microflora (Seeram *et al.*, 2007). EA is known for its antioxidant, anti-inflammatory and anticarcinogenic properties, besides it is considered as a biomarker for human bioavailability studies involving consumption of ETs containing food, as it is detected in human plasma (Seeram *et al.*, 2004). The 50% ethanolic extract of the peels standardized to contain the highest percent of EA ( $1.9 \pm 0.1\%$ ) exhibited a pronounced antioxidant activity ( $IC_{50} = 0.50 \pm 0.9$  mg/ml) compared to the fruit ( $0.3 \pm 0.05\%$  EA) and pulp ( $0.02 \pm 0.01\%$  EA) extracts showing an  $IC_{50}$  of  $1.09 \pm 0.5$  mg/ml and  $13.6 \pm 0.8$  mg/ml, respectively. These results show a direct correlation between the EA content in pomegranate extracts and its ability in quenching free radicals. The contents of total phenolics in pomegranate peel extract was reported to be 10-fold as much as its content in the pulp extract, which causes its stronger antioxidant ability (Li *et al.*, 2006).

The anticancer activity of pomegranate fruit, peels and pulp extracts has been standardized to their EA content (Motaal and Sherif, 2011). Cytotoxicity tested against MCF-7 cell line (human breast carcinoma) and HCT-116 cell line (human colon carcinoma) along with doxorubicin as a positive control. The anticancer activity against both the cell lines increased by increasing the extract concentrations from 1 to 10  $\mu$ g/ml for all three extracts. The pomegranate peel extract showed a pronounced cytotoxic activity against MCF-7 cells compared to the other two extracts at a concentration of 10  $\mu$ g/ml, confirmed by the least  $IC_{50}$  ( $7.7 \pm 0.01$   $\mu$ g/ml). It has been reported that the ellagitannins and their intestinal bacterial metabolites, urolithins, released in the colon upon consumption of pomegranate juice could potentially diminish the risk of colon cancer development, by inhibiting cell proliferation and inducing apoptosis (Kasimsetty *et al.*, 2010). Also pomegranate ET-derived compounds especially urolithin B have potential for the prevention of estrogen-responsive breast cancers by significantly inhibiting testosterone-induced MCF-7 cell proliferation (Adams *et al.*, 2010).

#### **Conclusion**

It is quite evident from this review that fruits are a potential source of phytoconstituents that reveals their usefulness in diet of humans. Fruits as well as their parts can be utilized in various ways for the treatment of various disorders in human beings such as diabetes, liver toxicity, fungal infections, microbial infections, inflammations etc. These are potential

source of antioxidants that can help scavenge harmful free radicals produced inside the body. Their possible role in cancer prevention has been researched and professed. Still, still there is a need to explore the medicinal properties of various fruits in order to utilize these in other therapeutic activities.

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