

Diversified therapeutic potential of *Avena sativa*: An exhaustive review

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ABSTRACT

Avena sativa belongs grasses family, the gramineae, commonly known as oat and are the third leading crop produced in United States after wheat and corn and the fourth most important crop worldwide. They are the most widely grown plant generally considered healthy food being commercially nutritious as well. Oat grain, oat bran, and oatmeal contain a soluble dietary fiber known as β -glucan, which can reduce serum concentration of total cholesterol and low-density lipoprotein cholesterol and also effective in lowering blood sugar levels. Various experimental studies have shown that oat is potential agent to prevent the induction and progression of various diseases such as cancer, bowel, malfunction, obesity, celiac disease etc. This review will discuss functional and medicinal properties of *Avena sativa*. However, owing to the numerous health benefits that they offer, their consumption has increased to quite an extent and they have now come to the forefront.

Keywords: *Avena sativa*, β -glucan, functional and medicinal properties

INTRODUCTION

Avena sativa is the scientific name of grass commonly known as oats and ‘‘Jai’’ or ‘‘Javi’’ in Hindi. It belongs to natural order *gramineae*. The common oat (*Avena sativa*) is a species of cereal grain grown for its seed, which is known by the same name (usually in the plural, unlike other grains). While oats are suitable for human consumption as oatmeal and rolled oats, one of the most common uses is as livestock feed. Oats make up a part of the daily diet of horses, about 20% of daily intake or smaller, and are regularly fed to cattle as well [1].

Taxonomical Classifications:

Botanical name : *Avena sativa*
Kingdom : Plantae (plants)

Subkingdom	: Tracheobionta (vascular plants)
Superdivision	: Spermatophyta (seed plants)
Division	: Magnoliophyta (flowering plants)
Class	: Liliopsida (monocotyledons)
Order	: Cyperales
Family	: Poaceae (Grass family)
Genus	: <i>Avena</i>
Species	: <i>A. sativa</i> (common oat), <i>A. byzantina</i> , <i>A. fatua</i> , <i>A. diffusa</i> , <i>A. orientalis</i>)



Fig.1: OAT (*Avene sativa*)

Origin and cultivation:

Oat has been cultivated for over 5000 years. Oats are the third leading crops produced in United States (after wheat and corn) and the fourth most important crop worldwide. They were once considered as weed which grows right with the barley and wheat. Later, oats started being planted as a crop. They are popular staple of British Island like Scotland. The grain was introduced into the America in 1602 by a Sea Caption who planted them into the Island of the coast of Massachusetts [2]. Oat or wild oat is annual grass, which is cultivated for its edible grains during early growth; the oat plant consists of leaves and a shortened stem, giving a rosette type of plant. The tillers grow into additional “branch plants” or tillers and under favorable conditions, the plant can form up to 30 tillers. The main stem and tillers can reach up to 2 or more feet depending on variety and growing condition [3]. These stems terminate in a large panicle that bears flowers and seeds or kernels. Each main and lateral stem as well as branch stem terminates in a spikelet that is removed during threshing. Generally two kernels, but occasionally one, are produced per spikelet. The oat kernel, also termed groat, is the part after the removal of palea and lemma. It is elongated spindle shaped, up to about 0.5 in. in length and 0.125 in. or less in width. It is generally covered with fine, silky hairs and includes the seed coat layers of cells, starchy endosperm and the embryo. Oat is an important food grain in temperate regions of the world. The sowing season is extended from October to December. The crop matures in about four to five month for fodder. Two and half cutting is taken from January to

March. The crop produces 500-600 quintal of green fodder and 2 to 3 quintal of grain per hectare with normal cultivation practices [4].

Oat Producer's Countries:

Top Oat Producers	
(Million metric tons)	
Russia	5.1
Canada	3.3
United States	1.7
Poland	1.3
Finland	1.2
Australia	1.1
Germany	1.0
Belarus	0.8
China	0.8
Ukraine	0.8 → 24.6

Source: UN Food & Agriculture Organization (FAO)

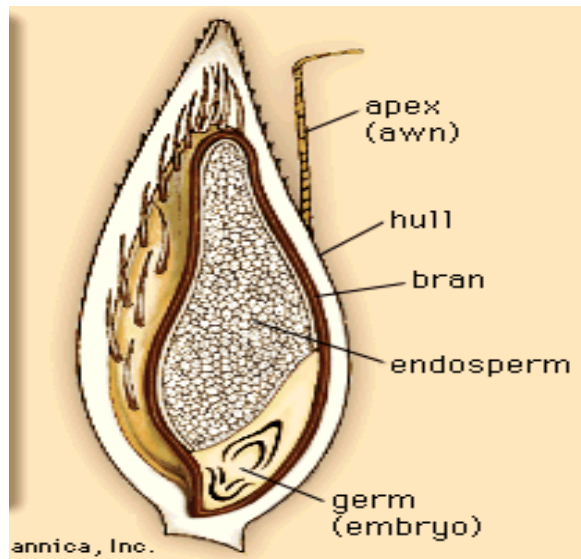


Fig.2: Structure of oat grain

Whole oat groat contains high amounts of valuable nutrients such as soluble fibers, proteins, unsaturated fatty acids, vitamins, minerals, and phytochemicals. The dietary fiber complex with its antioxidants and other phytochemicals is effective against cardiovascular disease and some types of cancer [5]. Oat groat contains significant amounts of β -glucan that varies between 2.3 and 8.5 g/100 g [6]. β -glucan in oat is distributed through the endosperm and is located in the endosperm cell walls constituting about 75% of the endosperm cell walls. It is also present in the aleurone cell wall lesser than in endosperm [7]. Bran is the edible, outermost layer of the oat kernel and it has total β -glucan and dietary fiber not less than 5.5 and 16.0% respectively with at least one third of total dietary fiber is soluble fiber [8]. Like oatmeal, oat bran contains B complex vitamins, protein, fat, minerals, and heart healthy soluble fiber called β -glucan. Oat bran contains 17.1% protein, 67.9% carbohydrates, 8.6% fat, 15– 22% dietary fiber, 10.4% β -glucan,

1.3 mg niacin, 171 mg magnesium, 6.4 mg iron, 0.17 mg copper, 441 mg potassium and α -tocopherol less than 0.5 mg [9].

β -glucan is a cluster of soluble fiber derived from multiple organic sources, including mushrooms, yeast, oats and barley. β -glucan is not a single molecule but is a type of polysaccharide that exists in different sizes and different degrees of solubility and ability to be absorbed into the bloodstream. One can find β -glucan that is big (of high molecular weight) or small (of low molecular weight). There are several different linkages between the different saccharide molecules that make up β -glucan. Molecular linkages can be of a (1, 4) type, a (1, 3) type and a (1, 6) linkage. These are important because each linkage type creates a different molecular shape for the β -glucan and may account for their function inside the body [10].

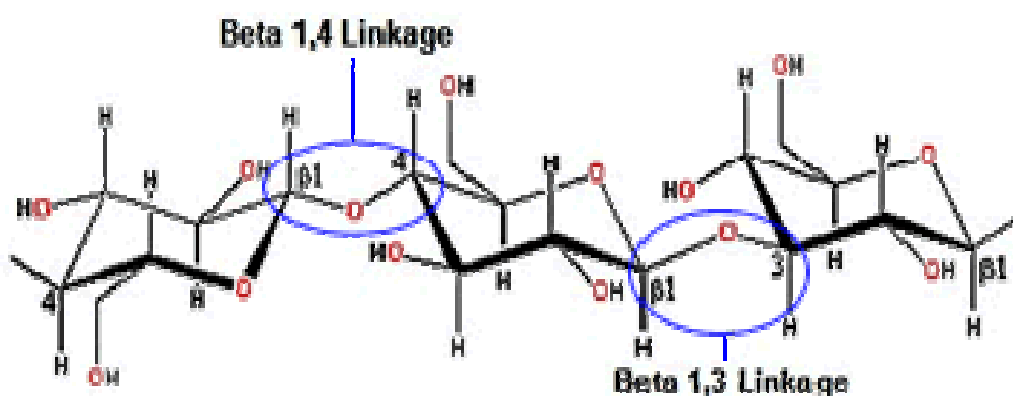


Fig.3: STRUCTURE OF β -GLUCAN (SOLUBLE FIBRE) IN OAT

Oat β -glucan is a soluble fibre and viscous polysaccharide made up of units of the monosaccharide D-glucose. Oat β -glucan is composed of mixed-linkage polysaccharides. This means the bonds between the D-glucose and D-glucopyranosyl units are β 1, 3 linkages or β 1, 4 linkages. The (1 \rightarrow 3)-linkages break up the uniform structure of the β D-glucan molecule and make it soluble and flexible. In comparison, the indigestible polysaccharide cellulose is insoluble. The reason for insoluble is that cellulose consists only of (1 \rightarrow 4)- β -D-linkages. The percentages of β -glucan in the various whole oat products are: oat bran, greater than 5.5% and up to 23.0%; rolled oats, about 4%; and whole oat flour about 4% [11].

The research has focused almost exclusively on only two positive effects that on cholesterol and blood sugar challenged individuals of β -glucan of oat. Various studies have shown that feeding an individual or animal dietary β -glucan from an oat source will lower the cholesterol by 9% [12]. Other research has showed oat consumption may lower insulin and blood sugar. The mechanism of action of this product against high blood sugar is unknown. In addition, oat-derived β -glucan seems to increase the amount of bile acids secreted in human test subjects. Bile acids come from the liver and gall bladder and contain a significant amount of cholesterol [13].

Therapeutic potentials of *avena sativa*

Like other whole grains, oatmeal is considered a nutritionally dense food, it contain plenty of complex slow digesting, low glycemic carbohydrates, cholesterol less, sodium less, nearly 5 gram of protein and sugar less [14]. *Avena sativa* has been in the reported as an antispasmodic

and stimulant. It is used mainly for its nutritional value and particularly beneficial in special diet for convalescent or for those with certain illness such as gastroenteritis and dyspepsia [15].

Oat and Cardiovascular Diseases: Cardiovascular diseases (CVD) is the name for the group of disorders of the heart and blood vessels and include hypertension (high blood pressure), coronary heart disease (heart attack), cerebrovascular disease (stroke), heart failure, peripheral vascular disease, etc [16]. Elevated total and low-density lipoprotein (LDL-C) cholesterol levels are considered major risk factors for cardiovascular disease. Oats are unique among the whole grains and are known to be healthy food for the heart due to their high β -glucan content. Oat β -glucan, a soluble dietary fiber that is found in the endosperm cell walls of oats, has generated considerable interest due to its cholesterol-lowering properties [17]. The consumption of oatmeal and oat bran, even for a short period of time, has been shown in most studies to reduce total plasma cholesterol and LDL-cholesterol levels, the main risk factors for CHD. This is mainly attributed to β -glucan, the soluble fiber content of oats. β -glucan interferes with the reabsorption of bile acid in the gut and reduces cholesterol levels [18]. Due to this well-established effect of oats on the risk of CHD, the United States Food and Drug Administration in 1997 approved the heart-health benefit claim on food labels of food containing soluble fiber from oats. In addition to its cholesterol-lowering effect, they have been shown to improve blood pressure when consumed with supplements of vitamin C [19].

Oat bran is potentially useful effect on plasma lipoprotein risk factors for cardiovascular disease [20]. The diets containing dietary fiber from wheat, oat, and rice bran; the oat bran has been found to be the only fiber source that significantly lowered total and low density-lipoprotein (LDL) cholesterol levels in mild hypercholesterolemics. Among all three, oat bran was found to slightly increase high-density-lipoprotein (HDL) cholesterol levels there were no significant changes in blood pressure, blood glucose, or serum insulin responses to a test meal on any of the bran supplemented diets. However, this potential benefit may be limited by the amount of fiber that individuals would need to consume [21].

Cereal-fiber sources decrease the chylomicron cholesterol concentration. The postprandial serum triglyceride response is significantly lowered with the addition of oat bran. Several mechanisms can be involved, such as impaired dietary triglyceride absorption from the small intestine, increased clearance of chylomicron particles and chylomicron remnant uptake, reduced liver very-low-density lipoprotein (VLDL-C) secretion, or increased VLDL-C catabolic rate [22].

Oat and Diabetes: Diabetes mellitus is characterized by abnormally high levels of blood glucose, either due to insufficient insulin production, or due to its ineffectiveness. The most common forms of diabetes are type-1 diabetes (5%), an autoimmune disorder, and type-2 diabetes (95%), which is associated with obesity [23]. Globally the total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 [24]. Diabetes, like most chronic health conditions, not only places substantial economic burdens on society as a whole but also imposes considerable economic burdens on individual patients and their families [25]. The risk of diabetes is higher with chronic use of several medications. Diabetes can be treated by increasing physical activity and decrease of carbohydrate that can refurbish insulin sensitivity [26]. The treatment with *Avena sativa* might be causes a release of insulin activity and improving

sensitivity for normalizing blood glucose level and reduce glucose production by the liver [27]. Control of blood glucose and insulin levels is essential in preventing many of the complications associated with diabetes. As the β -glucan, the soluble fiber of oats is digested, it forms a gel which causes the viscosity of the contents of the stomach and small intestine to be increased which may turn slows down digestion and prolongs the absorption of carbohydrates into the bloodstream. This means remarkable changes in blood sugar levels can be avoided [28].

Oat and Cancer: According to the World Cancer Report the cancer rates there would be 15 million new cases in the year 2020 i.e. a rise in 50%. Cancer has emerged as a major public health problem in developing countries, matching the industrialized nations. A healthy lifestyle and diet can help in preventing cancer [29]. Chronic inflammation is associated with a high cancer risk. At the molecular level, free radicals and aldehydes, produced during chronic inflammation, can induce deleterious gene mutation and post translational modifications of key cancer-related proteins. Chronic inflammation is also associated with immune suppression, which is a risk factor for cancer [30]. Recently, attention has been on phytochemicals that possess cancer-preventive properties. Oats, like other grains and vegetables, contain hundreds of phytochemicals (plant chemicals). Phytoestrogen compounds, called lignans, in oats have been linked to decreased risk of hormone-related diseases such as breast cancer [31]. Most of the research has been focused on breast cancer, but similar effects are expected on other hormone-related cancers such as prostate, endometrium and ovarian cancer. International research has shown that women with a higher intake of dietary fibre have lower circulating oestrogen levels, a factor associated with a lower risk of breast cancer. The insoluble fibers in oats are also thought to reduce carcinogens in the gastrointestinal tract [32].

Oat and Blood Pressure: The dietary approaches to stop hypertension (DASH) diet is a well accepted and widely recommended eating pattern shown to reduce blood pressure and widely affect blood lipids and insulin sensitivity. Although the DASH diet is typically understood as one that emphasizes fruits, vegetables, and low fat dairy products, it also emphasizes the consumption of whole grains [33]. Whole grains are a major contributor to the target nutrient of the DASH diet including calcium, potassium, fiber, protein, and zinc [34]. Daily serving of whole oats have been shown to improve endothelial function when consumed with supplements of vitamin-C rich in soluble fibre can reduce hypertension, or high blood pressure, and so reduce the need for anti-hypertensive medication. It usually has no symptoms, but can cause serious problems with the heart and blood vessels, leading to other complications [35].

Oat and Obesity: Obesity, defined as an unhealthy amount of body fat, is a well-established risk factor for many disorders like angina pectoris, congestive heart failure, hypertension, hyperlipidemia, respiratory disorders, renal vein thrombosis, osteoarthritis, cancer, reduced fertility etc [36]. Obesity is now a global public health problem, with about 315 million people are estimated to fall into the WHO classified obesity categories. One of the primary causes this rapid rise in obesity rates is the increased availability of high-fat, energy dense foods [37]. Excessive consumption of energy-rich foods (snacks, processed foods and drinks) can encourage weight gain, which calls for a limit in the consumption of saturated and trans fats apart from sugars and salt in the diet [38]. Caloric restriction and increased physical activity has been shown to be only moderately successful in managing obesity. Diet rich in whole grain are inversely associated with risk of weight gain and obesity [39]. As the soluble fiber of oats is digested, it

forms a gel, which causes the viscosity of the contents of the stomach and small intestine to be increased. The gel delays stomach emptying making you feel full longer which helps with weight loss. Americans Scientific Advisory Committee, which concluded that consumption of at least 3 serving of whole grain per day can help with weight maintenance [40]. New research suggests that children between ages 2-18 years old who have a constant intake of oatmeal lowered their risk of obesity. The research found that the children who ate oatmeal were 50% less likely to become overweight, when compared to those children that did not eat it [41].

Oat and General Health and Longevity: Oatmeal contains a good balance of essential fatty acids, which have been linked with longevity and general good health, and also have one of the best amino acid profiles of any grain. Oats have a high concentration of natural, well-balanced protein [42]. Oats contain phytochemical which have been associated with protection from chronic disease such as cancer [43]. Amino acids are essential proteins that help facilitate optimum functioning of the body and are necessary for optimum functioning of the body [44]. Oats are a good source of vitamins such as thiamin, folic acid, biotin, pantothenic acid, tocopherol and minerals- zinc, selenium, copper, iron, manganese and magnesium [45]. It exhibit hypocholesterolemic and anticoagulant properties. This results in faster healing [46]. A number of these properties of oats have been linked with longevity and general good health.

Oat and Celiac Disease: Celiac disease is an autoimmune hereditary disorder of the small intestine that occurs in people of all ages from middle infancy because of sensitivity to gluten in food. Normally the lining of the small intestine has a downy velvety texture, but in celiac disorder it becomes smooth and flat. This reduces its ability to absorb nutrients, including sugars, proteins, vital minerals and vitamins from food [47]. When persons with celiac disease take foods containing gluten, their immune system responds by damaging the small intestine lining. Tiny fingerlike protrusions, called villi are attacked by the immune system and are ultimately destroyed. Malnutrition occurs without these villi, no matter how much food a person consumes because the nutrients from food pass the gut without being absorbed (malabsorption), leading to diarrhoea, vitamin and mineral deficiencies, anaemia and osteoporosis [48]. Children usually develop it at between six and 18 months of age. However, the onset of the disorder can be delayed and it can occur at any age, when the symptoms come on slowly, perhaps over years, making early diagnosis difficult [49]. Presently, the only effective treatment of celiac disease is a life-long rely on gluten-free diet [50]. No medication exists that will prevent damage, or keep the body from attacking the gut when gluten is present. Strict adherence to the gluten free diet allows the intestines to heal, leading to resolution of all symptoms in the vast majority of cases and, depending on how soon the diet is begun, can also eliminate the heightened risk of osteoporosis and intestinal cancer [51].

Oat and Antioxidant: Several classes of compounds with antioxidant activity have been identified in oat (*Avena sativa* L.) including vitamin E, flavonoids, and phenolic compounds, phytic acid [52]. Additional investigations have further characterized the antioxidant capacity of oat fractions, including hulls, bran, and endosperm [53]. These antioxidants are concentrated in the outer layers of the kernel. A few examples show that an oat-containing diet boosted the antioxidant capacity of serum or meat in animals. Antioxidants function in helping to maintain the stability of processed oat products, and oat can stabilize oils and fats against rancidity [54]. These oat components have been added to food and beverage products to preserve quality and

are associated with flavor, color, and aroma [55]. Antioxidant phytochemicals may also play an important role in human health via scavenging reactive oxygen and nitrogen species [56] and modulating several enzyme systems, such as lipoxygenases [57]. Antioxidant compounds help to prevent free from damaging LDL cholesterol, thus reducing the risk of cardiovascular disease [58].

In addition to its fiber benefits, oats are also a very good source of selenium. A necessary cofactor of the important antioxidant, glutathione peroxidase, selenium works with vitamin E in numerous vital antioxidant systems throughout the body. These powerful antioxidant actions make selenium helpful in decreasing asthma symptoms and in the prevention of heart disease. In addition, selenium is involved in DNA repair and is associated with a reduced risk for cancer, especially colon cancer [59].

Oat and Infection: The polysaccharides β -glucans occur as a principal component of the cellular walls. Some microorganisms, such as yeast and mushrooms, and also cereals such as oats and barley, are of economic interest because they contain large amounts of β -glucans. These substances stimulate the immune system, modulating antibody and cell mediated immunity, and thereby have beneficial effect in fighting infections (bacterial, viral, fungal and parasitic[60]. β -glucan not only helps neutrophils (the most abundant type of non-specific immune cell) direct to the site of an infection more rapidly; it also enhances their ability to eliminate the bacteria [60]. According to study, β -glucan helps these immune defenders quickly locate the bacterial mother stratum within infected tissue. And this more rapid response to infection results in faster microbial clearance and healing. Since our non-specific immune defenses are the body's first strike army against invading pathogens, thus oatmeal may boost immune response in addition to energy levels.

Oats and Gout: Oats contain naturally-occurring substances called purines. Purine is a compound found in nucleic acids, heterocyclic compounds made of imidazole rings and pyrimidine. When purine is metabolized, it creates a crystalline compound including uric acid, caffeine and xanthine. It is this uric acid that is the cause of gout, a painful arthritic disease. Purines are found in many foods include beer and alcoholic beverages, yeast, organ meat, legumes, mushrooms, spinach, cauliflower and cereals [62]. In some individuals who are susceptible to purine-related problems, excessive intake of these substances can cause health problems. Since purines can be broken down to form uric acid, excess accumulation of purines in the body can lead to excess accumulation of uric acid [63]. The health condition called "gout" and the formation of kidney stones from uric acid is two examples of uric acid-related problems that can be related to excessive intake of purine-containing foods. For this reason, individuals with kidney problems or gout may want to limit or avoid intake of purine-containing foods such as oats. Yet, recent research has suggested that purines from meat and fish increase risk of gout, while purines from plant foods fail to change the risk [64].

Oat and Childhood Asthma: Asthma is a chronic inflammatory disorder of the airways in which many cells play a role, including mast cells and eosinophils. In susceptible individuals, this inflammation causes symptoms which are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment and causes an associated increase in airway hyper responsiveness to a variety of stimuli. It is the result of

complex and only partially understood interactions of respiratory, inflammatory, and neural cells and their mediators [65]. The result is difficulty in breathing. Increasing consumption of whole grains could reduce the risk of childhood asthma by about 50%, suggests the International Study on Allergy and Asthma in Childhood [66]. Oatmeal is a whole grain and it may be beneficial to children who are at risk for asthma. The researchers, from the Dutch National Institute of Public Health and the Environment, Utrecht University, University Medical Center Groningen, used food frequency questionnaires completed by the parents of 598 Dutch children aged 8-13 years. They assessed the children's consumption of a range of foods including fish, fruits, vegetables, dairy and whole grain products. Data on asthma and wheezing were also assessed using medical tests as well as questionnaires. While no association between asthma and intake of fruits, vegetables, and dairy products was found, the children's intake of both whole grains and fish was significantly linked to incidence of wheezing and current asthma [67].

Oat and Skin Disorders: In addition to β -glucan soluble fiber, oats also contain unique, low-molecular-weight, soluble phenolic compounds called avenanthramides (a type of antioxidants), which are not present in other cereal grains [68]. These compounds are antipathogens, which are produced by the plant in response to exposure to pathogens such as fungi [69]. For some time, oatmeal has been recognized as a remedy for the treatment of poison ivy, sunburn, eczema, and psoriasis. Oat colloidal extract containing avenanthramides has also proved to have antihistamine and anti-irritation activity [70]. While the anti-itching property of oats and oatmeal has been known for centuries, a recent report provided molecular evidence for the mechanism by which oat avenanthramides may exert their soothing effect on irritated skin [71].

Oat and Bowel Syndrome: Bowel Syndrome is a functional disorder of the gastrointestinal tract, unrelated to any structural defects. It is characterized by the presence of some or all of the following symptoms like abdominal pain or distention, irregular frequency of bowel movements, constipation/diarrhea, and abnormally large secretions of mucous from the colon, bloating, flatulence, nausea, anorexia, headaches and depression [72]. Possible factors that may contribute to irritable bowel syndrome include food allergies, lactose intolerance, excessive wheat bran consumption, parasitic infection, drugs especially antibiotics, metabolic disorders such as hypothyroidism and psychological factors such as stress, anxiety and depression [73]. The high dietary fiber in oats contributes to healthy bowel function. Insoluble fiber helps to make stools heavier. This accelerates their transit through the gut. It helps to eliminate constipation, and prevents piles which are mainly caused by chronic constipation [74].

Oat and Postmenopausal Breast Cancer: Oat meal which have been found to effective preventive measures for cancer. It is also suspected that the insoluble fiber in oatmeal reduces the toxicity in certain types of bile acids, which in turn reduces the risk of various types of cancer [75]. Results of a prospective study sated that postmenopausal women for an average of 8.3 years showed a 34% reduction in breast cancer risk for those consuming the most fruit fiber compared to those consuming especially cereal oat fiber, had a 50% reduction in their risk of breast cancer [76].

CONCLUSION

Various strategies are used to combat diseases and potential health risks. In addition to pharmaceutical approach, diet based strategies are also considered suitable to prevent various

disorders. In the developing countries, increased cost of medication and their side effects are of great concern to general public; opening new channels of pharmacological investigations focusing on natural medication and diverting human trends toward natural cure. Manipulation of different foods can be helpful to control different diseases. Oat grains are good source of B complex vitamins, protein, fat, minerals, and heart healthy soluble- fiber β -glucan. Moreover it is also useful for the control of diabetes and lipid profile. The incorporation of oat in daily diet is not only important from the nutrition standpoint but also for its therapeutic potential. Oats contain cereal protein globulin and also legume protein avenalin, as the major protein (80%), is twice richer in protein, Four times richer in calcium as compared to other grains. Thus it provides many health benefits such as serum cholesterol lowering, reduced coronary heart disease, and diabetic symptoms reduced blood pressure, and cancer prevention in humans. Primary health beneficial oat component is β -Glucan, an enriched oat hydrocolloid (OH) ingredient with 5-50% β -Glucan content (dry basis) commercially available. It can be adopted by the person on a crash diet for losing weight. Another health benefit of oat is that it has high protein and fiber content, which is comparable to the pulse and wheat. Thus, oats contain several bioactive compounds may contribute to the health effects and are easily available for consumption to increase the nutrition status as well as act as safe guarding against possible deficiencies.

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