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Foods for Specific Health Use (FOSHU): A Review

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ABSTRACT

Adequate nutrient intake (avoidance of excess or deficiency) is essential to ensure an optimum health status hence, no induction of risks related to lifestyle–diseases. Even nutrients and functional ingredients in foods are chemical substances but we need to draw a line of demarcation between such substances, based on long history of dietary habits and novel substances and/or xenobiotics. FOSHU contains highly purified or concentrated functional ingredients, present in ordinary foods,however, it is to take safety issues into consideration. FOSHU is the only type of food product, with functional ingredients, can carry health claims and affect the structure and physiological functions of the body. These consumed for health promotion or to control specified health conditions such as gastrointestinal conditions Therefore, FOSHU products target both healthy individuals and diseased people. When the products are manufactured or distributed, the government approval is required with prior hand rigorous evaluation of safety and effectiveness of proposed product. In a nutshell, comprehensive knowledge on structure and function of human body, pathogenesis of diseases, nutrients and their metabolism *etc*., as well as the mechanisms of efficacy vis-à-vis FOSHU, which ranges over pharmacology, medicine and food and nutrition, is required.

Key words: FOSHU, Functional ingredients, Health claims, Health promotion, Lifestyle diseases.

Apart from ample health related disorders, reduced work capacity, growth retardation, poor mental and social development may develop due to inappropriate and unbalanced diet, inadequate nutrition and lack of physical activity (Hippocrates 2009). World Health Organization predicted that 17.9 million worldwide died due to cardiovascular diseases (an estimation of 31% each year). Globally, prevalence of diabetes had been increasing more speedily among population of low income and middle-income countries In the year 2019, total deaths were considered as 1.5 million due to diabetes and it is ninth leading cause of death (WHO, 2021). The figures quoted by International Diabetes Federation indicated that 1.1 million children and adolescents are living with type 1 diabetes, however, 4.2 million deaths were reported. In year 2019, prevalence of diabetes was 9.3 per cent and it is estimated to be rise by 10.2 and 10.9 per cent by 2030 and 2045, correspondingly. It was higher in urban areas than rural (10.8 vs 7.2 per cent) and also in high income countries than in nations with lower income (10.4 vs 4.0 per cent) (Saeedi et al. 2019). An eye-opening fact has come to force that one in ten adults suffered from diabetes and if untreated, can lead to blindness, cardiovascular diseases and kidney failure (WHO, 2012).

Japan introduced the term functional foods in the mid-1980s and formulated a specific regulatory approval process known as “Foods for Specified Health Use (FOSHU)” by Japanese Ministry of Health and Welfare. By functioning in gastrointestinal tract to improve intestinal microflora and regulate nutrient absorption, thereby, more than 70 per cent of FOSHU products reduce the risk of metabolic syndrome. These are classified into eight categories according to their action on a particular part of body such as gut, tooth and gum health, bone strength, facilitation of mineral absorption and reduction in hypertension, blood cholesterol, blood sugar level and body fat accumulation to which these confer benefits (Hippocrates, 2009).

Soluble viscous properties of these products alter chyme present in the upper part of the gastrointestinal tract and affects the absorption of nutrients, gastric emptying and gut motility, prevents diabetes, lowers postprandial glucose and insulin responses. Flax fibers, oil and lignans have been found potent in reduction of atherosclerosis, arthritis, cancer, cardiovascular disease, diabetes, osteoporosis, autoimmune and neurological disorders. Therefore, various original research articles related to wheat, rice, oats and flax seed were studied to see the efficacy of FOSHU products overcome various health problems. Moreover, it tends to commensurate with some other risk factors such as high

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triglyceride level, hypertension, low high-density lipoprotein, cholesterol level and obesity (Simmons *et al.* 2010).

Plant foods constitute major part of human diet in developing nations but cannot be relied upon for providing a nutritionally adequate diet. Cereals generally contain poor quality protein and the bioavailability of micronutrients present in these such as iron, zinc, iodine and vitamin A is very low (Singla and Grover, 2017). Most commonly used cereal based functional foods and neutraceuticals, are the products made using wheat, rice, brown rice, corn, barley, millets, sorghum, oats, flaxseed and buckwheat (Otles and Cagindi, 2006). Nutritive and non-nutritive components of the cereals have been identified as prospective factors for reducing the risk of coronary heart disease, diabetes, tumor incidence, cancer risk, blood pressure, reduced levels of cholesterol and fat absorption and improved gastrointestinal health delayed gastrointestinal emptying. Thus, the regular consumption of right kind of cereals may lead to health endorsement and disease and escape avoidance. The current paper reviews the health benefits of different FOSHU products in terms of the prevention of diseases.

Role of FOSHU products in prevention of diseases

Some important FOSHU products are discussed below with regard to their health benefits.

Wheat

Worldwide, most commonly cultivated cereal grain in temperate climatic conditions, is wheat, is rich in micronutrients. All plant tissues including grains and some vegetables and fruits, starch is present as a mixture of two polymers of glucose *i.e.* amylose and amylopectin. A linear chemical structure of amylose is relatively slowly digested in comparison to more rapidly digested amylopectin due to its branched structure. The fibre content ranges from 11.6 to 12.7 per cent dry weight basis in whole wheat grain. When whole-wheat based food products *viz.* baked, extrudates are eaten in recommended amounts, showed significant reductions in risks for type-2 diabetes, heart disease and associated with management of body weight (Brounes *et al.* 2013).

Plant based foods and their products are widely used in Indian diets to cure many body ailments and shoot belongs to family *Graminea* prepared from the cotyledons of *Triticum aestivum* is called wheat grass, an annual and biennial grasses. It is cultivated almost in all regions the world over and is available as fresh juice and dried powder, useful for human consumption. Intake of fresh juice and powder of wheat grass is beneficial to keep away some health problems such as skin problems, ulcerative colitis, high blood pressure, diabetes cancers, obesity *etc*. Along with therapeutic properties, wheat grass is a store house of many nutrients including proteins, essential amino acids, vitamins, minerals, bio flavonoids, chlorophyll and active enzymes. This way, for healthy and rejuvenating body, wheat grass is an efficient source and provides all necessary nutrients and medicinal benefits too. Alongside, due to presence of important constituents, wheat grass retains antioxidant, antibacterial, anti ulcer and anti cancer property. Three essential effects of wheat grass on human body are blood purification, liver detoxification and colon cleansing. It enhances immunity, chemically neutralizes environmental pollutants and restores energy and vitality (Mogra and Rathi, 2013).

Wheat bran is typically the richest source of fibre, is present in outer layers, pericarp and seed coat of the grain. About 46 per cent non starch polysaccharide is therein and most commonly available non starch polysaccharides are arabinoxylan (70 per cent), cellulose (24 per cent) and beta-glucan (6 per cent), respectively. In wheat, soluble fibre content is less than 1 per cent, whereas, in other cereals, such as barley and oats, it ranges from 3 to 11 percent and 3 to 7 per cent. Correspondingly, several studies reviewed (Table 1) beneficial effect of consumption of wheat bran in the diet. It may be helpful in the prevention of some cancers (colorectal cancer), cardiovascular diseases, some gastrointestinal diseases (diverticulitis disease, constipation and irritable bowel syndrome), obesity and also improved digestion. Wheat bran also has a positive impact on cholesterol reduction. A study reported that with consumption of wheat bran-based breakfast cereal containing approximately 13.5 g of fibre for 3 weeks, a significant reduction (5.576 to 4.385 mmol/l) in total serum cholesterol was found among the experimental subjects. On the other hand, no reduction was found in beneficial high-density lipoprotein (Costabile *et al.* 2008).

Rice

Worldwide, over 900 million poor people, living in underdeveloped and developing countries are at a higher risk of hunger and suffer from food insecurity, every year. In view of food insecurity and inadequate intake of nutrients, underdevelopment of infants' and toddlers' immune systems is there and making them more vulnerable to viral and bacterial diseases such as pneumonia and diarrhea (Guerrant *et al.* 2008). Similarly, growth and development of children depends entirely on nutrition and inadequate nutrition may results in malnutrition, reduced work capacity, growth retardation, poor mental and social development. As rice bran has incomparable protein and fat content, high digestibility and hypoallergenic effects, is a great opportunity to include this into complementary foods (Table 2) ; Watson *et al.* (2014). In comparison to other cereal bran, rice bran is more appropriate because of its high-quality protein as it comprises a significant amount of lysine content which helps to meet the growth requirements of children. Lipids in rice bran can supply required energy depending upon the age (Khan *et al.* 2011). Being low in allergenicity, completely absorbable in the small bowel and low in fiber content; rice may work as the best carbohydrate source for people with functional bowel disorder. Many studies supported that complete absorption of rice in the small bowel lead to production of little intestinal gas and had low allergenicity. Thus, functional gastrointestinal disorders and irritable bowel syndrome patients should be advised to consume rice as a major source of carbohydrate (Gonlachanvit, 2010). About

77 per cent of the patients found with adequate relief from IBS symptoms (Austin *et al.* 2009). Kumari *et al.* 2018 nalyzed and compared the nutritional composition of full fat and defatted rice bran samples. The investigators revealed that defatted rice bran sample contained significantly higher content of crude protein, crude fiber, total dietary fiber, iron and calcium, when compared to full fat rice bran samples. Further, protein digestibility of full fat rice bran and defatted rice bran samples were found as 65.86 and 66.56 per cent, respectively. Thus, it was concluded that nutrient profile can be improved after removal of fat in rice bran, which can be further utilized as functional ingredients in treatment of many disorders.

Oats

Oats are good source of cholesterol lowering soluble dietary fiber β-glucan. Several whole oat feeding or supplementary studies have concluded that oats and oat bran may reduce serum cholesterol and may lower blood pressure in mild or borderline hypertension (Watson *et al.* 2014). The Quaker Oats Company (Chicago, Illinois) from 1980 to 1995, conducted 37 human clinical interventions to support their petition of health claim revealed a statistically significant (reduction in total and low density lipoprotein cholesterol in hypercholesterolemic subjects consuming oat bran or oatmeal with servings varied from 34 to 123 g per day. In addition, intake of 3 g β-glucan derived from oatmeal (60 g) or oat bran (40 g) based on its dry weight, lowered serum cholesterol level by 5 per cent in the human subjects. An oat product must comprise of 13 g oat bran or 20 g oatmeal and provide at least one g of β-glucan per portion without fortification, to qualify for a health claim. The first food-

Table 1: Wheat products in disease prevention.

FOSHU component	Study design	Results/findings	Mechanism	Source
Wheat bran	Total Subjects = 23 with type 2 diabetes (16 men and 7 postmenopausal women) Test: high fiber breakfast cereals and bread (19 g fiber/day) Control: low fiber breakfast or ferritin and magnesium, cereals and bread fasting (4 g fiber/day)	Similar results were observed among body weight, blood pressure, levels of calcium, iron blood glucose, HbA1c, serum lipids and serum uric acid. Higher LDL oxidation in test subjects than that of control	High and low fiber content	Jenkins *et al.* 2002
Wheat grass juice	Total subjects (>18 years) = 60 with Breast cancer on chemotherapy Intervention: daily 60 ml of wheat grass juice during first 3 cycles of chemotherapy Control: Regular treatment	Reduction in myelotoxicity and dose of chemotherapy Minimal side effects such as worsening of nausea	Apigenin, a potent bioflavonoid	Bar-Sela *et al.* 2007
Wheat based biscuits	Total subjects (18 to 25 years) = 10 Fasting blood glucose was evaluated. Biscuits with combine ratio of wheat flour (50), barley flour (25) and soy flour (25) containing 50 g of carbohydrates were given.	Blood glucose level was increased from 87 to 123 at 30 mins, 80 to 115 at 60 mins, 77 to 104 at 90 mins and 63 to 91 at 120 mins.	Lower glycemic index (36.4)	Naaz and Begum, 2021

Table 2: Rice bran in human health and disease.

Parts of food	Bioactive components	Mechanism	Benefits
Whole rice	Amino acid	Lysine	Growth and development; Hypoallergenicity
Brown rice	Non-saponifiable lipid (*i.e.*, ϒ-oryzanol)	Combination of ferulic acid, esters of sterol and triterpene alcohols	Antioxidant, antibacterial, cancer chemoprevention and reduces cholesterol absorption
	Vitamin E	α-Tocopherol, ϒ-tocopherol and tocotrienols	
	Phytosterols	β-Sitosterol, campesterol and stigmasterol	Anti-inflammatory, antioxidant, cancer chemoprevention, reduces cholesterol absorption and stimulates lymphocyte proliferation
	Polyphenols	Ferulic acid, α-lipoic acid, caffeic acid and salicylic acid	Antibacterial, anti-inflammatory, antioxidant and antiproliferative effect on cancer

Source: Watson *et al.* (2014).

specific health claim was given by Food and Drug Administration (FDA), in January 1997 for oats and oat products (Jr and Steffen, 2003).

Oat β-glucan consists mainly of the linear polysaccharide (1→3), (1→4)-β-D-glucan and lowers total and low-density lipoprotein, attenuates blood postprandial glycemic and insulinemic responses and improves high-density lipoprotein cholesterol and blood lipid profile along with maintenance of body weight. Hence, its intake is beneficial in the prevention, treatment and management of diabetes and cardiovascular diseases. Moreover, stimulation of immune functions have been ameliorated by oats intake through activation of monocytes/macrophages and higher amounts of immunoglobulin, natural killer cells and killer T-cells, helps in prevention and resistance to cancer, viral and parasitic diseases (Hui *et al.* 2007).

A total of 268 men and women were studied with high cholesterol level from Chicago (Daou and Zhang, 2012) and were provided with the tall oil-based phytosterols and β-glucan derived from whole grain rolled oats. Reduction in low density lipoprotein as well as total cholesterol levels was observed in patients with medium to moderate hypercholesterolemia when compared to control group who fed corn flakes with whole grain rolled wheat and crisp rice. Similarly, the effect of oat â-glucan on serum lipoproteins in hypercholesterolemic subjects was studied by providing them oat β-glucan enriched bread, cookies and orange juice with the mean intake of oat β-glucan was 5.9 g per day (Maki *et al.* 2003). Enriched orange juice decreased significantly (P = 0.001) low density lipoprotein-cholesterol (0.26 mmol/L) whereas the lipid profile of the subjects consumed enriched bread and cookie did not show any significant change. Formulation of bread with the addition of oat β-glucan (6 g) significantly increased plasma high density lipoprotein cholesterol from 39.4 to 49.5 mg/dL and significantly decreased total cholesterol from 231.8 to 194.2 mg/dL and low density lipoprotein cholesterol from 167.9 to 120.9 mg/dL when supplemented for a period of 8 weeks (Kerckhoffs *et al.* 2003). Furthermore, daily dose of oat β-glucan (3 g) increased high density lipoprotein cholesterol (0.03 mmol/L) and decreased the total cholesterol (0.60 mmol/L), low density lipoprotein cholesterol (0.66 mmol/L) and triglycerides/triacylglycerol (0.04 mmol/L) (Reyna *et al*. 2007).

Hypertension, a silent killer and there is an alarming increase in its incidence among the population of India and other developing countries. According to database from 1950 to 2013, overall prevalence of hypertension in India is 29.8%, about 33% urban and 25% rural Indian population. Africa has the highest prevalence, with over 40% adults affected by this disorder. It is also a leading cause of death in both men and women. A reduction in systolic (7.5 mm Hg) and diastolic (5.5 mm Hg) blood pressure was reported among subjects who had consumed standard American diet along with oats, whereas no change was observed in the control group who had consumed only the standard American diet (Tiwari and Cummins, 2011). When men suffering from type-2 diabetes consumed oat β-glucan (3 g in muesli) in breakfast for a period of 4 weeks, decreased in their cholesterol level and postprandial blood glucose levels peaks was observed while no effect was found on fasting plasma glucose and insulin levels (Chen and Huang, 2009). Similarly, studies summarized in Table 3, are in agreement with cholesterol lowering effect of above-mentioned investigations.

Oat β-glucan, comprises of soluble fiber, is beneficial for type-2 diabetics (Kabir *et al.* 2002). It helps to modify properties of chyme in the upper part of the gastrointestinal tract, lowers postprandial glucose and insulin responses, prevents diabetes and also affects gastric emptying, gut motility and nutrient absorption (Behall *et al.* 2006). In diverse preparations such as baked products, dairy products *etc.*, oats can be added as functional ingredients. It is also documented that the total and LDL cholesterol was reduced by 5 to 10 per cent, on consumption of oat β-glucan at the rate of 3 g/day (Dhavalagi *et al.* 2021).

Due to the viscous characteristics of oats, reductions in glucose and insulin responses was reported. The area under the plasma glucose curve for the postprandial was larger after ingestion of the oat bran crisp as compared to the oat bran flour. They fed the subjects with type 2 diabetes

Table 3: Oat products in disease prevention.

FOSHU component	Study design	Results/findings	Mechanism	Source
Oats flour	Six groups of 7 male Wister rats (4 weeks old) were provided with the diet (contained 10% oat flour) for 30 days.	Improvement in hypercholesterolemia Reduction in serum total cholesterol and LDL cholesterol	B-glucan, lipids and proteins Low ratio of -Lysine/Arginine -Methionine/Glycine	Guo *et al.* 2014
Oats, oat protein and oat glucan	Five groups of hamsters were provided with the diet for 30 days.	Better improvement was observed in hypercholesterolemia effects	Together Oat protein and Oat β-glucan	Tong *et al.* 2014
Dietary oat oil	Total subjects (18 to 25 years) = 10 Fasting blood glucose was evaluated. Biscuits with combine ratio of wheat flour (50), barley flour (25) and soy flour (25) containing 50 g of carbohydrates were given.	Blood glucose level was increased from 87 to 123 at 30 mins, 80 to 115 at 60 mins, 77 to 104 at 90 mins and 63 to 91 at 120 mins.	Lower glycemic index (36.4)	Naaz and Begum, 2021

in two series that is in series 1, oat bran flour, crisp and a glucose load provided 12.5 g glycemic carbohydrate whereas in series II, 25 g glucose load with 30 g oat bran flour and 25 g glucose load alone to control subjects. The results indicated that in both series, there was a reduction in postprandial glucose concentrations with the consumption of oat bran products during the 1st hour, but after 2 hours, it was greater than glucose load alone. Oat bran flour being high in β-glucan acting as an active ingredient had a low-glycemic response and decreasing the postprandial glycemic response in subjects with type2-diabetes (Tapola *et al.* 2005). Similar results were found by Juvonen *et al.* (2011) by performing experiment on healthy volunteers who were provided with four different types of meals such as without added cereal fibers and enriched with 10 g cereal fibers (wheat bran, oat bran and a combination of 5 g of each).

Flaxseed

Flaxseed (*Linum usitatissimum*) is important as a functional food ingredient (Table 4; Moghaddasi, 2011). It is rich in α-linolenic acid (omega-3 fatty acid), fiber and lignans. Flaxseed oil, fibers and flax lignans have possible health benefits reduced of risk of arthritis, atherosclerosis, cancer, cardiovascular diseases, diabetes, osteoporosis, autoimmune and neurological disorders. Flax protein helps in prevention and treatment of heart diseases along with supporting the immune system. Flax or flaxseed oil could be incorporated into various food products such as baked foods, dry pasta products, juices, macaroni, meat, milk products (Goyal *et al.* 2014). Flaxseed meal contains 2.3 to 3.3 per cent phytic acid. Though phytic acid has been known in reducing bioavailability of micronutrients but some studies showed that it has antioxidant, anticancer, hypocholesterolemic and hypolipidemic effects too (Mazza, 2008).

Dietary fiber is a natural way to manage irritable bowel syndrome (IBS). Inclusion of flaxseed in diet, significantly increased plasma and adipose levels of alpha linoleic acid (McCullough *et al.* 2011). Multi branched hydrophilic substances such as soluble non starch dietary fibers of flaxseed mucilage, form viscous solutions that aid in nutrient absorption from small bowel and delay gastric emptying. Constipation is a major health problem mainly in Western societies, because of the refined diet, however, dietary fiber is a keystone in the management of constipation but only in recommended amount (Tarpila *et al.* 2005). Flaxseed consists of dietary fibers, lignans and omega-3 fatty acids which provide protection against diabetes. Supplementation of flaxseed powder (10 g) for a month, lowered fasting blood glucose level by 19.7 per cent, in persons with type-2 diabetes, could be due to higher content of dietary fibers and lower content glycemic carbohydrates (Mani *et al.* 2011). Besides, Kapoor *et al.* (2011) reported that postprandial blood glucose levels were decreased by 7.9 and 19.1 per cent among females with type 2 diabetes on supplementation of 15 and 20 g/day of flaxseed powder for two months.

Flaxseed intake showed a positive impact on suppressing the development of atherosclerosis. Flaxseed and its bioactive components revealed antidiabetic and positive hypocholesterolemic effects among postmenopausal women (Patade *et al.* 2008). Dietary flaxseed provides protection against ischemic heart disease by inhibiting the incidence of ventricular fibrillation and improving vascular relaxation responses (Jennifer *et al.* 2010). Inclusion of flaxseed oil in the diet for a period of 28 days posed the reduction in high density lipoprotein fraction levels in human serum (Gillingham *et al.* 2011). Simultaneously, when patients with type-2 diabetes were fed with defatted flaxseeds for a period of two months, a significant improvement in plasma lipid profile, reduction in plasma glucose and lipid peroxidation was observed (Mohamed *et al.* 2012). Similarly, administration of flaxseed amounting 15 g/d administered for three months, resulted in lowering serum

Table 4: Flaxseed in management of various ailments.

Flax seed products	Preparation/processing method	Health benefits
Flaxseed tea	Flaxseeds are soaked in hot water for 30 min. and then removed while the water is still moderately warm	Beneficial against asthma, bad cough, bronchitis, dyspnoea, dysphonia
Flaxseed drink	Flaxseed powder (a tea spoon) is put into a glass of hot water, brewed and drained and at least a cup of this water is consumed daily.	Helps out constipation
Flaxseed flour	To make paste like consistency, mix flaxseed flour (10-gram) with honey for each concerned ailment. About 30-40 g of this paste is swallowed on on an empty stomach.	Curing mental disorders, disinfects gastrointestinal tract, management of age-associated distractibility, positive impact respiratory tract diseases, protects the skin getting dry, rapid healing of wounds through external use, reduce abdominal pains, bad cough, haemoptysis, inflammations of intestines, pulmonary tuberculosis, splenomegaly and stomach ulcer, strengthens memory and nervous system, treating the impairment of concentration, used as mouthwash in oral cavity, throat and gingival disorders and used in eczema and psoriasis diseases.

Source: Moghaddasi. (2011).

triglycerides and low density lipoprotein cholesterol, without any change in high density lipoprotein cholesterol levels (Shim *et al.* 2014).

Further, it was reported that long-term supplementation of omega-3 fatty acids was linked with a significant reduction in both systolic and diastolic blood pressure (Cicero *et al.* 2010). Hypertension is also a risk factor for chronic kidney disease. The probable effect of long-chain n-3 polyunsaturated fatty acids mechanism on blood pressure by which it protects the kidneys. Nevertheless, a positive association between α- linolenic acid and moderate chronic kidney disease was found (Gopinath *et al.* 2011). Consumption of whole flaxseed based products such as bar, bun and muffin, comprising 30 g flaxseed, significantly lowered systolic and diastolic blood pressure (Rodriguez-Leyva *et al.* 2013).

Simultaneously, Kajla *et al.* 2017 investigated the nutritional and anti-nutritional composition of four different varieties of flaxseed (JL-27, JL-23, JLS-6 and JLS-9) in raw form and after their germination for 48 hours. Significant variations in raw and treated samples were observed with regard to their micro mineral content. Maximum increase in manganese, iron and zinc contents were noted in the germinated sample of JLS-9 among all other samples. Moreover, reduction of 82.37 and 52.27 per cent in cyanogenic glycosides and phytic acid contents was noted in JLS-9 and JL-23, respectively.

CONCLUSION

To recapitulate, several studies stated that consumption of FOSHU products *i.e.* whole grain and other plant foods, were useful in maintenance of health and prevention and treatment of dreadful complications of degenerative diseases. Nutritive and non-nutritive properties of these products reducing risk of total mortality by 40 per cent. It can be implicated for both normal and therapeutic conditions as per suggested intakes and intervals to attain maximum benefits to the host.

Conflict of interest: None.

REFERENCES

Austin, G.L., Dalton, C.B., Hu, Y., Morris, C.B., Hankins, J., Weinland, S.R., Westman, E.C., Yancy, J. W.S., Drossman, D.A. (2009). A very low-carbohydrate diet improves symptoms and quality of life in diarrhea-predominant irritable bowel syndrome. Clinical Gastroenterology and Hepatology. 7: 706-708.

Bar-Sela, G., Tsalic, M., Fried, G., Goldberg, H. (2007). Wheat grass juice may improve hematological toxicity related to chemotherapy in Breast cancer patients: A pilot study. Nutrition and Cancer. 58: 43-48.

Behall, K.M., Scholfield, D.J., Hallfrisch, J.G. (2006). Barley b-glucan reduces plasma glucose and insulin responses compared with resistant starch in men. Nutrition Research. 26: 644-650.

Brounes, F.J.P.H., Buula, V.J.V., Shewry, P.R. (2013). Does wheat make us fat and sick? Journal of Cereal Science. 58: 209-215.

Chen, J.H. and Huang, X.F. (2009). The effects of diets enriched in β-glucans on blood lipoprotein concentrations. Journal of Clinical Lipidology. 3: 154-158.

Cicero, A.F.G., Derosa, G., Di, G., Bove, M., Gaddi, A.V., Borghi, C. (2010). Omega-3 polyunsaturated fatty acids supplementation and blood pressure levels in hypertriglyceridemic patients with untreated normal-high blood pressure and with or without metabolic syndrome: A retrospective study. Clinical and Experimental Hypertension. 32: 137-144.

Costabile, A., Klinder, A., Fava, F., Napolitano, A., Fogliano, V., Leonard, C. (2008). Wholegrain wheat breakfast cereal has a prebiotic effect on the human gut microbiota. British Journal of Nutrition. 99: 110-120.

Daou, C. and Zhang, H. (2012). Oat Â-Glucan: Its role in health promotion and prevention of diseases. Comprehensive Review in Food Science and Food Safety. 11: 355-365.

Dhavalagi, P., Hiremath, J.P., Madhusudan, N.M. (2021). Oats as a functional food. Bhartiya Krishi Anusandhan Patrika. 36: 350-352.

Gonlachanvit, S. (2010). Are rice and spicy diet good for functional gastrointestinal disorders? Journal of Neurogastroenterology and Motility. 16: 131-138.

Goyal, A., Sharma, V., Upadhyay, N., Gill, S., Sihag, M. (2014). Flax and flaxseed oil: an ancient medicine and modern functional food. Journal of Food Science and Technology. 51: 1633-1653.

Gillingham, L.G., Gustafson, J.A., Han, S.Y., Jassal, D.S., Jones, P.J.H. (2011). High-oleic rapeseed (canola) and flaxseed oils modulate serum lipids and inflammatory biomarkers in hypercholesterolaemic subjects. British Journal of Nutrition. 105: 417-427.

Gopinath, B., Harris, D.C., Flood, V.M., Burlutsky, G., Mitchell, P. (2011). Consumption of long-chain n-3 PUFA, a-linolenic acid and fish is associated with the prevalence of chronic kidney disease. British Journal of Nutrition. 105: 1361-1368.

Guerrant, R.L., Oria, R.B., Moore, S.R., Oria, M.O.B., Lima, A.A.M. (2008). Malnutrition as an enteric infectious disease with long-term effects on child development. Nutrition Review. 66: 487-505.

Guo, L., Tong, L., Liu, L., Zhong, K., Qiu, J., Zhou, S. (2014). The cholesterol lowering effects of oat varieties based on their difference in the composition of proteins and lipids. Lipids in Health and Disease. 13: 1-10.

Hippocrates. (2009). Health, food and prevention of diet related diseases. Joint Programming Initiative-Report. pp. 1-16.

Hui, Y.H., Chandan, R.C., Clark, S., Cross, N., Dobbs, J., Hurst, W.J., Nollet, L.M.L. et al. (2007). Functional Foods. In: Handbook of food products manufacturing: Health, meat, milk, poultry, seafood and vegetables. Hoboken New Jersey Canada: John Wiley and Sons Inc. pp. 922.

Jenkins, D.J.A., Kendall, C.W.C., Augustin, L.S.A., Martini, M.C., Axelsen, M., Faulkner, D., Vidgen, E. *et al.* (2002). Effect of wheat bran on glycemic control and risk factors for cardiovascular disease in type 2 diabetes. Diabetes Care. 25: 1522-1528.

Jennifer, L.A., Susan, J.W., Bernhard, H.J., Lilian, U.T., Jane, A. (2010). Health effects with consumption of the flax lignan secoisolariciresinol diglucoside. British Journal of Nutrition. 103: 929-939.

Jr, D.R.J. and Steffen, L.M. (2003). Nutrients, foods and dietary patterns as exposures in research: A framework for food synergy. The American Journal of Clinical Nutrition. 78: 508S-513S.

Juvonen, K.R., Salmenkallio-Marttila, M., Lyly, M., Liukkonen, K.H., L¨ahteenm¨aki, L., Laaksonen, D. E., Uusitupa, M.I. *et al.* (2011). Semisolid meal enriched in oat bran decreases plasma glucose and insulin levels, but does not change gastrointestinal peptide responses or short-term appetite in healthy subjects. Nutrition, Metabolism and Cardiovascular Diseases. 21: 748-756.

Kabir, M., Oppert, J.M., Vidal, H., Bruzzo, F., Fiquet, C., Wu'e, Rsch, P., Slama, G., Rizkalla, S. (2002). Four-week low-glycemic index breakfast with a modest amount of soluble fibers in type 2-diabetic men. Metabolism. 51: 819-826.

Kajla, P., Sharma, A., Sood, D.R. (2017). Effect of germination on proximate principles, minerals and anti-nutrients of flaxseeds. Asian Journal of Dairy and Food Research. 36: 52-57.

Kapoor, S., Sachdeva, R., Kochhar, A. (2011). Efficacy of flaxseed supplementation on nutrient intake and other lifestyle pattern in menopausal diabetic females. Ethnomedicine. 5: 153-160.

Kerckhoffs, D.A.J.M., Hornstra, G., Mensink, R.P. (2003). Cholesterol-lowering effect of β-glucan from oat bran in mildly hypercholesterolemic subjects may decrease when β-glucan is incorporated into bread and cookies. American Journal of Clinical Nutrition. 78: 221-227.

Khan, S.H., Butt, M.S., Anjum, F.M., Sameen, A. (2011). Quality evaluation of rice bran protein isolate-based weaning food for preschoolers. International Journal of Food Science and Nutrition. 62: 280-288.

Kumari, N., Khetarpaul, N., Vinita, Rani, P. (2018). Nutrient composition of full fat and defatted rice bran. Asian Journal of Dairy and Food Research. 37: 77-80.

Maki, K.C., Schinnick, F., Sceley, M.A., Veith, P.E., Quinn, L.C., Hallissey, P.J., Temer, A., Davidson, M.H. (2003). Food products containing free tall-oil based phytosterol and oat β-glucan lower serum total and LDL-cholesterol in hypercholesterolemic adults. Journal of Nutrition. 133: 808-813.

Mani, U.V., Mani, I., Biswas, M., Kumar, S.N. (2011). An open-label study on the effect of flax seed powder (*Linum usitatissimum*) supplementation in the management of diabetes mellitus. Journal of Dietary Supplements. 8: 257-265.

Mazza, G. (2008). Production, processing and uses of Canadian flax. First CGNA International Workshop, Temuco, Chile, August. 3-6. 2008.

McCullough, R.S., Edel, A.L., Bassett, C.M.C., LaVallee, R.K., Dibrov, E., Blackwood, D.P. ander, B. P., Pierce, G.N. (2011). The alpha linolenic acid content of flaxseed is associated with an induction of adipose leptin expression. Lipids. 46: 1043-1052.

Moghaddasi, M.S. (2011). Linseed and usages in Human life. Advances in Environmental Biology. 5: 1380-1392.

Mogra, R. and Rathi, P. (2013). Health benefits of wheat grass - A wonder food. International Journal of Food and Nutritional Sciences. 2: 10-13.

Mohamed, D.A., Al-Okbi, S.Y., El-Hariri, D.M., Mousa, I.I. (2012). Potential health benefits of bread supplemented with defatted flaxseeds under dietary regimen in normal and type 2 diabetic subjects. Polish Journal of Food and Nutrition Sciences. 62: 103-108.

Naaz, S. and Begum, N. (2021). Development of low glycemic index diabetic friendly biscuits. International Journal of Multidisciplinary Education and Research. 10: 133-143.

Otles, S. and Cagindi, O. (2006). Cereal based functional foods and nutraceuticals. Acta Scientiarum Polonorum, Technologia Alimentaria. 5: 107-112.

Patade, A., Devareddy, L., Lucas, E.A., Korlagunta, D.B.P., Arjmandi, B.H. (2008). Flaxseed reduces total and LDL cholesterol concentrations in Native American postmenopausal women. Journal of Women's Health (Larchmt). 17: 355-366.

Reyna, V.N., Bermudez, P.V., Mengual, M.E., Arias, N., Cano, P.C., Leal, G.E., Souki, A., Inglett, G.E. *et al.* (2007). Oat-derived β-glucan significantly improves HDLC and diminishes LDLC and non-HDL cholesterol in overweight individuals with mild hypercholesterolemia. American Journal of Therapeutics. 14: 203-212.

Rodriguez-Leyva, D., Weighell, W., Edel, A.L., LaVallee, R., Dibrov, E., Pinneker, R., Maddaford, T.G., *et al.* (2013). Potent antihypertensive action of dietary flaxseed in hypertensive patients. Hypertension. 62: 1081-1089.

Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karurabga, S., Unwin, N., Colagiuri, S., Guariguata, L. *et al.* (2019). Committee IDF Diabetes Atlas. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes federation Diabetes Atlas 9th edition. Diabetes Research and Clinical Practice. doi: 10.1016/j.diabres. 2019. 107843.

Shim, Y.Y., Gui, B., Arnison, P.G., Wang, Y., Reaney, M.J.T. (2014). Flaxseed (*Linum usitatissimum* L.) compositions and processing: a review. Trends in Food Science and Technology. 38: 5-20.

Simmons, R.K., Alberti, K.G., Gale, E.A., Colagiuri, S., Tuomilehto, J., Qiao, Q., Ramachandran, A. *et al.* (2010). The metabolic syndrome: Useful concept or clinical tool? Report of a WHO expert consultation. Diabetologia. 53: 600-605.

Singla, P. and Grover, K. (2017). Biofortified cereal crops: A sustainable approach for food and nutritional security. Current Journal of Applied Science and Technology. 24: 1-13.

Tapola, N., Harvonen, H., Niskamen, L., Mikola, M., Sarkkinen. (2005). Glycemic responses of oat bran products in type 2-diabetic patients. Nutrition, Metabolism and Cardiovascular Diseases. 15: 255-261.

Tarpila, A., Wennberg, T., Tarpila, S. (2005). Flaxseed as a functional food. Current Topics in Nutraceutical Research. 3: 167-188.

Tiwari, U. and Cummins, E. (2011). Meta-analysis of the effect of β-glucan intake on blood cholesterol and glucose levels. Nutrition. 27: 1008-1016.

Tong, L., Zhong, K., Liu, L., Guo, L., Cao, L., Zhou, S. (2014). Oat oil lowers plasma and liver cholesterol concentrations by promoting the excretion of faecal lipids in hypocholesterolemic rats. Food Chemistry. 142: 129-134.

Watson, R.R., Preedy, V.R., Zibadi, S. (2014). Rice bran: A Food Ingredient with Global Public Health Opportunities. In: Wheat and rice in disease prevention and health: benefits, risks and mechanism of whole grains in health promotion [(ed.) Borresen, E.C. and Ryan, E.P.)]. USA: Academic press. pPp. 302-306.

WHO. (2012). The world health statistics Report 2012. World Health Geneva. http://apps.who.int/iris/bitstream/10665/44844/1/9789241564441-eng.pdf.

WHO. (2021). Diabetes. World Health Organisation. World Health Geneva. https://www.who.int/news-room/fact-sheets/detail/diabetes.