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Saffron: A golden condiment and a repository of nutraceutical potential

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Saffron (*Crocus sativus* L.) is one of the world's most valuable condiments, whose dried stigmas have been used since antiquity for culinary and medicinal purposes. The ethnobotanical data reveal that the plant and stigma extracts have many medicinal properties. On the basis of ethnobotanical data, lots of research has been done to determine the nutraceutical potential of saffron. The studies reveal that saffron extracts increase memory retention; reduce coronary artery disease and blood pressure, have anti-depression, anti-inflammatory, antigastric, anti-parkinsonian, anti-mutagenic, tumoricidal, cytotoxic, anti-hyperglycemic, pancrease protective effects and many more. Saffron being a rich source of carotenoids also has anticancer and antitumor properties. Being a repository of medicinal benefits, the potential can further be explored and exploited to develop new formulations and this 'golden condiment' can be used as a complete and promising functional food.

Key Words : *Crocus sativus*, Indigenous medicine, Golden condiment, Nutraceutical potential

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INTRODUCTION

About 2,500 years ago Hippocrates was first to suggest the healing power of foods. He stated "Let food be thy medicine and medicine be thy food." Now consumer following this idea, believes in supporting a healthier life by choosing specific foods that provide health benefits beyond their basic nutritional values. Potentially all foods have nutritional value, aroma and taste, but now people are looking for foods having additional physiological properties like antioxidant potential, immune-modulatory potential, aiding digestion, anti-cancer properties and many more supporting health benefits. Saffron, the world most valuable condiment has attracted the world's attention because it has culinary aspects, health benefits and immense nutraceutical potential (Srinivasan, 2007).

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Saffron is a condiment which has been used since antiquity in our day to day life. The cultivation of saffron is about 2,500 years ago and has been used for medicinal purposes since decades. Modern pharmacological research confirms large parts of traditional knowledge regarding the medicinal effects of saffron (Wani *et al*., 2010). Saffron is a native of Southern Europe and cultivated in Mediterranean countries, particularly in Spain, Austria, France, Greece, England, Turkey, and Iran. Iran is considered to be one of the latest producers of saffron and nearly 90 per cent of the production of saffron is produced in here only (Moghaddasi, 2010).

According to some historical evidences, saffron was brought to India by the Persian rulers around 500B.C, whereas, some Hindu epics mention that the plant had been cultivated in Kashmir for more than two millennia (Saffron flower in India, 2013). At present, saffron in India is cultivated in the states of Jammu and Kashmir and Himachal Pradesh. The status of saffron production in India is given in the Table 1.

Biology of saffron:

Saffron (*Crocus sativus* L.) is a bulbous perennial plant belonging to family Iridaceae and popularly known as 'Golden

Table 1 : Status of saffron production in India (Source: Spices Board India, 2013)

Year	Area (in hectares)	Production(in tonnes)
2008-09	2667	5.93
2009-10	2691	4.86
2010-11	2715	7.99
2011-12	2989	9
2012-13(Estimated)	2989	8.85

Condiment'. The plant does not propagate by seeds, the underground portion - corms, divide to produce new plants (Fig. 1a). The lilacs to mauve colored flower emerge in autumn and have three stigmas 25 - 30 mm long (Fig. 1 b and c). There are also three yellow stamens which are not collected because they usually lack the active compounds. The stigma is attached to a style, which has little of the active components and is only included with the lower grades of saffron. Each bulb produces from one to seven flowers. It takes about 36,000 flowers to yield just 1 pound of the stigmas.

Fig. 1 (a): Saffron corm (b) Saffron floweres (c) Saffron stigmas

Chemical composition of saffron:

Saffron contains many active compounds as shown in Table 2. There are varieties of chemical components present in the stigma of the saffron plant. Stahl and Wagner (1969) had also done the microanalysis of important constituents of saffron. Among the estimated 150 volatile compounds found in saffron, approximately 40-50 constituents have been identified so far (Winterhalter and Straubinger, 2000). Crocin ($C_{44}H_{64}O_{24}$) is the most important chemical in the coloring of saffron.

Table 2: Proximate analysis of saffron (Srivastava *et al.*, 2010)

Components	Mass percentage
Water soluble components	53.0
Moisture	10.0
Gums	10.0
Starch	6.0
Pentosans	8.0
Pectin	6.0
Starch	6.0
Crocin	2.0
Carotenoids	1.0
Lipids	12.0
Valatile oil	1.0
Non-volatile oil	6.0
Proteins	12.0
Inorganic matter	6.0
HCI soluble ash	0.5
Crude fibres	5

Table 2a : Saffron (*C. sativus*) nutritional value per 100 g (Source: USDA, 2013)

Principal	Nutrient value	Percentage of RDA %
Energy	310 Kcal	15.5
Carbohydrates	65.37 g	50
Protein	11.43 g	21
Total fat	5.85 g	29
Cholesterol	0 g	0
Dietry fibre	3.9 g	10
Vitamins		
Folates	93 mcg	23
Niacin	1.46 mg	9
Pyridoxine	1.010 mg	77
Riboflavin	0.267 mg	20
Thiamin	0.115 mg	10
Vitamin C	80.8 mg	90
Vitamin A	530 IU	18
Electolytes		
Potassium	1724 mg	37
Sodium	148 mg	10
Minerals		
Calcium	111 mg	11
Copper	0.328 mg	37
Iron	11.10 mg	139
Magnesium	264 mg	66
Manganese	28.408	1235
Phosphorus	252 mg	36
Zinc	1.09 mg	10

Traditional medicinal uses of saffron:

Saffron stigmas have been used for medicinal purposes since decades. The ethnobotanical data reveal that the stigmas are having immense medicinal values. Saffron gets mention even in the oldest Ayurveda treatises like Charaka Samhita and Sushruta Samhita (Medicines and Saffron, 2013). It is one of the important ingredients of many indigenous medical treatments and also called: kumkum, Kesar, Kashmiran, Bahleeka, and Sankocha (Harper, 2001). Kalha and Gupta (2009) also mention saffron as one of the legendary crops. On account of its strong aphrodisiac, cardiotonic, carminative, diaphoretic, diuretic, stimulant, lactogogue, livotonic, nervine tonic, sedative and styptic properties, it has been highly valued in Ayurvedic medicines. It is also being used in acne, apoplexy, arthritis, asthma, colic, cough dyspepsia, hemierania, insect bites and stings, liver disorders, mental disorders, neurasthenia, oedema, painful menstruation, phthisis, prolapsed anus, sore throat and spleen disorders. It is attributed with extraordinary properties for improving weak eyesight and highly valued as a complexion builder (Chopra *et al.*, 1956).

Saffron has been used for medicinal purposes since decades. The ethnobotanical data confirm the traditional knowledge regarding the medicinal effects of saffron. The indigenous medicinal properties attributed to saffron are extensive. Some traditional health benefits of saffron are as follows:

– Helps in digestion, strengthens the stomach and is anti-tympanites, cures amoebic dysentery, inflammation of the liver, treat digestive disturbance.
– Activates the sexual desire, aphrodisiac in nature.
– Decoction is analgesic in nature, especially for colicky pains and gingivitis.
– Fights tumors and collection of free radicals (thus reacting against cancerous cells) decoction is euphoriant and alleviates neuralgia.
– Decoction also acts as a tranquilizer and also cures insomnia.
– Strengthens memory power, improve concentration, fights depression, helps in fighting Alzheimer's and Parkinson's diseases.
– Lowers the high cholesterol levels.
– Cures iron deficiency (anemia) in girls.
– Reduces chances of such heart diseases such as arteriosclerosis, and helps in improving heart conditions (due to the presence of thiamin, riboflavin and mineral components), controls blood pressure disorders.
– Cures respiratory disorders such as asthma, cough, influenza and cold.
– Helps in blood circulation in the retina and cures macula lutea.
– Cures rheumatism and bruises when used externally.
– Paste is applied to improve the overall skin condition, and specifically, to treat acne.
– Used to improve blood circulation and has emmenagogic properties.
– Regulates menstruation. The decoction of this condiment is useful in promoting and regulating menstrual periods. It soothes lumbar pains, which accompany menstruation.
– Saffron is also used as strengthening agent for the heart and as a cooling agent for the brain.
– Cures urogenital infections, found beneficial in the treatment of urinary problems. It acts as a diuretic, if soaked overnight in water and administered with honey. Saffron is also beneficial in the treatment of other ailments concerning female urino-genital system such as leucorrhoea and hysteria. Pessaries of saffron are used in painful conditions of the uterus. Saffron oil is used as an external application in uterine sores.
– A combination of saffron stigmas and ghee is used to treat diabetes.

Saffron: a repository of nutraceutical potential:

Biesalski (2001) defined nutraceuticals as "A food or part of food, that provides medical or health benefits, including the prevention and treatment of disease". Nutraceuticals are natural, bioactive, chemical compounds that have health promoting, disease preventing or medicinal properties. Arising from the awareness of the relationship between diet and disease has evolved the concept of nutraceuticals. Saffron is cultivated in different parts of the world and its wide range of medical uses, it has undergone extensive phytochemical and biochemical studies and variety of biologically active ingredients has been isolated. Characteristic components of saffron are crocin – responsible for the colour, picrocrocin – responsible for the bitter taste and safranal – responsible for the odor and aroma. Due to all the active constituents present, saffron has immense nutraceutical potential. Schmidt *et al*. (2007) also studied the pytotherapy, pharmacology and clinical uses of saffron. In the last two few decades there has been an upsurge on the use of saffron as nutraceutical, which has been thoroughly investigated and authenticated for medicinal use.

The nutraceutical potential of saffron extracts are mentioned below:

Anti-depression effect:

The aqueous and ethanolic extracts of the petal and stigmas showed the antidepressant effect (Karimi *et al.*, 2001). Hosseinzadeh *et al.* (2004) reported two constituents of saffron, safranal and crocin, have antidepressant activity in mice. The efficacy of petal of *C. sativus* in the treatment of mild-to moderate depression was confirmed by Akhondzadeh *et al.* (2007) and Moshiri *et al.* (2006). Hosseinzadeh and Sadeghnia (2007) results indicate that the saffron petal component, kaempferol, may be a valuable agent in the treatment of depression.

Effect on memory:

Memory is the ability of an individual to record the information and recall it whenever needed. Dementia is a mental disorder characterized by loss of intellectual ability which invariably involves impairment of memory. The most common cause of dementia is Alzheimer's disease. The saffron extracts containing two of its main ingredients crocin and crocetin, improved memory and learning behaviour impairments in mice and rats. Oral administration of saffron may be useful as treatment for neurodegenerative disorders and related memory impairment (Jagdeep *et al.*, 2009; Abe and Saito, 2000; Abe *et al.*, 1999; Sigura *et al.*, 1995).

Effects on ocular blood flow and retinal function:

Active constituents of saffron significantly increased the blood flow in the retina and choroid as well as facilitated retinal function recovery, and could also be used to treat ischemic retinopathy and/or age-related macular degeneration (Xuan, 1999).

Effect on coronary artery disease:

Due to presence of crocetin, saffron extract helps to reduce cholesterol level in the blood and severity of atherosclerosis, thus, reducing the chances of heart attacks. Saffron extracts have anti-depressant value. 50 mgs of saffron dissolved in 100 ml of milk was administered twice a day to human and there was significant decrease in lipoprotein oxidation susceptibility in patients with coronary artery disease (Verma and Bordia, 1998).

Effect on blood pressure:

Fatehi *et al.* (2003) observed that the aqueous and ethanolic extract of saffron reduces the blood pressure in a dose dependent manner. In a study, it was found that 400 mg daily doses of saffron for 7 days resulted in decrease in standing systolic blood pressure and mean arterial pressure (Modaghegh *et al.*, 2008).

Anti-nociceptive and anti-inflammatory effects:

Saffron stigma and petal extracts exhibited antinociceptive effects in chemical pain test as well as acute and/or chronic anti-inflammatory activity. These effects have been due to their content of flavonoids, tannins, anthocyanins, alkaloids and saponins (Hosseinzadeh and Yiounesi, 2002).

Anti-convulsant effect:

Saffron extracts have been reported to show behavioural effects on the central nervous system. Zhang *et al.* (1994) reported that an alcoholic extract of *C. sativus* decreased the motor activity and prolonged the sleeping time induced by hexobarbital. This study suggests that the ethanolic extract possesses sedative effects, which are probably responsible for the anticonvulsant effect of the extracts (Hosseinzadeh and Khosravan, 2002; Hosseinzadeh and Talebzadeh, 2005).

Anti-gastric effects:

Saffron is largely used as an indigenous medicine across India. It enjoys great reputation as a drug which strengthens the functioning of the stomach and promotes its action. It also counteracts spasmodic disorders and sustains the contraction of involuntary muscle. It is beneficial in the treatment of several digestive disorders, especially valuable in flatulent colic. It is also used in the fevers, melancholia and enlargement of the liver and spleen. It is used in medicines that reduce inflammation. *C. sativus* suspension possesses antiulcerogenic principles which protect against gastric mucosal damage induced by indomethacin and necrotizing agent, through inhibition of gastric acid and stimulation of mucus secretion in Shay rats. Probably the antiulcer effect is, partly at least, due to the presence of flavonoids in the saffron, although, the involvement of other compounds in saffron cannot be ruled out (Al-Mofleh *et al.*, 2006).

Anti-parkinsonian effect:

Crocetin, which is an important ingredient of saffron and helpful in preventing Parkinson's disease (Ahmad, 2005).

Anti-mutagenic effects:

It was reported that crocin and dimethyl-crocetin isolated from saffron have non-mutagenic effect (Salomi, 1991). Abdullaev (2002) demonstrated that the saffron extract itself in concentration up to 1500 mg/plate was non-toxic, nonmutagenic and non antimutagenic. A test compound was considered mutagenic if the number of the His+ revertant colonies was increased at least twice over the value of the corresponding control (MI > 2), over at least three doses levels and a reproducible dose-response curve could be demonstrated.

Antigenotoxic effect:

It has been reported that saffron or the compounds it contains, such as crocin and dimethylcrocin, are not mutagenic or genotoxic (Salomi *et al.*, 1991; Abdullaev *et al.*, 2002 and 2003). Premkumar *et al.* (2001; 2003 and 2006) also showed that saffron aqueous extract protects from genotoxicity as well as genotoxins-induced oxidative stress in mice. In these studies, oral pretreatment with aqueous saffron extract (20, 40 and 80 mg/kg) for 5 consecutive days significantly inhibited the genotoxicity of antitumor drugs (cyclophosphamide, mitomycin C and cisplatin), *in vivo*, as revealed by micronucleus and comet assay. It was suggested that saffron could exert its antigenotoxic and chemopreventive effects by the modulation of antioxidants and/or detoxification systems (Premkumar *et al.*, 2001 and 2006).

Tumoricidal effect:

Saffron is a rich source of carotenoides due to which it has anti cancer and anti tumor properties (Abdullaev, 2002 and 2004; Fernandez, 2004). The oral administration of the saffron extract increased the life span of Swiss albino mice intra-peritoneally transplanted with sarcoma-180 (S-180) cells, Ehrlich ascites carcinoma (EAC) and Dalton's lymphoma ascites (DLA) tumors (Nair *et al*., 1991). In an animal model (frog embryos), crocetin, from saffron was effective in treating certain types of cancer (Martin, 2002). The long-term treatment with crocin significantly increased survival time and decreased tumor growth rate, induced by rat adenocarcinoma DHD/K12-PROb cells (Garcia-Olmo *et al.*, 1999). An increase in the levels of beta-carotene and vitamin A in the serum of laboratory animals under oral administration of saffron extracts was detected and suggested that saffron carotenoids possessed provitamin A activity according to the hypothesis that the action of carotenoids was dependent upon its conversion to retinal (Vitamin A), because most of the evidence supporting the anticancer effects of carotenoids were referred to be carotene (Daly, 1998; Tarantilis *et al.*, 1994). The application of saffron in cancer-treatment experiments performed on laboratory animals has proved successful (Baker and Negbi, 1983; Zargari, 1993).

Cytotoxic effect:

The ethanolic saffron extract significantly inhibited the colony formation and cellular DNA and RNA synthesis, whereas inhibition of protein synthesis was not detected (Hosseinzadeh and Sadeghnia, 2007). Crocetin, from saffron inhibited intracellular nucleic acid and protein synthesis in malignant human cell lines and had no effect on colony formation. The inhibition of growth of human chronic myelogenous leukaemia K562 and promyelocytic leukaemia HL-60 cells by dimethylcrocetin, crocetin and crocin with 50% inhibition (ID50) reached at concentrations of 0.8 and 2 mM, respectively (Morjani, 1990; Tarantilis *et al.,* 1994). Cytotoxicity of dimethylcrocetin and crocin to various tumors cell lines (DLA, EAC, S-180, L1210 leukemia and P388 leukemia) and to human primary cells from surgical specimens (osteosarcoma, fibrosarcoma and ovarian carcinoma) was detected (Nair *et al.,* 1995). The inhibitory effect of the ethanolic saffron extract on the *in vitro* growth of HeLa cells (ID50 = 2.3 mg/ml) was mainly due to crocin (ID50 of 3 mM) (Escribano *et al.*, 1996).

Anti-hyperglycemic and pancrease- protective effects:

Ethanolic extract of *C. sativus* L. stigmas when administered orally and intraperitoneally at different doses (20, 40, 80 mg kg^{-1}) caused a significant decrease of plasma glucose levels in diabetic rats and this effect was more potent after repeated intraperitoneal administration as, a marked normalization of blood glucose levels in these animals was achieved after 2 weeks of treatment (Daryoush *et al.*, 2009). Assimopoulou *et al*. (2005) confirms that administration of *C. sativus* stigma extract function on the protection of vital tissues including pancreas, thereby reducing the causation of diabetes in these animals.

Anti-hypertensive activity:

Fatehi *et al.* (2003) investigated the effects of *C. sativus* petals' extract on blood pressure in anesthetized rats and also on responses of the isolated rat vas deferens and guinea -pig ileum induced by electrical field stimulation (EFS). Aqueous and ethanol extracts of *C. sativus* petals' reduced the blood pressure in a dose-dependent manner. Administration of 50 mg/g of aqueous extract changed the blood pressure from 133.5 ± 3.9 to 117 ± 2.1 (mmHg). This reduction could either be due to the effect of the *C. sativus* petals' extracts on the heart itself/total peripheral resistance, or both. The effect of extracts on peripheral resistance seems to be more important (Fatehi *et al.*, 2003). In the rat isolated vas deferens, contractile responses to EFS were decreased by the petals' extracts. Contractions of the vas deferens to EFS are mediated by a combination of noradrenaline and ATP released as co-transmitters from sympathetic nerves (Hoyle and Burnstock, 1991). The ethanol extract induced greater changes in EFS in the rat isolated vas deferens and guinea-pig ileum than the aqueous extract (Fatehi *et al.*, 2003).

Effect on sexual behaviour:

The aphrodisiac activities of *C. sativus* stigma aqueous extract and its constituents, safranal and crocin, have been evaluated in male rats. The aqueous extract (80, 160 and 320 mg/kg body wt.), crocin (100, 200, and 400 mg/kg body wt.), safranal (0.1, 0.2, and 0.4 ml/kg), sildenafil (60 mg/kg body wt., as a positive control), and saline were administered intra-peritoneal to male rats. Mounting frequency (MF), mount latency (ML), intromission latency (IL), and ejaculation latency (EL) were the factors evaluated during the sexual behaviour study. Crocin, at all doses, and the extract, especially at doses 160 and 320 mg/kg body wt., increased MF, IF, and EF behaviors and reduced EL, IL and ML parameters. Safranal did not show aphrodisiac effects. This study exhibited an aphrodisiac activity of saffron aqueous extract and its constituent crocin (Hosseinzadeh *et al*., 2008).

Ophthalmic effect:

Xuan (1999) reported that the carotenoid crocin and its analogs have protective effect on retina. As a dietary supplement, saffron extract prevents retinal damage and may have a role in the treatment of ischemic retinopathy and age-related macular degeneration (Maccarone *et al.*, 2008; Abdullaev *et al.*, 2003).

Atherosclerosis and arthritis treatment:

In the studies conducted on hemorrhaged rats, it has been observed that crocetin increases alveolar oxygen transport and enhances pulmonary oxygenation. It improves cerebral oxygenation and positively acts in the atherosclerosis and arthritis treatment (Giaccio, 2004).

Saffron as dye:

Historically, saffron was particularly important as a dye plant. Saffron dye used in small quantities will impart a yellowish-orange colour, with increasing redness as applied in more concentrations. In India, Tibet and China, saffron has been used to produce the yellow-red colour of robes for Hindu and Buddhist monks (Dharmananda, 2005). The main dye component, crocin, a flavonoid, has also been found in the less expensive gardenia fruit, which is now being developed as an alternative source for dye purposes in China. This crocin on hydrolysis produces glucose and crocetin (Kafi, 2002).

Marketing of saffron:

Saffron is the most expensive condiment of the world. It predominantly contains certain chemical constituents that are responsible for imparting colour, flavour, aroma and medicinal properties. As it is a triploid plant, it fails to produce seeds upon self or cross pollination. So, it propagates through corms. The growing area for its production is not extensive, although its demand is increasing day by day. Many scientists have started the research on its production. So the overall steps like, climatic and soil conditions, planting time, corm size and weight, nutrient management, weed management, growth regulators, post harvest management also affects its quality and quantity (Kumar *et al.*, 2008).

Saffron is an herb most people are unlikely to utilize, either for medicinal or culinary purposes, primarily because the material has a justified reputation for being extraordinarily expensive. Bulk quantities of relatively low-grade saffron can reach upwards of $500/pound, while retail costs for small amounts may exceed 10 times that rate. But, one cannot avoid this valuable condiment because very small quantity is needed as for medicinal use: 1 - 3g in decoction; 0.5 -1.5 g ingested as powder; or 30 mg of its dried extract per day is considered adequate in standard applications. For culinary use, just a few strands are sufficient to flavour food (about 2 - 4 strands per person; there are about 70,000 - 200,000 strands per pound) (Dharmananda, 2005).

Katawazy (2013) has done a beautiful review on both institutional and market reforms to the government to tackle some of the existing challenges; including agriculture and development of a specialized industrial central processing and packaging unit, provision of long-term interest free financing solutions for farmers, technical and management skills trainings as well as forming of a saffron association board which is not biased to any particular business man.

Notwithstanding the great nutraceutical potential and the considerable increase in consumer demand for saffron, the future of this plant is still uncertain (Gresta *et al.,* 2008). Overall, the obstacles in the effective development and production of saffron results from a number of constraints summarized below:

–The limited areas of cultivation in countries where it is traditionally grown,
–The more demand of this sophisticated condiment,
–Management techniques executed by hand,
–The very high price of the crop,
–Higher probability of adulteration ,
–Absence of well organized marketing system and
–Unawareness among the common man about its complete health and medicinal benefits even when taken in small quantities.

In order to tackle all the above mentioned issues, it is essential to adopt a holistic approach covering all the aspects of marketing and production. The government should take into account some policies and strategies for cultivation, growth, production and marketing of saffron crop. The outcome of such initiatives will substantially enhance the income, besides the development of nutraceutical potential of the crop.

Adulteration in saffron:

Because of the cost, saffron is frequently adulterated with cheaper substitutes such as marigold flowers and safflower. The flower styles are used as a tea substitute. The substances used may be grouped in three categories, *viz.*,
–Substitution of other materials that have some external resemblance to saffron;
–Exhausted saffron recovered by dyes and
–Substances added to saffron in order to increase its weight.

For adulteration materials used as substitutes may be mixed with saffron or supplied in place of saffron. The materials which have been used for adulteration are; styles of *Crocus*, which are yellowish, slender and unbranched; stamens and strips of the corolla of saffron crocus; ligulate corolla of florets of the marigold, *Calendula officinalis*, which are often colored with methyl orange and sometimes known as feminell or Chinese safflower; ligulate florets of safflower, *Carthmus tinctorious* L. often found in the cake saffron of commerce; slender stems and roots of some monocotyledons (e.g., Carex) coloured artificially and stigmas of *Zea mays* L., known as corn silk (Wallis, 2005).

Genuine saffron is tough, spurious saffron will be brittle and break easily. Genuine saffron dissolves easily in water giving the aroma of saffron. Saffron should not include the yellow styles. When pressed between filtering paper, it should not leave an oily stain. When chewed, it tinges the saliva deep orange-yellow. When soaked in water, it should not deposit any pulverulent, mineral matter, nor show the presence of organic substances differing in shape from that described. On agitating 1 part of saffron with 100,000 parts of water, the liquid should acquire a distinct yellow colour. No colour is imparted to benzene agitated with saffron (absence of picric acid and some other coal-tar colours). On drying saffron at 100°C (212°F), it should not lose more than 14 per cent of its weight (absence of added water). When dried and ignited with the free access of air, 100 parts of the dry saffron should not leave more than 7.5 per cent ash (absence of foreign inorganic substances) (Srivastava *et al.*, 2010).

Saffron toxicity:

Saffron is a potent condiment. Excessive intake can be harmful. Saffron is generally not associated with toxicity when ingested in culinary amounts (Schmidt *et al*., 2007). The dosage of saffron varies according to many conditions like climate (whether hot or cold), the health and age of the individual, the manner in which the dosage is taken etc. Saffron should be taken for medical reasons always under proper medical advice. At a high dose, saffron has narcotic and ecstasy effect and excessive delight which finally lead to temporary paralysis. In small doses, Saffron promotes production of gastric juices, but especially pregnant women need to beware. A large dose causes contractions in the smooth muscle of the uterus and may induce abortion (Zargari, 1993; Basker and Negbi, 1983). Saffron corms have however, very toxic effect when eaten by young animals (Basker and Negbi, 1983). Doses upto 1.5 g/day of saffron are considered to be safe, whereas, toxic effects have been reported at 5 g.

Future aspects and conclusion:

Saffron has been recognized to possess medicinal properties and the ethnobotanical data reveals their use in traditional systems of medicines since decades ago. It has been a promising condiment for nutraceutical industry due to its varied health benefits and medicinal properties ranging from mild fever treatment to anti-cancerous nature and also DNA repair. In this paper, mainly the biological and ethnobotanical data, nutraceutical potential, adulteration and toxicity of the saffron have been reviewed by the authors. Colour, taste and aroma are the three essential features on which the quality of saffron stigmas is determined. Their unique biomedical property is dependent upon the bioactive compounds and has a vast scope to be used in various food and pharmaceutical industries. This review presents an overview of vast nutraceutical potential of saffron, which can further be explored and exploited to develop new formulations. Therefore, saffron is a repository of nutraceutical potential and truly be called as ‘golden condiment’.

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