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Tradition and medicinal value of Indian gooseberry: A review

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Abstract

Research in medicinal plants has gained a renewed focus recently. The prime reason is that other system of medicine although effective come with a number of side effects that often lead to serious complications. Plant based system of medicine being natural does not pose any serious problems. Aonla is one of the oldest oriental medicines mentioned in Ayurveda as potential remedy for various ailments. The fruit is rich in quercetin, phyllaemblic compounds, gallic acid, tannins, flavonoids, pectin, and vitamin C and also contains various polyphenolic compounds. A wide range of phytochemical components including terpenoids, alkaloids, flavonoids, and tannins have been shown to possess useful biological activities. In this review, we have focused our interest on phytochemistry, traditional uses, cancer chemo-preventive, anti-microbial and antimutagenicity activities activity of *aonla*. It is having a strong memory enhancing property, in lowering cholesterol level applicable in ophthalmic disorder, antimicrobial action and in neutralizing snake venom.

Keywords: medicinal herb, anticarcinogenic, antitumor activity, chemoprevention

Introduction

Aonla (*Phyllanthus emblica* L.) as a euphorbiaceous plant is widely distributed in subtropical and tropical areas of China, India, Indonesia, and Malaysia. Aonla fruit is well accepted by consumers for its special taste. It has abundant amounts of vitamin C and superoxide dismutase (Verma and Gupta, 2004) ^[86] and is used in many traditional medicinal systems, such as Chinese herbal medicine, Tibetan medicine and Ayurvedic medicine (Zhang *et al.*, 2000) ^[91]. Aonla fruit is reported to have hypolipidemic (Anila and Vijayalakshmi, 2000) ^[5]; (Jacob *et al.*, 1988) ^[27], (Mathur *et al.*, 1996) ^[41], (Thakur *et al.*, 1988) ^[78] and hypoglycemic activities (Abesundara *et al.*, 2004) ^[1], (Anila and Vijayalakshmi, 2000) ^[4] and acts as an important constituent of many hepatoprotective formulations available (Antarkar *et al.*, 1980) ^[7], (De *et al.*, 1993) ^[18]; (Pnada and Kar, 2003). It is also used as antimicrobial agent; (Godbole and Pendse, 1960) ^[25], (Rani and Khullar, 2004) ^[55], anticancer (Jeena *et al.*, 2001) ^[30]; (Zhang *et al.*, 2004) ^[92], and anti-inflammatory agent (Asmawi *et al.*, 1993) ^[9]; (Perianayagam *et al.*, 2004) ^[49], and can improve the metal induced clastogenic effects (Biswas *et al.*, 1999) ^[14]; (Dhir *et al.*, 1990) ^[20]. Free radicals play an important role in some pathogenesis of serious diseases, such as neurodegenerative disorders, cancer, liver cirrhosis, cardiovascular diseases, atherosclerosis, cataracts, diabetes and inflammation (Aruoma, 1998) ^[8]. Compounds that can scavenge free radicals have great potential in ameliorating these diseases (Kirakosyan *et al.*, 2003) ^[37]. It is reported that phenolic compounds in plants possess strong antioxidant activity and may help to protect cells against the oxidative damage caused by free radicals (Kahkonen *et al.*, 1999) ^[33]. Due to the presence of the conjugated ring structures and hydroxyl groups, many phenolic compounds have the potential to function as antioxidants by scavenging superoxide anion (Robak and Dryglewski, 1988) ^[56], singlet oxygen (Husain *et al.*, 1987) ^[26] and lipid peroxy radicals (Torel *et al.*, 1986) ^[79] and stabilizing free radicals involved in oxidative processes through hydrogenation or complexing with oxidizing species (Shahidi and Wanasudara, 1992) ^[66]. It was reported that aonla has a strong antioxidant activity (Bafna and Balaraman, 2004) ^[10]; (Anila and Vijayalakshmi, 2003) ^[6]; (Jose and Kuttan, 1995) ^[31], which may be partially due to the existence of flavonoids and several gallic acid derivatives including epigallocatechingallate (Anila and Vijayalakshmi, 2002) ^[5]; (Sabu and Kuttan, 2002) ^[57]. Aonla is highly nutritious and is one of the richest sources of vitamin-C, amino acids and minerals (Srivasuki, 2012) ^[73], chemical constituents like tannins, alkaloids and phenols (Zhang *et al.*, 2003) ^[90] Among all tannins, Emblicanin A and B, gallic acid, ellagic acid are reported to possess biological activity. Almost all parts of aonla tree possess medicinal properties, particularly fruit, which has been used in Ayurveda as

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a powerful *rasayana* and for treatment of diarrhoea, jaundice, inflammation and several other ailments (Udupa, 1985) [81]. The fruit is widely used to treat common cold and fever, as diuretic, laxative, liver tonic, refrigerant, stomachic, restorative, anti-pyretic, hair tonic; to prevent ulcer and dyspepsia. Pharmacological research reports indicates its analgesic (Sharma *et al.*, 2004) [67] anti-tussive (Nosal *et al.*, 2003) [46], anti-atherogenic (Santoshkumar *et al.*, 2013) [62], adaptogenic (Murugandam *et al.*, 2002) [44], cardio (Baliga *et al.*, 2013) [11], gastro (Chatterjee *et al.*, 2010) [17], nephron (Yokozawa *et al.*, 2007) [88], neuro protective (Vasudevan *et al.*, 2007) [83], and anticancer (Madhuri, 2008) [40] properties. It is also reported to possess chemo preventive (Krishnaveni and Mirunalini, 2010) [38] radio (Adil *et al.*, 2010) [2], chemo (Deep *et al.*, 2005) [19], and immune modulatory (Varadacharyulu *et al.*, 2009) [82], free radical scavenging (Prakash *et al.*, 2012) [53], antioxidant (Nripendranath *et al.*, 2010) [47], anti-inflammatory (Santoshkumar *et al.*, 2013) [63], anti-mutagenic activities. These properties are very much effective in the prevention of diseases like cancer, atherosclerosis, diabetes, peptic ulcer, anemia, liver, heart diseases and various other disorders.

Chemical constituents

It contains tannins, alkaloids and phenols (Zhang *et al.*, 2003) [90]. Fruits have 28% of the total tannins distributed in the whole plant. The fruit contains two hydrolysable tannins Emblicanin A and B (Bhattacharya *et al.*, 2002) [13] which have antioxidant properties; one on hydrolysis gives gallic acid, ellagic acid and glucose wherein the other gives ellagic

acid and glucose, respectively. The fruit also contains Phyllembin (Yi-Fei *et al.*, 2009) [87]. (Ghosal *et al.* 1996) [24] also reported that tannins like emblicanin-A (37%), emblicanin-B (33%), punigluconin and pedunculagin are reported to provide protection against oxygen radical included haemolysis of rat peripheral blood erythrocytes. The mechanism behind antioxidant activity is due to the recycling of sugar moiety and conversion of the polyphenol into medium and high molecular weight tannins. The powerful antioxidant Ellagic acid, present in *aonla* can inhibit mutations in genes and repairs the chromosomal abnormalities (Pandey and Govind, 2011) [48]. Aonla inhibits the growth and spread of various cancers like breast, uterus, pancreas, stomach and liver cancers. It can prevent and/or reduce the side effects of chemotherapy and radiotherapy (Bhattacharya *et al.*, 2002) [13], (Pandey and Govind, 2011) [48]. More than 18 compounds were identified in aonla fruit which can exert anti-proliferative activity on gastric and uterine cancer cells. The main mechanism behind its activity is by enhancing Natural Killer (NK) cell activity in various tumor cells (Madhuri *et al.*, 2008) [40]. Fruit contains flavonoids like quercetin, alkaloids like phyllantine and phyllantidine, kaempferol-3-O-alpha L-(6"-methyl) rhamnopyranoside and kaempferol-3-O-alpha L (6"-ethyl), rhamnopyranoside (Zhang *et al.*, 2003) [90] are found. The various compounds present are given in Table 1. Vitamin C (478.56mg/100mL) levels of fruits are more than those in oranges, tangerines and lemons (Jain *et al.*, 2004) [28], (Scartezzini *et al.*, 2006) [65].

Table 1: Chemical constituents of fruit

Hydrolysable Tannins	Emblicanin A and B, Punigluconin, Pedunculagin, Chebulinic acid (Ellagitannin), Chebulagic acid (Benzopyran tannin), Corilagin (Ellagitannin), Geraniin (Dehydroellagitannin), Ellagotannin
Alkaloids	Phyllantine, Phyllembin, Phyllantidine
Amino acids	Glutamic acid, Proline, Aspartic acid, Alanine, Cystine, Lysine
Carbohydrates	Pectin
Vitamin	Ascorbic acid
Flavonoids	Quercetin, Kaempferol
Organic acid	Citric acid

Aonla fruit ash contains chromium-2.5ppm, zinc-4 ppm and copper-3 ppm. Compounds isolated from fruit are gallic acid, ellagic acid, 1-Ogalloyl-beta-D-glucose, 3,6-di-O-galloyl-D-glucose, chebulinic acid, quercetin, chebulagic acid, corilagin, 1,6-di-O-galloyl beta-D-glucose, 3-Ethylgallic acid (3-ethoxy-4,5-dihydroxybenzoic acid) and isostrictinin (El-Desouky *et al.*, 2008) [22].

Traditional uses

In folk medicine, the fruits, which are sour, astringent, bitter, acrid, sweet and anodyne. Exert several beneficial effects include cooling, ophthalmic, carminative, digestive, stomachic, laxative, dyspepsia, aphrodisiac, rejuvenative, diuretic, antipyretic and tonic. They are useful in various conditions of tridosha, diabetes, cough, asthma, bronchitis, cephalalgia, ophthalmopathy, dyspepsia, colic, flatulence, hyperacidity, peptic ulcer, erysipelas, skin diseases, leprosy, haematogenesis, inflammations, anaemia, emaciation, hepatopathy, jaundice, diarrhoea, dysentery, haemorrhages, leucorrhoea, menorrhagia, cardiac disorders, intermittent fevers and premature greying of hair (Krishnaveni and Mirunalini, 2010) [38]. Aonla is also stated to have hepato, cardio, nephro and neuroprotective effects; antioxidant, anti-

inflammatory, analgesic, antipyretic and restorative properties.

Medicinal uses

Over the past few decades scientific investigations have laid a credible basis for some of the traditional ethnomedical uses of the *Phyllanthus emblica*. The history of *Phyllanthus emblica* with respect to development of mankind is impressive. *P. emblica* has a long history as a medicinal remedy to treat a wide range of complaints. According to Ayurveda, the fruits are sweet, sour, astringent, bitter and pungent. The dried fruits are used for hemorrhages, diarrhea, dysentery. A fruit mixed with lemon juice were used to treat acute bacillary, dysentery, fruit juice for inflamed eyes. A fruit with seeds used for asthma, bronchitis and biliousness (Singh *et al.*, 1979) [68]. A decoction of the fruit with stems of *Tinospora cordifolia* is a well known remedy for urinary diseases. It is also part of multi component drugs for hemorrhage, anemia, colic, acute leprosy, jaundice, and cough, indigestion, asthma. The juice of the bark mixed with honey and turmeric used for gonorrhoea. An infusion of leaves with fenugreek seed is given for chronic diarrhea (Jayaweera, 1982) [29]. The Barks have been reputed to exert anti-diarrheic effects and for treatment

of leucorrhoea (Brun and chumacher, 1987) [16]. The fruits have been reputed as a tonic to favor long life, health and young appearance. The fruits are used as an expectorant, an antidote to "mineral" poisons, particularly vermilion and sulfur. The crushed fruits have a good effect on hair growth and prevent hair graying (Stuart, 1911) [74]. In Tibetan medicine, the fruit have been described as having a sour taste with cooling potency. It is used as a febrifuge, as an anti-inflammatory and unusually as an antidiuretic (Tsarong and Tsewang, 1994) [80]. Indonesians used the fruits for the treatment of dysentery, diarrhea, cholera and biliary disorders (Dragendorff, 1898) [20]. The pulp of the fruit is smeared on the head to dispel headache and dizziness caused by excessive heat (Perry and Metzger, 1980) [51].

Uses of Aonla in Cancer

Hepato-cellular carcinoma (HCC) is the fifth most common cancer worldwide and also existing as a leading cause of death (Quaglia and Bhattacharya, 2001) [54]. More and more efforts have been made in search of natural materials and foods as a means of chemical prevention of liver cancer (Young and Lee, 1999) [89]. Only a few studies have speculated the chemo-preventive effects of aonla against liver cancer. It was tested *in vivo* in wistar rats treated with carcinogen Diethyl nitrosamine (DEN) (200mg/kg) to induce liver cancer. The results showed that pretreatment of methanolic fruit extract (100 and 200 mg/kg) exhibited significant pathological manifestations at both the doses. Aonla has the potential to be useful in ameliorating the carcinogen-induced response in rat (Sultana *et al.*, 2008) [75]. According to the World Cancer Report, it constitutes 30% of all newly diagnosed cancers in the world and solar ultraviolet (UV) radiation (particularly, its UVB component; 290-320 nm) is an established cause of 90% of skin cancers (Miller and Weinstock, 1994) [42]. The cancer preventive effect of aonla was investigated on two stage process of skin cancer induced by 7, 12-dimethylbenz (a) anthracene (DMBA) in swiss albino mice. It showed significant chemo-preventive effects on DMBA-initiated and croton oil (1% in 100 μ l of acetone) promoted skin cancer development. *P. emblica* exhibited a significant reduction in tumour incidence, tumour yield, tumour burden and cumulative number of papillomas. These findings were indicative of chemo-preventive potential of *P. emblica* against skin-carcinogenesis (Alam and Gomes, 2003) [3].

Triphala has been reported to exhibit chemo-preventive potential. Triphala also significantly increased the antioxidant status of animals which might have contributed to the chemoprevention (Deep *et al.*, 2005) [19]. The breast-cancer is one of the most common cancers in women. Lipid-metabolizing enzymes, lipids and lipoproteins have been associated with the risk of breast cancer. Kalpaamruthaa (KA) is a modified Siddha preparation containing aonla, *Semecarpus anacardium* (SA) and honey. The elevated levels of free cholesterol, total cholesterol, triglycerides, phospholipids and free fatty acids and decreased levels of ester cholesterol in plasma, kidney and liver found in cancer suffering animals were reverted back to near normal levels on treatment with KA and SA (Veena, *et al.*, 2006) [85]. Chemoprevention with food phyto-chemicals is presently considered as one of the most important strategies to control cancer. Aonla is valued for its unique tannins and flavanoids which exhibit very powerful antioxidant properties. The inhibition of tumor incidences by fruit extract of this plant has been evaluated on two-stage process of skin carcinogenesis in

Swiss albinomice. Chemo-preventive potential of aonla fruit extract on 7, 12-dimethylbenz (a) anthracene (DMBA) induced skin tumorigenesis in Swiss albino mice have been found (Sancheti *et al.*, 2005) [60]. Triphala indicates to its potential use as an anticancer drug for clinical treatment (Sandhya *et al.*, 2006) [61]. The suppression of the growth of cancer cells due to the gallic acid-a major polyphenol as observed in "Triphala" have been reported (Kaur *et al.*, 2005) [35]. Ethanolic extract of aonla was experimentally evaluated for protection against genotoxicity induced by DMBA. The protection induced by aonla might be due to its antioxidant capacity and through its modulatory effect on hepatic activation and detoxifying enzymes (Banu *et al.*, 2004) [12]. Cyclophosphamide is one of the most famous alkylating anticancer drugs in spite of its toxic side effects including hematotoxicity, immunotoxicity and mutagenicity. Aonla or its medicinal preparations may prove to be beneficial as a component of combination therapy in cancer patients under cyclophosphamide treatment (Pandey and Raisuddin, 2001) [49]. Phenolic compounds and the major components from the fruit juice of EO and from the branches, leaves and roots showed stronger inhibition against B16F10 cell growth than against HeLa and MK-1 cell growth. Norsesquiterpenoid glycosides from the roots showed significant anti-proliferative activities (Zhang *et al.*, 2004) [92].

Uses of Aonla in Diabetic

Oral administration of the extracts (100 mg/kg body weight) reduced the blood sugar level in normal and in alloxan (120 mg/kg) diabetic rats significantly within 4 hours. EO and an enriched fraction of its tannoids are effective in delaying development of diabetic cataract in rats (Suryanarayan *et al.*, 2007) [77].

Uses of Aonla in Immuno modulation

Immune activation is an effective as well as protective approach against emerging infectious diseases. Albino rats were used to assess the immune modulatory activities of Triphala on various neutrophil functions like adherence, phagocytic index, avidity index and nitro blue tetrazolium. Oral administration of Triphala appears to stimulate the neutrophil functions in the immunized rats and stress induced suppression in the neutrophil functions were significantly prevented by Triphala (Srikumar, *et al.*, 2005) [72]. Aonla and *Evolvulus alsinoides* (Shankhpushpi) were assessed for its immune modulatory activity in adjuvant induced arthritic (AIA) rat model. Complete Freund's Adjuvant (CFA) was injected in right hind paw of the animals induced inflammation. Lymphocyte proliferation activity and histopathological severity of synovial hyperplasia were used to study the anti-inflammatory response of both the extracts. Both the extracts showed a marked reduction in inflammation and edema and cause immuno suppression in AIA rats, indicating that they may provide an alternative approach for the treatment of arthritis (Ganju, L *et al.*, 2003) [23]. Immu-21 is an Ayurvedic polyherbal formulation containing extracts of EO, *Ocimumsanctum*, *Withaniasomnifera* and *Tinosporacordifolia*. Its immuno modulatory activity was studied on proliferative response of splenic leukocytes to T cell mitogens, concanavalin (Con)-A and phyto hemagglutinin (PHA) and B cell mitogen, lipopolysaccharide (LPS) *invitro* by [³H]-thymidine uptake assay in mice. Pre-treatment with Immu-21 selectively elevated the proliferation of splenic leukocyte to B cell mitogen, LPS and cytotoxic activity against K 562 cells in mice (Nemmani, K.V., *et al.*,

2002)^[45]. Aonla have been reported to inhibit Cr-induced free radical production and also restored the anti-oxidant status back to control level. It relieved the immune suppressive effects of Cr on lymphocyte proliferation and even restored the IL-2 and gamma-IFN production (Sai, *et al.*, 2002)^[59]. Extracts of aonla fruits possess anti-pyretic and analgesic activities. A single oral dose of ethanolic extract and aqueous extract (500 mg/kg.) showed significant reduction in hyperthermia in rats induced by brewer's yeast. Both of these extracts elicited pronounced inhibitory effect on acetic acid-induced writhing response in mice in the analgesic test (Perianayagam *et al.*, 2004)^[50]. This may be due to the presence of tannins, alkaloids, phenolic compounds, amino acids and carbohydrates.

Uses of Aonla in Memory Enhancing

Amla-churna produced a dose-dependent improvement in memory of young and aged rats. It reversed the amnesia induced by scopolamine and diazepam. Amla-churna may prove to be a useful remedy for the management of Alzheimer's disease due to its multifarious beneficial effects such as memory improvement and reversal of memory deficits (Vasudevan and Parle, 2007)^[84]

Uses of Aonla in management of Ophthalmic Disorders

Ophthacare is a herbal eye drop preparation containing basic principles of different herbs viz *Carumcopticum*, *Terminaliabelerica*, aonla, *Curcuma longa*, *Ocimum sanctum*, *Cinnamomum camphora*, *Rosa* conducted in patients suffering from different ophthalmic disorders namely, conjunctivalxerosis, conjunctivitis, acutedacryo cystitis, degenerative conditions and postoperative cataract patients with a herbal eye drop preparation. In most cases improvement was observed with the treatment of the herbal eye drop. During the course of study no side effects were observed and the eye drop was well tolerated by the patients. Ophthacare exhibit beneficial role in a number of inflammatory, infective and degenerative ophthalmic disorders (Biswas *et al.*, 2001)^[15].

Uses of Aonla in Reducing Cholesterol and Dyslipidemia

Cu (2+) induced LDL oxidation and cholesterol-fed rats were used to investigate the effects of Aonla on low-density lipoprotein (LDL) oxidation and cholesterol levels *in vitro* and *in-vivo*. It was concluded that Aonla may be effective for hypercholesterolemia and prevention of atherosclerosis (Kim *et al.*, 2005)^[36]. Aonla and *Mangifera indica* contains flavonoids which reduce the levels of lipid in serum and tissues of rats induced hyperlipidemia. Both cause the degradation and elimination of cholesterol (Anila and Vijayalakshmi, 2002)^[5].

Uses of Aonla as Snake Venom Neutralizer

Aonla and *Vitex negundo* were explored for the first time for anti-snake venom activity. *Najakaouthia* and *Viperarussellii* venom was antagonized by the plant extracts significantly both *in-vivo* and *in-vitro* studies. *V. russellii* venom-induced coagulant, haemorrhage defibrinogenating and inflammatory activities were significantly neutralized by both plant extracts. No precipitating bands were formed between the snake venom and plant extract which confirmed that the plant extracts possess potent snake venom neutralizing capacity and need further investigation (Alam and Gomes, 2003)^[3].

Uses of Aonla as antimicrobial and antimutagenicity activities

Aonla has been reported for the antimicrobial activities (Srikumar *et al.*, 2007)^[71]. The plant have been reported to possess potent antibacterial activity against *Escherichia coli*, *K. ozaena*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *S. paratyphi A*, *S. paratyphi B* and *Serratiamarcescens* (Saeed and Tariq, 2007)^[58]. Water, chloroform and acetone extracts of Triphala were investigated to evaluate an anti-mutagenic effect using an Ames histidine reversion assay having TA98 and TA100 tester strains of *Salmonella typhimurium* against the direct-acting mutagens, 4-nitro-o-phenylenediamine (NPD), sodium azide and the indirect-acting promutagen, 2-aminofluorene (2AF), in the presence of phenolbarbitone-induced rat hepatic S9. The results with chloroform and acetone extracts showed inhibition of mutagenicity induced by both direct and S9-dependent mutagens (Kaur *et al.*, 2002)^[34].

Uses of Aonla in curing of other diseases

Triphala containing one of the ingredients as aonla is used to treat diseases such as anemia, fever, chronic ulcers, constipation, jaundice and asthma. Polyphenolic fractions isolated from Triphala exhibit anti-mutagenic effect (Singh *et al.*, 2008)^[69]. Active principles of Triphala were further evaluated and used as an excellent the rapeutic formulation for infected wounds. Aqueous plant extract was tested on Swiss albino mice for its radio-protective properties against sub-lethal gamma radiation (9 Gy). Most effective dose of fruit pulp extract was found to be 100 mg/kg body weight against radiation. This dose elevated the survival time and lowered the mortality rate of mice significantly. Furthermore, body weight loss in extract administered irradiated animals was significantly less in comparison with animals who were given radiation only (Singh *et al.*, 2005)^[70]. Flavonoids derived from aonla exhibit maximum beneficial action by eliciting highly potent hypolipidaemic and hypoglycaemic activities. In addition to this, flavonoids were found to be effective in elevating the haemoglobin levels in rats (Anila and Vijayalakshmi, 2000)^[4]. It is also reported to be as antitumor (Jose *et al.*, 2001)^[31]. Aonla has been evaluated against thioacetamide (TAA) and CCl induced changes in rat liver. Treatment with TAA and CCl produced abnormal histopathology indicative of pre-fibrogenic events. Aonla reversed such alterations with significant regenerative changes indicating its preventive role in prefibrogenesis of liver (Mir, *et al.*, 2007)^[43]. Extract of *Withania. Somnifera* root, but not aonla fruit, caused a reproducible, dose dependent, inhibition of colony formation of CHO cells (Sumantran *et al.*, 2007)^[76]. Hyper-cholestermia is one of the factors that create coronary artery disease. Triphala formulation exhibit hypolipidemic effects on the experimentally induced hyper cholesteremic rats were reported (Saravanan *et al.*, 2007)^[64].

Uses of Aonla in antigenotoxicity

The protective effect of aonla fruit extract against clastogenecity induced by lead nitrate on the incidence of sperm head abnormalities in the germ cells of mice. The results clearly indicate that extract exhibited significant reduction in the frequency of sperm head abnormalities. The finding of the above study shows that *P. emblica* plays a key role in inhibition of heavy metal mutagenesis in mammals

(Srikumar *et al.*, 2007) [71]. The ethanolic extract of aonla fruit extract was evaluated for protection against geno-toxicity induced by the rodent carcinogen, 7,12-dimethylbenz(a) anthracene (DMBA). The results showed that extract significantly increases glutathione (GSH), glutathione peroxidase (GPx), glutathione reductase (GR) and detoxifying enzyme glutathione-S-transferase (GST). The extract also reduced the hepatic levels of the activating enzymes cytochrome (CYt) P450 and Cyt b5. The protection afforded by aonla may be associated with its antioxidant capacity and through its modulatory effect on hepatic activation and detoxifying enzymes (Saeed and Tariq, 2007) [58]. An aqueous extract of *Embllica officinalis* fruit protected mice against the chromosome damaging effects of the well known carcinogen 3,4-benzopyrene (Kaur *et al.*, 2002) [34].

Uses of Aonla in antimutagenicity

The activation and mutagenicity of 2 Acetamidofluorene (2AAF) was inhibited by *P. emblica*. It also inhibits the cytochrome P-450, aniline hydroxylase. The antimutagenic potential of water, acetone and chloroform extracts of *Embllica officinalis* has been evaluated on sodium azide and 4-nitro-o-phenylenediamine induced his revertants in TA100 and TA97 tester strains of *Salmonella typhimurium*. The study revealed that chloroform extract was less active compared with water and acetone extracts (Singh *et al.*, 2008) [69].

Uses of Aonla in toxicology

Phyllanthus emblica has been widely consumed by persons for thousands of years, largely without untoward incident, and thus is considered generally safe. It was found to be non-toxic to human and experimental animals (Jose *et al.*, 2001) [31]. No toxicity or mutagenicity was observed in the toxicological results of the experimental models in the highest dose range (Mir *et al.*, 2007) [43]. Toxicological studies in animals stated that LD50 for orally administered extract in rats was reported to be about 1 g/kg body weight (Sumantran *et al.*, 2007) [76], (Saravanan *et al.*, 2007) [64].

Conclusions

Aonla is a versatile plant due to its various medicinal properties. It is one of the oldest medicinal plant mentioned in Ayurveda as potential effects for various ailments. Fruit of *Embllica officinalis* are rich in Vitamin C, phyllaemblic compounds, gallic acid, tannins, flavonoids, pectin, and quercetin and also contains various polyphenolic compounds. A variety of phytochemicals such as tannins, flavonoids, terpenoids, alkaloids are reported to indicate several pharmacological properties such as antioxidant, anticancer, antitumor, antigenotoxic, and anticarcinogenic effects. It is considered to be a safe herbal medicine without any adverse effects.

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