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Wheat Grass: A Functional Food

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Abstract
The paper explores basics of wheat grass cultivation and health enhancing ability. Wheat grass has been of high interest to cancer functional food researchers, pharmacologists and biochemists and natural cure reactionaries due to its involvement in heavy metal chelation, anti-carcinogenic agent, anti-oxidant, anti-diabetic and anti-anaemic activity among other functions. The juice, tablet or powder is the key forms that the grass is consumed. Previous studies have shown that wheat grass is effective anti-anaemic agent which has given it the name green blood. In this review, we focused on wheat grass as a functional food with respect to its ability to manage/control or prevent a range of diseases in respect to its components.
Keywords: Antioxidant, Anti-diabetes, Anticancer, composition

Introduction
Wheat grass is a sprout from common wheat, *Triticum aestivum, harvested before it flowers*. It is an edible food/functional food that is consumed as fresh juice, dried into powder or made into tablets (Sunil D Kulkarni *et al.*, 2006; Rajagopalan and Shakya, 2014). Wheat grass cultivation and processing is practiced in several countries at different scales, the origin of wheat grass is not clearly known (Rana, Kamboj and Gandhi, 2011). The grass has been established to be highly nutritious being rich in protein/amino acids (essential and non-essential amino acids), vitamin C, minerals, enzymes and chlorophyll (Chauhan, 2014). According to Ran et al. (2011), "the nutritional composition of wheat grass per 3.5 grams has been found to contain 860 mg protein, 18.5 mg chlorophyll, 15 mg calcium, 38 mg lysine, 7.5 mg vitamin C and containing abundance of micronutrients and amino acids (Rana, Kamboj and Gandhi, 2011). Moreover, grass is rich in enzymes responsible for its pharmacological actions such as protease, lipase, cytochrome oxidase, transhydrogenase amylase and super oxide dismutase (SOD). In addition, wheat grass is rich in amino acids such as aspartic acid, glutamic acid, arginine, ala-nine and serine (Rana, Kamboj and Gandhi, 2011).

In many developing countries, families rely on simple diets consisting of dominant staple food crops such as maize, wheat and rice resulting in poor sources of nutrients and minerals (PauliČKOVÁ *et al.*, 2007). Studies done on wheat grass have found many beneficial effects in providing a wholesome nutrition for a healthy and rejuvenating body (Ashish *et al.*, 2012). In most countries including Asia and Europe, consumption of wheat grass is mainly done in form of juices, tablets (medicines) health supplements (powders and various wheat grass extracts) (Beetz, 2002; S.D. Kulkarni *et al.*, 2006). Wheat grass juice has been established to be very beneficial in boosting immune function, aiding efficient blood purification, curing thalassemia, distal ulcerative colitis and solving digestive problems among other nutritive benefits (S.D. Kulkarni *et al.*, 2006). Moreover, it can reduce cases of blood transfusion in poor countries (Singh, Verma and Pandey, 2012; Mohan, Jesuthankaraj and Thangavelu, 2013b; Chauhan, 2014). Despite the health benefits of wheat grass consumption, its acceptance and use is still low worldwide. This could be attributed to it being consumed only by people in poor health conditions, short shelf life, low organoleptic characteristics and difficulty in obtaining good quality wheat grass (Ashish *et al.*, 2012). In many countries wheat is consumed as wheat grain products, which are made into bread, scones and other baked or steamed products, but with the realization of the value of wheat grass as a functional food, and owing to its fast maturity, ability to be grown in different medium and dense nutrition, there is a need to explore wheat grass as either an alternative venture or functional food resource, especially in developing countries where there is a dual nutritional burden of malnutrition and obesity.. Studies have shown the need for more research to be done in this area to make wheat grass widely acceptable as an economic activity to not only aid in the fight against malnutrition but also improve the general population health in countries where poverty, unemployment, malnutrition and lifestyle diseases are rapidly rising (Ashish *et al.*, 2012).

Production of wheat grass
Wheat grass is one of the cereal grains that can be sprouted. Others include rye, oats, barley, rice, buckwheat and millet. Cultivated just like any cereal crop, it is often done in a hydroponic system using only water. There are two main methods of wheat grass cultivation: field and bed method. In field method the grass seeds are cultivated in a well-drained, fertile soils with good moisture content, greater than 375 mm of rainfall and high lime soils. The grass is not that tolerant to drought, salinity and waterlogging (Beetz, 2002). Seed production is better suited to heavier soil textures. Excellent seed production on lighter textured soils requires dependable

precipitation. Bed method on the other hand involves growing seeds in shallow beds made up of a mixture of soil and peat moss/vermiculite. The grains are initially soaked until the root radicle emerges from the seed coat. They are then placed in the beds. The seeds grow in the dark at first and then, after two or three days, they are exposed to light. Shallow trays are often used to grow them (Zendehbad, Mehran and Malla, 2014), however, in some cases greenhouses are used for production. The greenhouse method begins with laying thermal tubing on top of polystyrene, which rests on the ground. This is covered with black plastic. Thermal tubing distributes heat from hot water heaters and functions as a root-zone heating system. Next, a layer of compost or soil-less potting mix is laid on top of the plastic about an inch deep. Soaked grains are spread on top of the compost-mixture so that each makes contact with the soil. The seeds are kept moist by watering, as needed.

The sprouts are ready for harvest just before the second pair of leaves appears, usually within one week or eight days. The result looks like a small, lush lawn. Harvesting is done by cutting with either scissors or a knife just above soil level or is pulled out with the roots. If they are cut, there is often a second harvest during the next week. Careful attention to correct temperature, light, and moisture is critical for consistent harvests. The product is very perishable hence should be processed or preserved soon after harvest.

Preparation of wheat grass juice/tablet/powder

Wheat grass juice preparation can be done using the following procedure: the grass is washed in water containing antibacterial substance e.g. Sodium Metabisulphite (SMS) and chopped with a knife to about 3 cm length. Water is then added to the grass in a ratio of 3:1 and blended under high sped to make a fine paste. The paste is then filtered with a mesh strainer lined with cheese cloth over a clean container. The filtrate is diluted with portable water or juice or make into tablets by pressing. Alternatively, the wheat grass powder can be prepared by drying the grass then milling to attain a powder. Care should be taken to avoid loss of vitamin C, lysine and other volatile compounds.

Functional activity of wheat grass

Anti-anaemic properties

Past studies have so far revealed wheat grass to contain about 70% chlorophyll which is almost chemically identical to haemoglobin with the only difference seen in the central element containing magnesium and haemoglobin in chlorophyll and haemoglobin respectively. Therapeutic effect of wheat grass has been applied in the treatment of anaemia, thalassemia among other diseases due to the fact that wheat grass contains higher proportions of various nutritional elements as discussed above; such as chlorophyll, amino acids, minerals, phytochemicals, vitamins and enzymes (Chauhan, 2014). By consuming foods rich in chlorophyll the haemoglobin levels of subjects has been found to increase (Kulkarni *et al.*, 2007; Rana, Kamboj and Gandhi, 2011; Payal *et al.*, 2015).Vitamin B6, B12, is important in haemoglobin formation, and their deficiency has been linked to anaemia. Moreover, iron is vital in fighting anaemia (Baker and Campbell, 2015). Wheat grass is used in managing anaemia and has got the name 'green blood' owing to its effectiveness in treating anaemia (Mujoriya and Bodla, 2011; Mohan, Jesuthankaraj and Thangavelu, 2013a).

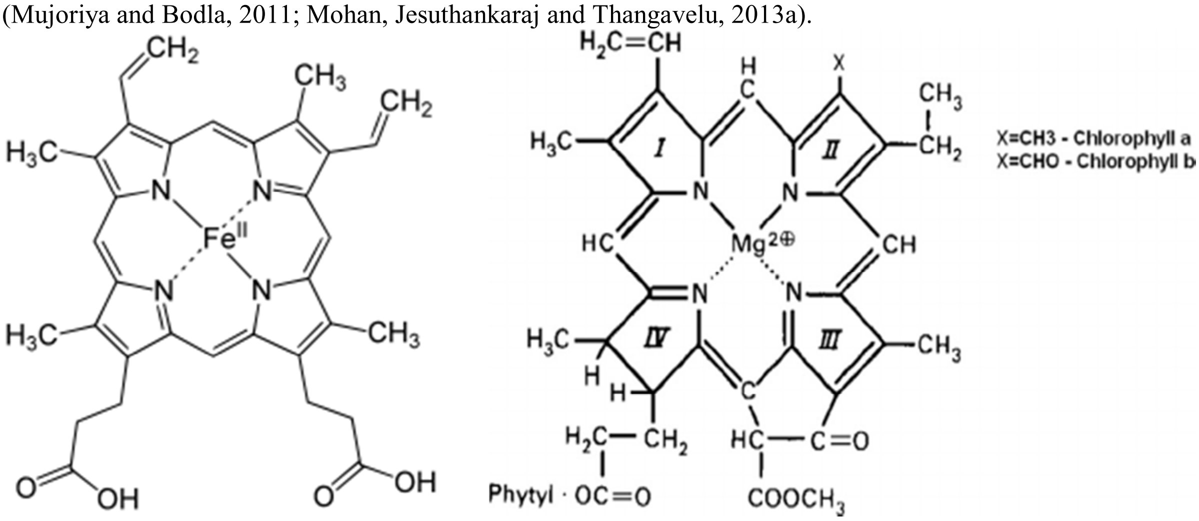

Figure 1. The structure of haemoglobin (L) and Chlorophyll (R). Iron is the central metallic element in Haemoglobin while Magnesium is the central element in chlorophyll.

Anticancer Properties

Wheatgrass is a rich source of chlorophyll that is responsible for inhibiting the metabolic activation of carcinogens. So far wheat grass juice, tablet and powder are alternative medicine approach of anticancer therapy, due to its high antioxidant content, chlorophyll, laetrile and antioxidant enzyme super oxide dismutase (SOD) which converts dangerous reactive oxygen species (ROS) into hydrogen peroxides and an oxygen molecule. Chlorophyll, like other tetra-pyrroles, has the ability to induce mammalian phase 2 proteins that protect cells against oxidants and electrophiles. The capacity of this compound to induce the phase 2 response depends upon its ability or that of its metabolites to react with thiol groups. It is effective in inducing the phase 2 enzyme NAD (P) H:quinoneoxidoreductase 1 (NQO1) (Chauhan, 2014). Chlorophyll is low in inducer potency, but it may play some role in the disease-protective effects attributed to diets rich in green vegetables like wheatgrass because it occurs in much higher concentrations in the plants.

Aqueous extracts of wheatgrass are good sources of antioxidants. Significant antioxidant activity was demonstrated by in vitro studies. The clinical studies conducted on human breast cancer have shown that chlorophyllin, a compound that is similar to chlorophyll produced synthetically, has capability to reduce the risk of breast cancer In another in-vitro study it was found that wheat sprout extract inhibited the metabolic activation of carcinogens and decreased their cancer causing ability by up to 99 percent (Rajagopalan and Shakya, 2014; Zendehbad, Mehran and Malla, 2014).

Antioxidants are effective cancer prevention compounds by quenching radicals from oxidants. Antioxidants can decrease oxidative stress induced carcinogenesis by a direct scavenging of reactive oxygen species (ROS) and/or by inhibiting cell proliferation secondary to the protein phosphorylation. B-carotene may be protective against cancer through its antioxidant function, because oxidative products can cause genetic damage. Thus, the photo protective properties of B-carotene may protect against ultraviolet light induced carcinogenesis. Immunoenhancement of B-carotene may contribute to cancer protection. B-carotene may also have anti-carcinogenic effect by altering the liver metabolism effects of carcinogens. Vitamin C may be helpful in preventing cancer. The possible mechanisms by which vitamin C may affect carcinogenesis include antioxidant effects, blocking of formation of nitrosanimes, enhancement of the immune response, and acceleration of detoxification of liver enzymes. Vitamin E, an important antioxidant, plays a role in immunocompetence by increasing humoral antibody protection, resistance to bacterial infections, cell-mediated immunity, the T-lymphocytes tumour necrosis factor production, inhibition of mutagen formation, repair of membranes in DNA, and blocking micro cell line formation. Hence vitamin E may be useful in cancer prevention and inhibit carcinogenesis by the stimulation of the immune system (Lobo *et al*., 2010).

Another Constituent of wheatgrass implicated as an anticancer agent is the plant hormone abscisic acid (ABA). This hormone is 40 times more potent 4 hours after cutting the wheatgrass plant. ABA can neutralize the effect of the hormone chorionic gonadotropin and a compound similar to this hormone has been found to be produced by the cancer cells. Novel anticancer approach utilizes high alkalinity in the cancer chemotherapy. Firstly, an alkaline diet helps to reduce the number of microbes in the diet. This attenuates the incidence of secondary infections to a certain degree in the patient. Secondly, the cancer cells succumb in a highly alkaline environment. As the pH of the wheatgrass juice is around 7.4, it is being considered a viable option under this approach. Other postulated mechanisms by which wheatgrass juice appears beneficial include antioxidant activity in preventing oxidative damage to deoxyribonucleic acid (DNA) and lipid peroxidation, stimulation of gap junction communication, effects on cell transformation and differentiation, inhibition of cell proliferation and oncogene (cancer causing gene) expression, effects on immune function and inhibition of endogenous formation of carcinogens. Furthermore, chlorophyll derivatives have also been found to provide beneficial effects in liver, colon, stomach and gastrointestinal cancer cases. In vitro studies with chlorophyllin on animal model have shown that chlorophyllin is an inhibitor of the cytochrome P-450 liver enzymes (Singh, Verma and Pandey, 2012), and all in-vivo studies where cytochrome P-450 enzyme activity is reduced, resulting in lower cancer rates and longer lifespan.

Detoxification properties

The vitality of liver is of high concern for the overall well- being of an individual as it is the major organ implicated in detoxification. In addition to the stimulating and regenerative properties of chlorophyll, other constituents of wheat-grass juice like choline and its high mineral content are responsible for the therapeutic benefit. In a study conducted to observe the effect of choline on liver, it was seen that choline prevents the deposition of fats in the experimental animals' liver when they were administered a diet rich in cholesterol (Payal et al., 2015).

Choline promotes the removal of the esters of both cholesterol and glycerol, with the effect on the glyceride fraction preceding that on the cholesterol esters. The lipotropic action of choline is attributed to its in vivo conversion to an active compound which is retained within the hepatic cells and enhances the oxidation of fatty acids and formation of tissue lecithins. The latter effect augments lipoprotein synthesis, which acts as a transport form of fatty acids in plasma and thus helps in removal of lipids from a fatty liver. Previous research reports have demonstrated experimentally that the dietary indoles like indole-3-carbinole and ascorbigen increase the activity of phase I and phase II xenobiotic metabolic enzymes in the liver and intestinal mucosa (Singh, Verma and Pandey, 2012; Payal et al., 2015). Thus the in-dole compounds of wheatgrass may have a role in the deactivation of carcinogens.

Antioxidant activity
Plant based food products including wheatgrass contain phytochemicals such as flavonoids which help rid human body of free radicals. The grass is rich in the following antioxidant enzyme systems; cytochrome oxidase, transhydrogenase amylase and super oxide dismutase (SOD), which converts dangerous free radical reactive oxygen species (ROS) into hydrogen peroxides (having extra oxygen molecule to kill cancer cells) and an oxygen molecule, and phytochemical (S.D. Kulkarni et al., 2006; Mohan et al., 2013). In addition, wheat grass extract has been found to exhibit antioxidant activity as it inhibits DNA oxidative damage and suppresses superoxide radical due to the presence of redox enzymes including catalase in wheat which prevent various diseases in humans (Ashish et al., 2012). Analysis of aqueous extracts from wheatgrass also revealed presence of alkaloids, saponin, tannins, amino acids and protein, carbohydrates, coumarin, phenols, alkaloids, terpenoids and cardiac glycosides (Durairaj et al., 2014). Butein is a polyphenol associated with activity against nitric oxide formation hence leading to protection of pancreatic β-cells against toxicity due to cytokines (Mishra et al., 2015).

The antioxidant activity of wheat grass extract has been studied based on its chemical content and found to contain phenolic compounds such as polyphenols and flavonoids which have been found to inhibit free radical induced membrane damage (Chauhan, 2014). Wheat grass is a rich source of minerals which include magnesium, selenium, zinc, chromium. The antioxidant properties of wheat grass can be explained by the fact that wheat grass contains various sources of antioxidants which include beta-carotene (pro-vitamin A), vitamin E and vitamin C (Zendehbad, Mehran and Malla, 2014). Wheat grass contain 17 amino acids of which aspartic acid, glutamic acid, arginine, alanine and serine have been found to constitute higher proportion (Singh, Verma and Pandey, 2012). The sulphur containing amino acids and peptides have high anti-oxidant activity. Moreover previous studies showed that free amino acids are associated with increased plasma anti-oxidant activity (Meucci and Mele, 1997). Wheat grass being rich in amino acids makes it a good anti-oxidant.

Antidiabetic Activity
Diabetes is a condition in the human body resulting in metabolic disorder in the normal regulation of insulin in the body which may be caused by a number of factors including imbalanced diet which affects millions of people globally. It is characterized by disturbances of carbohydrate, fat and protein metabolism emanating from malfunction in insulin secretion and/or action (Mishra et al., 2015). Reduction of fibrous foods in man's normal diet has been cited as one of the factors leading to development of type two diabetes (T2 D) (Mohan et al., 2013). This may further affect the normal metabolic processes of fat, carbohydrates and proteins in the body. Wheat grass juice, tablet or powder comes handy as a fibrous food product which may be used to cure diabetic related complications. The high amount of fibrous material and chlorophyll in wheat grass is very important in the optimization of blood sugar levels in the body and acting as anti-diabetic agent respectively. Thus stimulating metabolism, restoring blood alkalinity due to abundance in alkaline minerals, and acting as anti-diabetic agent and a detoxificant to restore healthy cells (Rana, Kamboj and Gandhi, 2011). The antidiabetic potential of wheat grass extract was done on diabetic rats and showed significant anti-hyperglycemic and hypolipidemic effect due to the presence of lipase, cytochrome oxidase, super oxide dismutase enzymes responsible for the pharmacological properties of wheat grass (Mohan et al., 2013).

Vitamins and minerals play crucial role in glucose metabolism, hence has a potential role in type-2 diabetes prevention and management as supplements (Martini, Catania and Ferreira, 2010) Vitamin B complex, A, C,D, E and K, and carotenoids and minerals, calcium, magnesium, sodium, and potassium are particularly vital in diabetes type 2 regulation (Martini, Catania and Ferreira, 2010). Wheat grass is rich in iron, phosphorus, magnesium, manganese, copper & zinc.

The antidiabetic potential of wheat grass extract was done on diabetic rats and showed significant anti-hyperglycemic and hypolipidemic effect on diabetic rats (Mohan et al., 2013). Hypoglycaemic effect of phytochemicals involves inhibition of carbohydrate metabolizing enzymes, β-cell regeneration and enhancing insulin releasing activity. Polyphenols such as anthocyanins have been demonstrated in both in vitro and in vivo studies to impact glucose absorption (Mishra et al., 2015), catechin and epicatechin subunits mimic insulin activity and resulted to lowered glucose levels molecules in vitro. Phytochemicals like vitamin C, D, E and polyphenols which are rich components of wheat grass are able to quench oxidizing species from oxidants thus maintaining redox balance (Mishra et al., 2015).

Heavy metal chelation
Ferrous ions are one of the most effective pro-oxidants present in food systems as they result in the formation of oxidized radicals which can cause lipid peroxidation and reactive oxygen species build-up in the body. Wheat grass possess iron chelation activity and has been shown to chelate iron from the body thus has the capacity to

combat heavy metal poisoning (Rajagopalan and Shakya, 2014). Moreover, the antioxidant and therapeutic action of wheat grass has been found to be associated with the high content of various bioflavonoids such as laetrile, quercetin, luteolin, apigenin and indole compounds which exhibit chelating properties for iron overload disorders (Rajagopalan and Shakya, 2014). An agent with ability to chelate Iron, is equally able to chelate other polyvalent metal ions e.g. Arsenic, Lead, Cadmium, Mercury etc.

Safety concerns

Wheat grass just like other sprouts has potential to harbour considerable food safety concerns because of seed-borne diseases. Some of the most frequently identified pathogens include Salmonella spp, Streptococcus aureus, E.coli, Listeria monocytgenes (Beetz, 2002). The environment necessary for wheatgrass production is also favourable to the growth of fungal and bacterial contaminants. Therefore, sanitation during production and harvest is extremely vital. When it is being cut, water quality is the main concern. In either case, proper postharvest storage temperature, handling, and packaging are critical.

Conclusion and recommendations

Given the heath value of wheat grass, its short production period, low nutritional requirement and ability to grow in different geographical areas, the crop is a useful tool for fighting malnutrition, unemployment, and raise communities' income through its mass production and commercialization. Moreover, with massive malnutrition in Sub-Saharan Africa, wheat grass can fight silent-malnutrition and be used as a functional food against several health conditions.

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