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SPINACIA OLERACEA LINN: A PHARMACOGNOSTIC AND PHARMACOLOGICAL OVERVIEW

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Received: 06-07-2010; Revised: 12-08-2010; Accepted: 16-09-2010

ABSTRACT

Herbal and natural products of folk medicine have been used for centuries in every culture throughout the world. Scientists and medical professionals have shown increased interest in this field as they recognize the true health benefits of these remedies. “Let food be your medicine and let medicine be your food” was advised by the father of medicine, Hippocrates, over two million ago. It’s still true today that “you are what you eat.” Spinach is a leafy green vegetable that came originally from south-western Asia and is now grown in most parts of the world. Scientifically it is known as *Spincia oleracea* Linn. (Family-Chenopodiaceae). Though Spinach is most often used as a food, it has medicinal value as well. Spinach is packed with vitamins such as vitamin C, vitamin A and vitamin E and minerals like magnesium, manganese, iron, calcium and folic acid. Spinach is also a good source of chlorophyll, which is known to aid in digestion. Spinach is also rich in the carotenoids beta-carotene and lutein. It is a good source of the bioflavonoid quercetin with many other flavonoids which exhibits anti-oxidant, antiproliferative, antiinfammatory, antihistaminic, CNS depressant, protection against gamma radiation, hepatoprotective properties in addition to its many other benefits. Spinach is also used to prevent the bone loss associated with osteoporosis and for its anti-inflammatory properties in easing the pain of arthritis. Spinach is good for the heart and circulatory system and has energy-boosting properties. Spinach is truly one of nature's most perfect foods.

KEYWORDS: *Spinacia oleracea*, Spinach, Flavonoids, Antioxidant.

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INTRODUCTION

Plants are one of the most important sources of medicines. The medicinal plants are rich in secondary metabolites (which are potential sources of drugs) and essential oils of therapeutic importance. The important advantages claimed for therapeutic uses of medicinal plants in various ailments are their safety besides being economical, effective and their easy availability[1]. *Spinacia oleracea* Linn. (SO) is an annual plant having medicinal property native to central and southwestern Asia. It is cultivated for the sake of its succulent leaves and was introduced in Europ in the 15th century. It is the favorite food among Indians in winter season[2]. The *Spinacia oleracea* is commonly known as Spinach (English), Chhurika (Sanskrit), Palak (Hindi; Gujarati; and Marathi), Palakh (Kashmiri), Palang (Bangla), Pasalai (Tamil), and Mathubucchali (Telugu)[3]. In different traditional medicinal system it is known by different names. It's Ayurvedic name is 'Paalankikaa', in 'Unani' it is called as 'Paalak', where as in 'Siddha' it is known by 'Vasaiyila-keerai'[4].

PLANT PROFILE

***Spinacia oleracea* Linn**

Scientific Classification

Kingdom	: Plantae
Subkingdom	: Tracheobionta
Superdivision	: Spermatophyta
Division	: Magnoliophyta
Class	: Magnoliopsida
Subclass	: Caryophyllidae
Order	: Caryophyllales
Family	: Chenopodiaceae
Genus	: Spinacia L.
Species	: *Spinacia oleracea* L.[5]

BOTANICAL DESCRIPTIONS

Stem: Erect from 30-60 cm high, round, smooth, piped, succulent, sometime reddish.

Leaves: Alternative, the lower ones very long petioled, variously lobed with lobes of an acute triangular shape, smooth on both the side.

Flowers

Male- Flowers on long terminal glomerate spikes and on shorter ones from the axial, very numerous, sessile, calyx 4-parted, stamen 4, anthers twin, very large.

Female- Flowers axillary, sessile, crowded. Calyx 2-tipped with a projecting horn in each side, growing into spines when the seed is ripe. Styles generally 4, white tapering. Capsule 1-celled, 1-valved, armed, with 2 opposite short horns, and crowned with the small remaining calyx [3]. (Figure 1)

CHEMICAL CONSTITUENTS

1. Flavonoids: *Spinacia oleracea* is very rich in the flavonoids. Various flvonoids reported to be present are querecetin; myricetin; kampeferol[6]; apigenin; luteolin; patuletin; spinacetin; jaceidin; 4'-glu-curonide; 5,3',4'-trihydroxy-3-methoxy-6:7-methylenedioxyflavone-4'-glucuronide; 5,4'-dihydroxy-3.3'-dimethoxy-6:7-methylene dioxyflavone-4'-glu-curonide[7]; 5,4'-dihydroxi-3,3'-dimithoxi-6,7-methylene-dioxi- flavone (C18H14O8.); 3,5,7,3',4'pentahydroxi-6-methoxiflavone[8].

2. Phenolic Compounds: The polyphenols isolated from the plant are *para*-coumaric acid, ferulic acid, *ortho*- coumaric acid [9].

3. Carotinods: Spinach shows presence of different carotinoids like lutein, β-carotene, violaxanthin and 9'-(Z)-neoxanhin[2].
4. Vitamins: *Spinacia oleracea* contains high concentration of vitamin A, E, C, and K. and also folic acid, oxalic acid[2].
5. Minerals: Along with these chemicals various minerals present in the spinach. These are magnesium, manganese, calcium, phosphorus, iron[2], zink, copper and potash[8].

DITRIBUTION

Native to South- west Asia; cultivated throughout India[4].

TRADITIONAL USES

The plant is sweet, cooling, carminative, laxative, alexipharmic; useful in diseases of blood and brain, asthma, leprosy, biliousness; causes "kapha" (Ayurveda). It has been used in the treatment of urinary calculi. In experiments it has been shown to have hypoglycemic properties.

The leaves are cooling, emollient, wholesome, antipyretic, diuretic, maturant, laxative, digestiblle, anthelmentic, useful in urinary concretion, inflammation of the lungs and the bowels, sore throat, pain in joints, thirst, lumbago, cold and sneezing, sore eye, ring worm scabies, leucoderma, soalding urine, arrest vomiting , biliousness, flatulence. And have been used in the treatment of febrile conditions.

The seeds are useful in fevers, leucorrhoea, urinary discharges, lumbago, diseases of the brain and of the heart (Yunani). Seeds are laxative and cooling. They have been used in the treatment of difficulty in breathing, inflammation of the liver and jaundice. The green plant is given for the urinary calculi[3,10].

PHARMACOLOGICAL ACTIVITIES

Protection Against Gamma Radiation

The protective effect of 1100 mg/kg/day of 50% methanolic extract of *Spinacia oleracea* L. (MESO) against radiation-induced oxidative stress were evaluated in terms of lipid peroxidation (LPO) product and tissue levels of glutathione. The animals were exposed to gamma radiation at a rate of 1.07 Gy/min with a source-to-surface distance of 77.5 cm. The animals were autopsied at 1, 3, 7, 15 and 30 days post-exposure. LPO increased after irradiation up to day 15 in the untreated-irradiated mice and up to day 7 in MESO pre-treated irradiated mice. LPO values were significantly lower in the MESO pre-treated irradiated mice as compared to respective untreated-irradiated mice at all intervals, which reached normal values from day 7 onward.

It was found that radiation-induced augmentation in malondialdehyde contents and depletion in glutathione changes in liver can be altered by MESO. The protection may be attributed to the combined effects of its constituents rather than to any single factor as the leaves are rich in carotenoid content (b-carotene, lutein, Zeaxanthine), ascorbic acid, flavonoids and p-coumaric acid[11].

The radioprotective efficacy of spinach against radiation induced oxidative stress was studied by Verma and Bhatia in 2003. For the experiments, Swiss albino male mice treated with *Spinacia oleracea* leaves alcoholic extract (SE) once daily at the dose of 1100 mg/kg/day p.o. for 15 days. The animals are exposed to single dose of 5 Gy of gamma radiation at the dose rate of 1.07 Gy/min. After the exposure mice were sacrificed at different autopsy intervals viz. 1, 3, 7, 15 and 30 days. Brain was removed and processed to estimate LPO.

Radiation induced significant elevation in the LPO values, which were lowered by supplementation of SE prior to irradiation at all the intervals studied. The protection rendered with SE in LPO value of brain in this study indicates the possible role *Spinacia oleracea* as radioprotector to some extent if taken continuously which might be due to synergistic effect of antioxidant constituents present in the spinach[12].

Antioxidant Activity

The chemical fraction of natural antioxidant (NAO) components in *Spinacia oleracea* was reported by Grossman in 2001. Spinach leaves were extracted with water and the 20,000 g supernatant which contained the antioxidant activity was extracted with a water:acetone (1:9) solution. The 20,000 g supernatant obtained was further purified on reverse phase HPLC using C-8 semi-preparative column. Elution with 0.1% TFA resulted intensive hydrophilic peaks.

Elution with acetonitrile in TFA resulted in seven additional hydrophobic peaks. All the peaks were detected at 250 nm. All the fractions obtained showed antioxidant activity when tested using three different assays. Based on ^{1}H and ^{13}C NMR spectroscopy four of the hydrophobic fractions were identified as glucuronic acid derivatives of flavonoids and three additional fractions as trans and cis isomers of p-coumaric acid and others as meso-tartarate derivatives of p-coumaric acid. The study demonstrated for the first time the presence of both flavonoids and p-coumaric acid derivatives as antioxidant components of the aqueous extract of spinach leaves[13].

Inhibition of Mammalian DNA Polymerases

The purification of the major glycolipids in the class of monogalactosyl diacylglycerol (MGDG), digalactosyl diacylglycerol (DGDG) and sulfoquinovosyl diacylglycerol (SQDG), from green vegetable spinach (*Spinacia oleracea* L.) was reported. MGDG was an inhibitor of the growth of NUGC-3 human gatric cancer cell, but the DGDG and SQDG has no cytotoxic effect. So researcher studied MGDG and its monoacylglycerol-form, monogalactosyl monoacylglycerol (MGMG) in detail. MGMG with one fatty acid molecule was obtained from MGDG with two fatty acid molecule by hydrolizing with the pancreatic lipase. MGMG was also found to prevent the cancer cell growth. MGDG was the potent inhibitor of replicative DNA polymerases such as α ó and ε. MGMG inhibited the activities of the all mammalian DNA polymerases including repair-related DNA polymerases β with IC_{50} value of 8.5-36 µg/ml and the inhibition by the MGMG was stronger than that by the MGDG. Both the MGDG and MGMG could halt the cell cycle at G 1 phase, and subsequently induced severe apoptosis[14].

Sulphite Oxidase Activity

The spinach chloroplasts possess a sulphite oxidase activity coupled with oxygen consumption and reduction of ferricyanide. This activity is associated with thylakoids and solubilized by non-ionic biological detergents. The pH and temperature dependencies of sulphite oxidase activity solubilized by Triton X-100 from spinach thylakoids were consistent with those of an intrinsic membrane protein. This isolated activity was insensitive towards radical scavengers (mannitol, mannose and fructose) and catalase, and was inhibited only with very high concentrations of superoxide dismutase. Thus, observed sulphite oxidation was not induced through the photosynthetic electron transport system, but achieved via a thylakoid membrane enzymic system showing a sulphite oxidase activity. Kinetic parameters of thylakoid sulphite oxidase were measured and compared with those of other sulphite oxidases[15].

Hepatoprotective Activity

Gupta and Singh 2006 reported the amelioration by Spinacia *oleracea* L. leaves alcoholic extract (SE) against the hepatosuppression induced by carbon tetrachloride (CCl_4). This was evaluated in terms of serum-marker enzymes like GGT, AST, ALT , LDH, SDH, GDH, ALP, serum-total bilirubin and total protein levels along with concomitant hepatic-antioxidants like SOD, CAT ,GSH , GPx GR, GST ,ascorbic acid (vitamin-c), β-carotene and cytochrome *P*-450 enzyme. Whereas, LPO was monitored in both serum and liver. These biochemical parameters were significantly ($P<0.001$) altered by the single dose of CCl_4 (1.0 ml/kg, i.p., with olive oil, 1:1).

Pretreatment with SE prior to the administration of CCl_4, at the doses of 100 and 200 mg/kg/day, p.o. for 7 days, significantly restored to all the serum and liver parameters near to the normal levels. The hepatoprotective potential of *S. oleracea* L. against hepatosuppression possibly involves mechanism related to its ability to block the *P*-450 mediated CCl_4 bioactivation through selective inhibitors of ROS (reactive

oxygen species). Thus *S. oleracea* L., showing protection in liver, may prove as a rich source of antioxidants[16].

Inhibition of Clastogenisity

The homogenate of spinach reduces induction of micronuclei by benzo[*a*]pyrene (BaP) by 43–50% in the in vivo mouse bone marrow micronucleus assay. Inhibition of genotoxicity by spinach was not caused by any delay in maturation of micronucleated erythrocytes as shown by experiments with sampling times of 24, 48, and 72 h after dosing of BaP. Pre-treatment of the mice with spinach 48, 24, and 12 h before application of BaP resulted in a 44% reduction of micronuclei.

A post-treatment procedure administering spinach 6 h after dosing of BaP did not indicate any protective effects. When *trans*-7,8-dihydroxy-7, 8-dihydrobenzo[*a*]pyrene (BaP-7,8-OH) was applied for induction of micronuclei spinach reduced the number of micronuclei by 55%. Pre-treatment of mice with spinach 96, 72, and 60 h before sacrifice caused a decline of hepatic 7-ethoxyresorufin-*O*-dealkylase (EROD) and of 7-pentoxyresorufin-*O*-dealkylase (PROD) activities by factors of 2.2 and 1.4, respectively. However, statistical significance was not reached[17].

Anticancer Activity

In one study spinach ethanol extract (SE) and the three fractions by the hydrophobic column chromatography were investigated for their inhibition of calf, DNA polymarases (pol). The spinach glycoglycerolipid fraction dose dependent inhibited the activity of pol α with IC50 value of 43.0μg/ml and the fat soluble fraction slightly inhibited the activity of pol α, although the water soluble fraction did not show such an effect. The ethanol extract from spinach had no effect on pol α, although the extract contains pol inhibitory glycoglycerolipid. This concluded that the spinach glycoglycerolipid fraction can inhibit mammalian pol activity, human cultured cancer cell growth, and in vivo solid tumor proliferation with oral administration. This fraction could help to prevent cancer and be a functional food with anticancer activity[18].

CNS Depressant Effect

Treatment with Spinacia oleracea extract (SO; 400 mg/kg body weight) decreased the locomotor activity, grip strength, increased pentobarbitone induced sleeping time and also markedly altered pentylenetetrazole induced seizure status in Holtzman strain adult male albino rats. SO increased serotonin level and decreased both norepinephrine and dopamine levels in cerebral cortex, cerebellum, caudate nucleus, midbrain and pons and medulla. Result suggests that SO exerts its CNS depressive effect in PTZ induced seizure by modulating the monoamines in different brain areas[2].

Inhibition of Proliferation of Human Gastric Adenocarcinoma Cells

Four kinds of assays (i) cell growth assay, (ii) colony forming assay, (iii) MTT colorimetric assay, and (iv) 3H-TdR incorporation assay, were used to study the effect of a fat-soluble extract of spinach powder (SPFE) on the proliferation of human gastric adenocarcinoma cell line (SGC-7901) in vitro. The concentrations of SPFE expressed as the level of beta-carotene in the medium were 2 x 10(-8), 2 x 10(-7) and 2 x 10(-6) mol/L beta-carotene in assay (i)-(iii), but 4 x 10(-8), 4 x 10(-7) and 4 x 10(-6) mol/L beta-carotene in assay (iv) respectively. The results indicated that SPFE inhibited the proliferation and colony forming ability of SGC-7901 cells. And in MTT assay, SPFE inhibited the viability of SGC-7901 cells, but no inhibitory effect of SPFE was observed on the viability of lymphocytes in peripheral blood of healthy people. Finally, in the 3H-TdR incorporation test, both SPFE and beta-carotene showed significant inhibitory effects on DNA synthesis in SGC-7901 cells, but SPFE was more effective than beta-carotene[19].

Anthelmintic Activity

Dave et al., 2009 evaluated the anthelmintic activity of crude extract of *Spinacia oleracea* Linn. and different extract namely fresh juice extract and methanolic extract using *Pheretima posthuma* as test worms. Different concentrations 10 mg/ml, 20 mg/ml, 30 mg/ml, 40 mg/ml and 50 mg/ml of fresh juice extract and methanolic extract of Spinacia oleracea Linn (MSO) were studied to determine the time of paralysis and time of death of worms. Both the extract performed invitro anthelmintic activity. Albendazole was used as

standard reference and saline water as control. The result was revealed that the fresh juice extract may show more potent anthelmintic activity than MSO[20].

CONCLUSION

Spinach (*Spinacia oleracea* L.) is a leafy vegetable that belongs to the goosefoot family. Various pharmacological activities of *Spinacia oleracea* such as, anti-oxidant, antiproliferative, antiinfammatory, antihistaminic, CNS depressant, protection against gamma radiation, hepatoprotective have been reported. Various secondary metabolites like flavanoids, carotinoids, phenolic compounds have been reported from this plant. Thus *Spinacia oleracea* merits further phytochemical, pharmacological and clinical investigations for development of an effective natural remedy to provide therapeutically effective lead compounds or extracts.

ACKNOWLEDGEMENT

Authors are thankful to Rajgad Dnyanpeeth's College of Pharmacy, Bhor for providing platform to carryout this work.

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Figure 1: *Spinacia oleracea*

Source of support: Nil, Conflict of interest: None Declared